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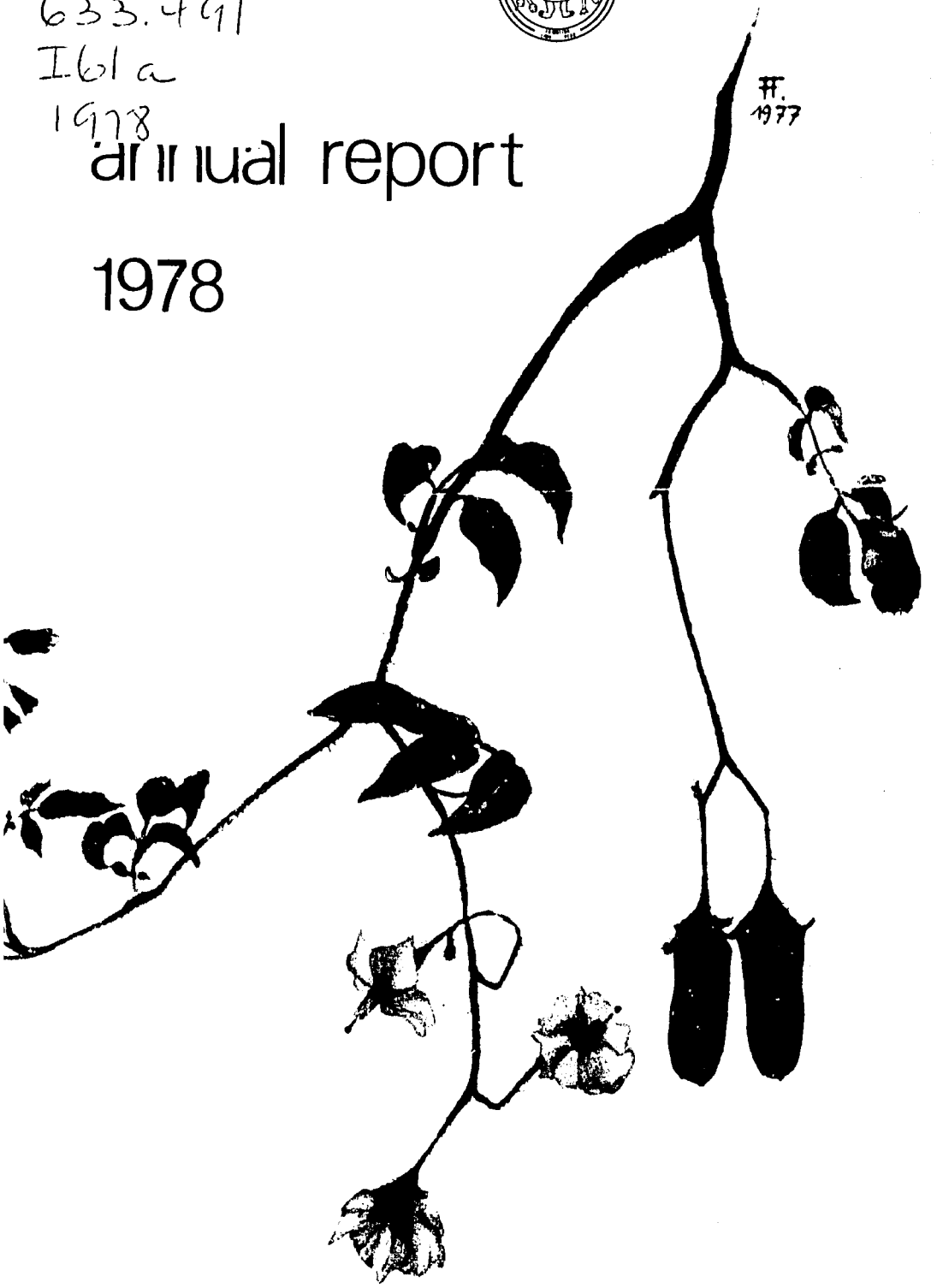


FRONT AND BACK COVERS

CIP's 1978 Annual Report is set off by paintings of two rare wild species of potatoes discovered during plant collection expeditions headed by Carlos Ochoa, well-known potato taxonomist and head of the CIP Taxonomy Department. The paintings are by Franz Frey.

Solanum subpanduratum Ochoa sp. nov. (front cover) is a wild species from the Venezuelan Andes from the series Conicibaccata and with 2n = 4x = 48 chromosomes. It was discovered by the CIP Expedition to Venezuela in the Páramo Los Aticos, 3,400 meters elevation, Estado de Mérida, October 1976. It is reproduced approximately natural size.

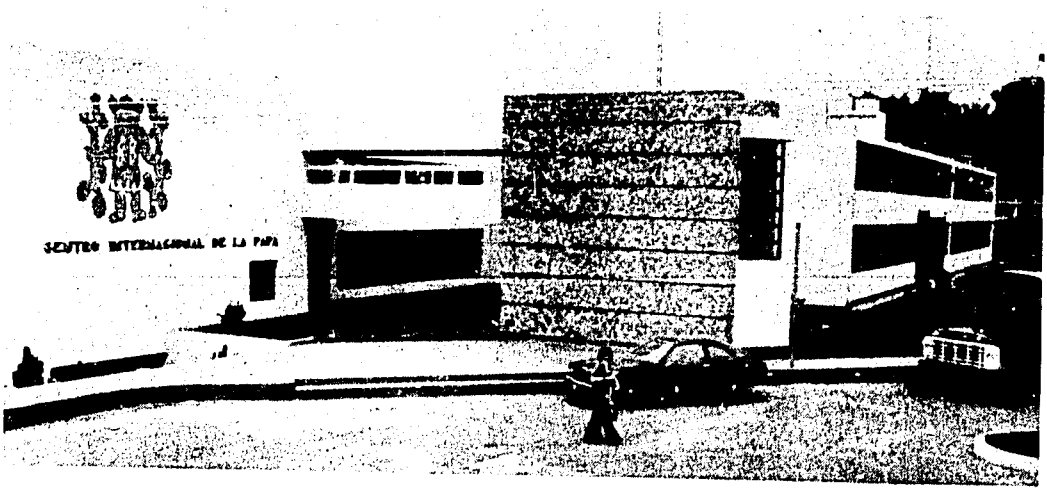
Solanum sotisii Hawkes (back cover) is a wild species from the series Piurana, with 2n = 4x = 48 chromosomes. Collected for the first time by E. K. Balls in 1939, between Azogues and Cañar, Ecuador, it was rediscovered by CIP Expedition to Ecuador in May 1976 in the vicinity of Río Yambagua, Chimborazo. It is approximately 90 percent natural size.

Both species are tetraploids and the only living collections in existence are at the International Potato Center, Lima, Perú.

(continued, inside back cover)

annual report

1978



International Potato Center
Apartado Postal 5969
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This is the seventh annual report published by the International Potato Center. Printed for worldwide distribution, the report covers the period of calendar 1978.

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.

Correct citation for this report is International Potato Center, 1978. CIP Annual Report, 1978, Lima, Peru.

Entire production of this annual report was by CIP personnel using CIP facilities. Date of distribution: July 1, 1979.

Director General's Report

More than ten years ago I came to Perú for the first time, intrigued by the opportunities in the ancestral home of the potato to help resolve the world food problem. Thanks to the benevolence of the Peruvian Government, an enlightened group of donors, an understanding Board of Trustees and especially due to the grace of God, there is now an International Potato Center with a worldwide program.

My role in the Center has gradually changed from builder to janitor. Being janitor is equally as exciting and possibly more so than being a builder. Fifteen years ago, the potential of the potato as a food was recognized. However, the potato remained only a rich man's vegetable in most tropical areas of the world except for the highlands. Today, this is changing rapidly. Countries where income is low, population is high, and food is scarce recognize that the potato potentially can produce more well balanced protein and calories per unit area, per unit of time and per unit of water than any other major food crop. Furthermore, these countries realize that the International Potato Center is doing the research to produce the technology that will permit them to utilize the potato.

Research has already produced a lowland tropical potato. The technology is being developed for production of the potato in the hot, humid tropics. Seed has long been a major constraint in distribution and utilization of the potato as a food especially for tropical subsistence farming. CIP's research is producing the technology for use of true seed instead of tubers in potato production. The tubers used for seed in traditional potato planting account for 50 to 70 percent of the total production costs. The new technology utilizing true seed, obtained from the plant's fruit and flower, will reduce seed costs to less than 5 percent of the total cost of production. Potentially this could place the potato in every backyard "home" garden within the next few years.

Forward planning has received major attention since CIP's initiation, through the use of periodic International Planning Conferences for each major area of research concentration. Recently published is a Profile of CIP 1970-1995 which designates goals and explains to donors and recipient countries CIP's philosophy of interaction.

The profile indicates those things for which CIP has a comparative advantage and those things which countries could and should be doing for themselves. The profile indicates that by 1990, some of CIP's present activities should be handed on to prepared national programs and CIP could confine its programs to those activities for which it will have a continuing comparative advantage.

I would like to personally thank the donors for the support they have given and are still giving to us; a Board of Trustees that has been very actively involved in the development of a Center with a different approach, and to a group of scientists who have taken a crop, the potato, back to the tropics from where it came and are exploiting it in an effective and efficient way for the good of mankind.

Richard L. Sawyer
Director General
International Potato Center

Representatives of newspapers, magazines, radio and TV obtain first hand information about CIP's potato research during a tour conducted by the Director General (center) following a September 1978 press conference.

The jar of true potato seed (circle) represents the amount needed to plant one hectare of the crop while the bags in the background represent the amount of tuber seed necessary to plant the same area.

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(Ing. Marciano Morales Bermúdez resigned from the Board as of May 31, 1978)

CIP's logogram (reproduced above) represents one of many art forms displayed in museums and archeological collections indicating the importance and high regard that ancient Peruvian cultures gave to the potato. The potato originated in the high plateau (altiplano) of the Andes mountains where wild plants are still being collected.

This "Portador de Papa" from the Fourth Century Nazca Culture, is depicted as holding harvested potato plants, one (in the figure's right hand) a healthy plant and the other obviously diseased.

The International Potato Center, in the Spanish language known as Centro Internacional de la Papa (CIP), is a scientific institution, autonomous and non-profit making, established by means of an agreement with the Government of Peru for the purpose of developing and disseminating knowledge for greater utilization of the potato as a basic food worldwide. International funding sources for technical assistance in agriculture finance the Center.

CIP Donors 1978

In 1972 only three donors were listed as contributing to the financial support of the International Potato Center. The donor list for 1978 is as follows:

	Core	Special Project
IBRD/IDA	X	
Australian Development Assistance Bureau	X	
Danish International Development Agency (DANIDA)	X	
Swiss Development Corporation	X	X
Netherlands Government	X	X
Belgium Goverment	X	
Swedish Agency for Research Cooperation with Developing Countries (SAREC)	X	
United Kingdom Overseas Development Agency	X	
Canadian International Development Agency (CIDA)	X	X
International Development Research Centre (IDRC)		X
German Agency for Technical Cooperation, Ltd. (GTZ)	X	
United States Agency for International Development (USAID)	X	
Inter-American Development Bank (IDB)	X	X
The Refrigeration Research Foundation		X
Ford Foundation		X

Thrusts...

The term "Thrust," as used by the International Potato Center, is based on the meaning of the word ". . . to extend, as in growth." It is an appropriate term for CIP's action-oriented, progressive research program. "Thrust" is also used in coordinating CIP's framework of projects into convenient research goals. Five research departments administratively serve as units for grouping personnel and for allocating project funding. "Thrusts" integrate the various research disciplines essential for a successful team approach for solving production problems.

CIP Research Summary

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

More than 4,000 duplicates of primitive cultivars in CIP's Germ Plasm Collection have been identified by plant appearance and by tuber protein patterns. Before discarding duplicates, composites of true seed were obtained for storage. Species determinations were made on more than 7,000 accessions.

In 1978, the second year of collecting wild species, three expeditions collected 121 specimens. Of approximately 170 known wild species of tuber-bearing *Solanums*, 54 do not exist in the living state. In Perú, the species *S. dolichocremastrum* was rediscovered; it was collected originally more than 200 years ago.

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

More than 8,000 primitive cultivars were maintained in the field for taxonomic evaluation and as source material for breeding. In research on adaptation to the lowland tropics, the most genetically diverse clones were the highest yielding and most stable in six lowland tropical sites. One hundred and twenty tetraploid clones were selected for observation under lowland conditions for combined bacterial wilt and root-knot nematode resistance. Of more than 25,000 seedlings screened for frost resistance, many had resistance to -5° C temperature while 44 survived a temperature of -8° C in the field.

No apparent barriers exist to screening for combined virus resistance. Up to 48 percent of seedlings were symptomless, indicative of resistance, following inoculation with combined X, Y and leaf roll viruses. Marked reductions were observed in infestations by epidemic levels of insects entrapped on glandular foliage hairs of hybrid plants selected for dense glandular pubescence. Preliminary observations indicate that glycoalkaloids also deter infestations by leaf hoppers.

Thrust III – Control of Important Fungal Diseases of Potatoes

Of 75,000 seedlings screened for field resistance to late blight, about 20 percent were retained for further blight testing and screening for additional useful traits. In contract research it has been established that components of blight resistance can be manipulated through selective breeding. In separate seedling populations tuber resistance was correlated with either resistance to entrance or invasion of the blight fungus into foliage.

An efficient and rapid seedling screening technique for wart resistance was developed during 1978. The screening technique was used to verify wart resistance in previously identified wart-resistant clones. Monitoring of smut and pink rot continued in highland fields in Perú as well as the evaluation of soil fungicides.

Thrust IV – Control of Important Bacterial Diseases of Potatoes

Breeding and screening for bacterial wilt resistance received major emphasis; research on *Erwinia* diseases was increased. The bacterial wilt resistant variety "Molinera" has been instrumental in lifting the quarantine imposed in the Department of Huánuco, Perú. Seventy to 90 percent resistant plants belonging to nine *Solanum* species have broadened the reserve of wilt resistance. "CRUZA 148" has repeatedly shown resistance under severe wilt conditions. Resistance to *Erwinia chrysanthemi* has been demonstrated.

Thrust V – Control of Important Virus Diseases of Potatoes

An efficient technique for screening for potato leaf roll virus (PLRV) resistance has been developed. PLRV-resistant clones were sent for field test to 12 countries. Improved techniques were initiated to detect the potato spindle tuber viroid (PSTV). One hundred and twelve of 118 clones were confirmed to be resistant to PVY using ELISA and latex serological techniques as well as grafting studies; 77 additional PVY-resistant clones were also identified. The host range of the novel viruses coded UC and Pep. MV as well as 11 isolates of PVS were studied. The X_{HB} strain of PVX was shown to infect USDA 41956 and the variety "Saco" previously considered immune to PVX.

Thrust VI – Control of Important Nematode and Insect Pests of Potatoes

Approximately 1,100 seedlings were retained through 1978 of a total of over 19,000 screened for cyst nematode resistance since 1974. Many seedlings were resistant to one or two diverse cyst nematode populations; none were resistant to four test populations. Fertilizer trials in cyst nematode infected soils significantly increased yields, particularly with phosphorus. Crosses involving *Solanum sparsipilum* as either male or female parent had the highest segregating progenies among 6,482 seedlings screened for root-knot nematode immunity. *Andigena* clones from contract research were susceptible to a Peruvian population of root-knot nematodes indicative of the occurrence of root-knot nematode races. A soil-drying technique was devised for isolating monocultures of false root-knot nematodes mixed with root-knot nematodes. Thirty-seven fungi were isolated from infected cyst nematode females and eggs as well as one from root-knot nematode females and eggs.

Studies continued on the inheritance of foliar glandular hairs in insect resistance. Sticky tip hairs segregated in a ratio indicating single dominant gene control in crosses of *S. berthaultii* and *S. tarijense*.

A more complex inheritance of foliar hairs with sticky tips is suggested for *S. berthaultii* and *S. phureja* crosses.

Thrust VII – Physiological, Agronomic Management of Potatoes Adapted to Environmental Stress

Research was initiated to develop agronomic techniques to produce consumer potatoes from true seed. It was clearly established that commercial yields and adequate tuber uniformity can be produced by plants grown from true seed. An on-farm program to optimize productivity was started using agroeconomic methods. Yield increases were obtained with various phosphorus sources under diverse environmental conditions. Mulching reduced soil erosion and runoff in field studies on mountain and high jungle slopes.

Physiological studies under high temperature field conditions suggest that low net carbohydrate synthesis may be due to high respiratory losses resulting in inefficient dry matter accumulation in non-heat adapted clones. Under contrasting water stress and optimal irrigation treatments genetically diverse clones yielded differentially. Some *Solanum* species possess relatively greater drought tolerance than drought avoidance. Anatomical differences related to frost hardiness as well as the capacity for certain *Solanum* species to acclimate to cold were demonstrated in contract research conducted at the University of Minnesota.

Thrust VIII – Development of Post-Harvest Technology and Improvement of Nutritional Quality

Various low cost storage structures were compared with respect to quality maintenance of different grades of seed tubers. A socioeconomic survey to determine distribution of potato production on 45 farms was conducted in contrasting ecological zones in the Mantaro Valley, Perú. Facilities and equipment were developed for the following steps in small-scale potato processing: storage, washing, cooking, peeling, cutting and solar drying. Approximately 7,000 analytical determination of nutritional quality were performed during 1978.

Thrust IX – Seed Production Research for Developing Countries

A detection and eradication program was started to ensure the potato spindle tuber-free status of CIP export material. Thirty-six tuber families grown under quarantine conditions were harvested for export while 182 other families were in various stages of production in the quarantine facilities. Adequate low-virus seed was produced for CIP field research requirements.

Low-temperature storage of plantlets derived from multimeristem cultures has been developed for maintaining pathogen-tested stock with only one transfer per year. Encouraging results have been obtained in low-temperature eradication of the potato spindle tuber viroid.

A socioeconomic survey of 80 farmers was conducted in Perú's central coast to determine the role of seed quality in subsequent yield and profitability of crop.

Thrust I

Collection and Classification of Tuber - Bearing *Solanums*

Research in taxonomy follows guidelines set in a 1976 Planning Conference Report, "Exploration and Maintenance of Germ Plasm Resources." The general objectives are to complete the collection and classification of primitive cultivars by 1982, and to begin systematic explorations for wild tuber-bearing *Solanums* of which 54 of approximately 170 species do not exist in the living state.

A wild species, difficult to recognize as a potato plant, growing amid the stony landscape of its natural habitat in the Andes mountains of Perú. Elevation: about 2,000 meters.

Taxonomic Identification

A total of 7,705 primitive cultivar accessions were examined in 1978 to determine the species distribution in CIP's Germ Plasm Collection (Table I - 1).

Table I - 1. Summary of primitive *Solanum* cultivars classified during 1978.

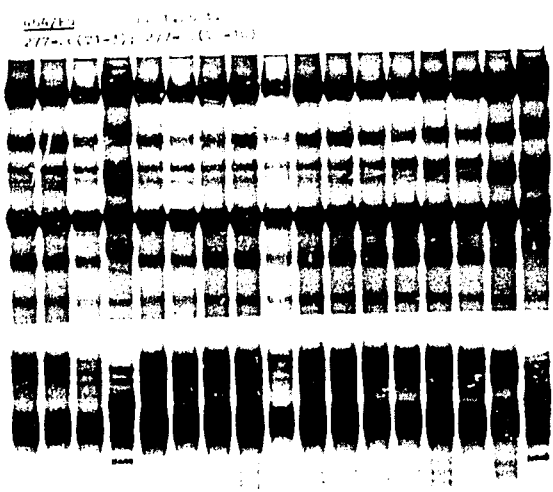
Species	2n	Number	Percent
S. stenotomum	24	659	8.6
S. goniocalyx	24	181	2.3
S. phureja	24	70	0.9
S. ajanhuiri	24	65	0.8
S. x *chaucha*	36	585	7.6
S. x *juzepczukii*	36	200	2.6
S. tuberosum			
spp. *andigena*	48	5,606	72.8
spp. *tuberosum*	48	117	1.5
S. curtilobum	60	222	2.9
		7,705	100.0

The identification by tuber or plant appearance of duplicates in CIP's collection of more than 13,000 cultivars is a difficult yet necessary task to provide an initial grouping prior to examination of tuber electrophoresis patterns. The state-of-the-art relies on human taxonomic expertise (morphology) and reproductibility of protein and esterase patterns by electrophoresis.

Discrepant samples are always retained as field specimens while composite seed samples of synonyms within a group are stored for future studies.

Collection of Wild Species

In 1978, the second year of collecting wild species, three extensive expeditions were conducted: one in the Republic of Bolivia and two in the Department of Ancash in Perú. Several short collecting trips were also made in the Peruvian



Photograph of similar and different electrophoretic protein patterns from potato tubers.

Departments of Junín, Pasco and Lima.

In seven weeks of plant exploring in Bolivia, 121 accessions were collected in the Departments of La Paz, Oruro, Potosí, Chuquisaca, Tarija, Santa Cruz and Cochabamba. In Perú the species *Solanum dolichocremastrum* was rediscovered. This species was collected originally by Dombey almost 200 years ago and described by Bitter at the beginning of the present century. It has now been recovered in the living state.

A summary of the accessions collected and classified during 1978 is included in Table I - 3.

During the year, 122 accessions of wild species were requested for use or evaluation by CIP scientists. A total of 135 accessions was sent to the Inter-Regional Potato Intro-

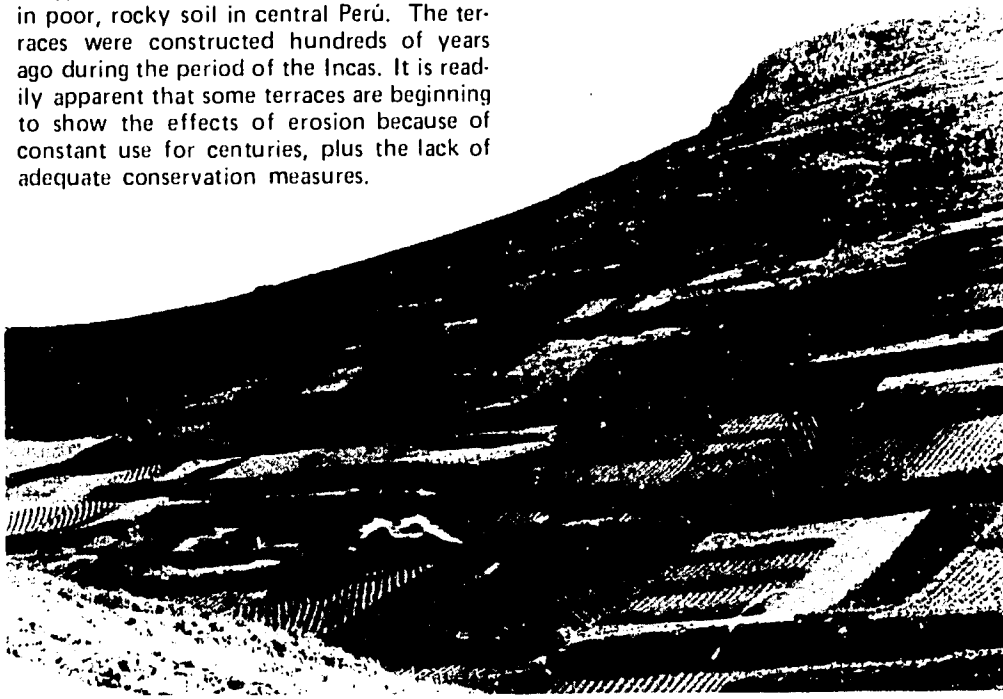
Table I - 3. Bolivian and Peruvian wild *Solanum* species collected and classified in 1978.

Country	No. of Accessions	
	Classified	Total Collected
Bolivia	82	121
Perú	63	117
	145	238

The Pacific Ocean laps at this central Chilean shore where wild potato plants may be found growing between the rocks or in sandy soils. The importance of primitive potatoes growing in this specific area is that they may contain desired characteristics of lowlands adaptability plus a certain amount of salt tolerance. One of CIP's objectives is to expand growing of potatoes in tropical lowlands. Additionally, a salt tolerance factor may be of use to the plant breeder who seeks to develop a potato variety that will grow under very poor or saline soil conditions.

duction Project (IR-1), Sturgeon Bay, Wisconsin and the Plant Introduction Station, Maryland, USA.

A typical view of high altitude farming area in poor, rocky soil in central Perú. The terraces were constructed hundreds of years ago during the period of the Incas. It is readily apparent that some terraces are beginning to show the effects of erosion because of constant use for centuries, plus the lack of adequate conservation measures.



Thrust II

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

More than 8,000 primitive cultivated potatoes were maintained in the field for taxonomic evaluation and as source material for breeding. In breeding for various agronomic features, attention was directed toward selecting uniform seedling families of potential use for field-scale propagation from true seed. Heterozygous seedling populations were identified with acceptable yields and stability over a range of environmental conditions.

Additional frost-resistant material was tested under field conditions in Perú, Bolivia and México. A wide range of clones produced good yields under high altitude cold conditions. A number of seedlings survived a temperature drop to -8°C in México.

Screening breeding material for resistance to bacterial wilt, late blight, PVX, PVY and PLRV continued. Clones with single and multiple disease resistance were selected with increasing frequency as a result of previous rigid selection of parental material. Improved resistance to combined root-knot nematode and *Pseudomonas* has been developed. Resistance to certain insects by entrapment on glandular hairs was further evaluated.

Maintenance and Distribution

It is the responsibility of CIP to maintain a world collection of potato germ plasm in a usable form. Some 8,400 samples of primitive cultivated potatoes were planted in late 1978 for field maintenance near Huancayo in the Peruvian highlands. Included were 639 new entries recently collected in Colombia and Ecuador. For security, tuber samples of each clone in the collection are stored at two sites in Perú and one in Colombia. The collection comprises 74 percent tetraploid, 13 percent diploid and 13 percent triploid and pentaploid samples.

An important aspect of Thrust II research is the elimination of duplicate cultivars in the germ plasm bank as a first step in reducing field maintenance. Before elimination of duplicates, true seeds are obtained by open pollination or bulk pollination. The true seed is then stored in a controlled environment.

A computer program that utilized 19 morphological characteristics was used to identify 3,014 duplicate entries from a sample of 5,448. In addition, 1,672 of 3,580 cultivars were tentatively identified as duplicates on the basis of plant and tuber characteristics. About 80 percent of 4,686 duplicates consisted of groups of two to five cultivars. Detailed morphological comparisons as well as electrophoretic analyses of proteins and esterases are being conducted prior to the elimination of any duplicate cultivars.

Use of Germ Plasm

Distribution of material from the germ plasm collection for routine evaluation and breeding purposes at CIP continued. However, distribution of material outside Perú was restricted following detection of spindle tuber viroid.

Agronomic Selection

Following preliminary trials to identify superior genetic combinations, 20,000 plants from 68 families were grown from seed and observed at La Molina for uniformity, yield and earliness (Table II-1).

Forty hybrid neo-tuberosum families were compared in the field at La Molina in research investigating the use of true seed for commercial potato production. A split plot design with six replications was used. Average yield of 300 seedlings per family is shown in Table II - 2 for some top yielding families.

Research on the relationship between levels of heterozygosity and adaptation to the lowland tropics was completed in 1978. Twenty-five hybrids were obtained by mating tetraploid parents with varying degrees of genetic divergence to form five groups with

Table II - 1. Pedigree, average yield and number of clones selected per family from a population of 20,000 seedlings grown at La Molina in a 90-day period from planting to harvest.

Family	Pedigree	Yield tons/ha	No. of clones
377873	N503.165 x 1356.3	61.2	5
377200	(P_6C_1.16 x LB) x LB bulk	53.5	7
377928	DTO-2 x R614.5	49.4	10
377950 *	Anita x DTO-28	44.8	30
377896	R258.21 x P_2C_6.2	44.1	38
377887 *	N568.7 x R704.1	41.7	88
377922	2001.10 x R646.1	40.5	48

* Potentially useful for propagation from true seed because of yield, vigor and uniformity.

Table II - 2. Tuber yield of plants grown from true seed 120 days after transplanting at La Molina, Perú.

Families	Yield kg/plant	Yield tons/ha
6.4	1.62	53.5
6.2	1.54	50.9
4.2	1.52	50.2
4.4	1.47	48.6
1.1	1.45	47.8
10.3	1.43	47.1
Population average 12,000 seedlings	1.26	41.7

five families in each. During the summer, the hybrids were evaluated at six lowland sites in Perú (Table II - 3).

It is significant that Groups I and II, the most heterozygous, were the highest yielding and most stable over the environmental range. This suggests that higher levels of heterozygosity provide a greater buffering capacity and increased homeostasis. These results further substantiate CIP's philosophy of population breeding to increase yield by maximizing heterozygosity combined with adaptation and resistance to pests and diseases.

In cytological studies contracted at the University of Wisconsin, diploid clones that have high 2n egg frequencies have provided some clones as to the mode of 2n egg formation. Second division restitution 2n eggs appear to be formed due to the omission of the second meiotic division. A possible mechanism for first division restitution found in one clone appears to be due to poor pairing in meiosis in megasporocytes and is apparently under control of a simple Mendelian recessive; it does not affect pairing in microsporocytes. This is a unique finding.

In a separate study at the University of Wisconsin, potato silage has been found to be very palatable to both goats and cattle. Digestibility tests indicate potato silage is comparable to alfalfa.

Frost Resistance

Breeding for frost resistance

Table II - 3. Average yield of groups in decreasing order of heterozygosity.

Group	Crosses *	Yield kg/plant
I	(neo-tbr) x (tbr x (tbr x phu))	.56
II	tbr x neo-tbr	.47
III	(tbr x (tbr x phu)) x (tbr x (tbr x phu))	.43
IV	neo-tbr x neo-tbr	.40
V	tbr x tbr	.39

* tbr = *S. tuberosum*; neo-tbr = *S. tbr* spp. *andigena*; phu = *S. phureja*.

continued in 1978 using the following materials:

(a) The wild resistant *Solanum* species *S. acaule*, *multidissectum*, *megistacrolobum*, *toralapanum*, *commersonii*, *boliviense*, *sanctaerosae* and *vernei*.

(b) The cultivated *Solanum* species *S. curtilobum*, *ajanhuiri*, *juzepczukii*, *stenotonum*, *phureja*, *andigena* and *tuberosum*.

(c) Backcrosses to more resistant F_1 hybrids obtained in previous years.

(d) Intercrosses among resistant selected clones to increase resistance and yield.

(e) Crosses of high yielding and/or late blight resistant tetraploids to diploids with high frost resistance using 2n gametes.

(f) Crosses of frost resistant clones to either nematode or late blight resistant clones.

Amount of material tested and selected for frost resistance is indicated in Table II - 4.

Field trials were in Usibamba, Perú (3,700 meters); Belén Experimental Station, Achacachi, Bolivia (3,900 meters); and Toluca, México (2,650 meters). In all locations frost to -3.5°C was recorded with an extreme of -8°C in Toluca. Field results are summarized in Table II - 5.

In Toluca 511 of 2,510 seedlings survived a temperature of -5°C while 44 seedlings survived a drop in temperature to -8°C.

In growth chamber studies at CIP, 90 selected clones were grown under controlled conditions simulating the highlands (Puno) of Perú. After three months growth the

Table II - 5. Yield of 10 best of 460 clones grown at 3,900 meters under cold stress conditions at Belén Experimental Station, Bolivia, Nov. 1977 - April 1978.

Clone no.	Yield kg/plant
374110-7	1.6
375577-5	1.5
375089-32	1.3
375057-45	1.3
374080-5	1.2
375089-6	1.2
375512-24	1.2
375089-31	1.1
375528-2	1.1
375579-15	1.1
Willa Imilla, local control	0.7

Table II - 4. Frost resistant materials selected from various crosses, 1977-78.

Materials	La Molina	Regional	Total
Crosses	202	23	225
Seedlings tested	21,383	3,894	25,277
Resistant seedlings selected	2,862	573	3,435

plants were subjected to -5°C for 2 hours during two consecutive days. Twenty-six clones survived the tests.

Disease Resistance

The diploid species *S. phureja*, *S. stenotonum*, *S. sparsipilum*, *S. chacoense* and *S. microdontum* are being used to form a wide base gene pool for resistance to bacterial wilt caused by *Pseudomonas solanacearum*. Over 7,000 seedlings have been screened for resistance to bacterial wilt; 75 families were screened for root-knot nematode resistance. Clones combining both resistances have been selected and crossed to tetraploids adapted to the lowland tropics. From these crosses, 120 tetraploid clones have been selected for further observation for both wilt and root-knot nematode resistance. This population also contains an input of late blight, PVX and PVY resistances.

A population of 6,850 seedlings in 40 tetraploid families derived from *S. phureja* with resistance to bacterial wilt as well as tropical adaptation were screened for resistance to bacterial wilt and late blight. From this work, 51 clones were selected and are being multiplied for international testing. From the same population, 35 percent of 2,462 seedlings survived under severe bacterial wilt conditions in Costa Rica. Sixty-two of 132 clones selected for resistance yielded 1 kg per plant or more; the maximum yield under severe stress conditions was 2.6 kg per plant.

PVY and PVX immunity is confirmed in selected clones by grafting with infected scions and testing for presence of virus by serology or indicator plants.

A breeding program has been developed with the objective of combining immunity to the viruses PVX and PVY with resistance to infection by PLRV. The steps in the selection cycle are as follows:

1. Seedlings are screened for resistance in the greenhouse;
2. Resistant tuber families are planted at San Ramón (800 meters);

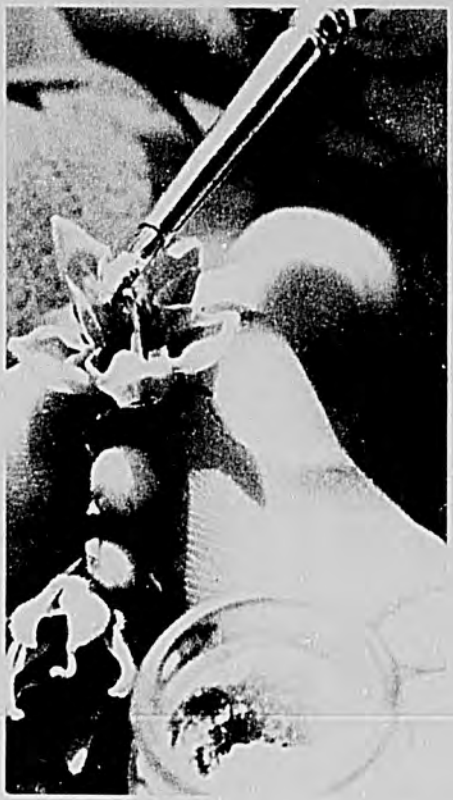
3. Agronomic characteristics and tuber quality are evaluated;
4. Immunity to PVY and/or PVX is confirmed by graft-testing;
5. PLRV resistance is confirmed by field infection trials during two seasons under the high temperature environment at San Ramón.

Results from two groups of material were obtained in 1978. In one group, screened for PLRV resistance, 329 out of 1,260 seedlings survived to the clonal selection stage. From these, 44 clones yielded more than 1 kg/plant, eight more than 2 kg/plant while two yielded more than 3 kg/plant. In the second group screened for PVY immunity, selected immune clones were crossed with clones that had performed well at the San Ramón site. Out of a total of 2,557 seedlings from these crosses, 352 survived to be selected in the field. One hundred twenty-one of these yielded more than 1 kg/plant, 17 more than 2 kg/plant and four more than 3 kg/plant. Due to the use of parents selected for tropical adaptation in the pedigree of the PVY progenies, the percentage of clones selected from this group

Table II - 6. Screening seedlings for resistance to combinations of PVX, PVY and PLRV.

	Parents *	Seedlings Total no.	Seedlings Symptomless percent
	X + Y + LR		
1.	66.1168/24 x VDI-144	103	9.7
2.	VD 4628 x 62.47/20	24	45.8
3.	BI 61-74-167 x Schwalbe	147	48.3
4.	BI 61-74-167 x BI 54-121	53	34.0
	Y + LR		
1.	71.254/54 x 62.47/20	14	7.1
2.	VD 72.33/22 x 62.47/20	32	53.1
3.	VD 8749 x 62.47/20	37	10.8
	X + LR		
1.	67.104/16 x 8750 B	100	49.0
2.	70.90/11 x VD 4667	107	43.0
3.	70.90/11 x VD 4668	110	44.5

* Parents no. 3 and 4 were obtained from the Foundation for Plant Breeding, Wageningen, the Netherlands. All other parents were obtained from the Max. Planck Institute, Cologne, Germany.



Making a cross: removing anthers (emasculation), above, and manual pollination, right.

in the field under San Ramón conditions was roughly twice the percentage selected from PLRV group, i.e. 27 percent vs. 14 percent, respectively.

CIP experiments showed no apparent barriers to combined virus screening. Table II - 6 illustrates the results of several different combinations of virus infection applied to different groups of material. In theory, most symptomless seedlings should be immune to PVX and/or PVY, depending on the group, and, in addition have some degree of resistance to infection by PLRV.

Research continued with *andigena* populations under Contract Research at Cornell University. Sixty selections from the sixth (1977) cycle generated the seventh (1978) cycle. Primary selection pressure was applied for resistance to PVX and PVY and for tuber and vine type. Blight was also evaluated by placing seedling transplants in 2 x 2-inch cells and placing them between rows of plants on which the late blight fungus was sporulating. A total of 14,069 tubers were harvested from selected progeny for increase in the greenhouse and indexing for PSTV before distribution. During 1978 seed and tubers were distributed to 17 scientists in 13 countries.

Nematode and Insect Resistance

In breeding and selecting improved potato populations a continuing effort was made to increase the use of wild species to bring the valuable genetic traits they possess into cultivated populations. Various combinations belonging to the species *Solanum phureja*, *S. chacoense* and *S. sparsipilum*, and *S. andigena* tetraploids were crossed to select genotypes resistant to the root-knot nematode, *Meloidogyne incognita acrita*. Results indicate that certain crosses are more compatible than others (Table II - 7).

From this research about 850 immune clones were selected for resistance to root-knot nematode. The same gene pool also had a high frequency of genotypes showing resistance to both root-knot nematodes and *Pseudomonas* bacteria (see Thrusts IV and VI).

F_1 and F_2 interspecific hybrids (*S. berthaultii* x *S. tuberosum*) were evaluated for density of glandular hairs on the foliage which function to trap insects. In replicated field trials the best clones reduced insect infestations (in comparison to the non-glandular cultivar, "Superior") as follows: potato leafhopper, 81 percent reduction; potato flea beetle, 69 percent, and green peach aphid, 27 percent. Highest yield among these newly developed hybrids was 8 kg/20 plants versus 11 kg/20 plants for the popular "Superior" variety. No insecticides were applied and infestations were at epidemic levels. The physical entrapment of insects by glandular exudates from leaf hairs offers a potential resistance mechanism for field control of potato insect pests (Table II - 8).

The presence of glycoalkaloid as a deterrent to insect infestations is also being studied by the Cornell group. Total glycoalkaloid extracts from foliage of leafhopper-resistant wild *Solanum* species were shown in bioassays to limit nymphal sur-

Table II - 7. Families derived from inter- and intra-specific crosses of diploids and tetraploid *Solanum* species used for resistance to *Meloidogyne incognita acrita*.

Female parents	Male parents: spl *	chc	phu	adg	Total families/genotypes
spl	3	6	8	–	17/846
chc	3	1	–	–	4/264
phu	20	1	14	–	35/3566
adg	–	–	–	49	49/1806
TOTAL	26	8	22	49	105/6482

* spl = *S. sparsipilum*; chc = *S. chacoense*; phu = *S. phureja*; adg = *S. andigena*

Table II - 8. Field infestations of potato leafhopper adults on *S. tuberosum* (tbr), *S. tuberosum* x *S. berthaultii* (tbr x ber), and *S. berthaultii* clones in trials at Ithaca, N. Y., 1978.

Clone	Species	Average no. *Empoasca fabae* adults/3 plants *				
		Seasonal total (12 plants)	12 July	26 July	10 Aug	23 Aug
Kennebec	tbr	235 a	3.0 a	35.5 a	99.5 a	99.8 a
Superior	tbr	192 ab	1.8 ab	28.5 ab	69.8 ab	92.3 a
Katahdin	tbr	182 ab	1.0 abc	24.5 abc	66.5 ab	90.0 a
A 444-9	tbr x ber	87 c	0.3 bc	14.8 c	28.8 c	43.3 b
PCB 4-42	tbr x ber	85 c	0.5 bc	23.8 abc	28.5 c	34.8 b
PCB 4-103	tbr x ber	21 d	0.5 bc	3.0 d	6.8 e	11.0 c
PI 265858-36	ber	2 e	0.0 c	0.0 e	0.5 f	1.5 d

* Means within a column followed by the same letter(s) are not significantly different at P = 0.05 by Duncan's Multiple Range Test.

vival and to interfere with normal feeding behavior. In comparison to a standard diet, nymph survival was reduced by 95 percent and total feeding time reduced by 73 percent on diets containing glycoalkaloids at levels found in foliage of *S. hougasii.*

PLRV-resistant progenies ready for export to national programs worldwide.

Thrust III

Control of Important Fungal Diseases of Potatoes

In accordance with recommendations of the Planning Conference on the "Control of Important Fungal Pathogens" in June 1978, major emphasis was placed on screening for field resistance to late blight. Screening efficiency for black wart resistance has increased greatly so that dual wart and frost resistant screening was accelerated. Studies of smut and pink rot and their control continue because these are problem diseases in CIP's research fields. A collection of potato disease specimens and microscope slide mounts is being assembled for CIP's Training Program.

Late Blight
(*Phytophthora infestans*)

Some 66,000 seedlings of 444 families were tested for late blight resistance with about 20 percent saved for further testing. In addition to material from breeding programs for blight resistance, increasing amounts of material was submitted for blight screening in combination with other traits, such as bacterial wilt resistance, lowland tropic adaptation (Table III - 1).

In another program, about 8,000 seedlings were field tested at Toluca, México, for late blight resistance. Approximately 30 percent were highly resistant, 470 of which were selected at harvest for yield and tuber characteristics. Previously selected clones were also field tested at CIP's San Ramón site with 416 out of 897 seedlings retained. A second field test at San Ramón failed because late blight did not occur. Another field test at Molinos, Huánuco Department, Perú resulted in 62 of 114 clones with no blight lesions developing during a severe epi-

Table III - 1. Seedling screening for late blight resistance at La Molina – 1978.

Program	No. of families	No. of seedlings	
		Tested	Selected/ Percent
Late blight breeding	143	37,970	13,115/35
Lowland tropics	100	23,039	607/3
Bacterial wilt	95	2,960	230/8
Wild species	106	2,041	138/7

demic, indicating that the selected clones may have had major genes other than those of the races present (0, 1, 2, 4 and combination).

CIP regional staff field tested clones for late blight resistance on the Irazú volcano in Costa Rica. Test material included best selections from the 1977 Mexican International Late Blight tests and clones with late blight and bacterial wilt resistance from the University of Wisconsin Research Contract program. In both 1977 and 1978, the R-gene differentials, R_0, R_1, R_2, R_3, R_4, R_7, R_{10} and R_{11} were heavily attacked but R_5 was not affected. Among 63 clones selected for blight resistance, 28 had superior resistance and seven yielded more than 1 kg of tubers per plant. Both the Wisconsin materials and the European cultivars were too susceptible under severe blight conditions in Costa Rica. Exceptions were the acaule - bulbocastanum - phureja - tuberosum crosses bred for CIP under contract in the Netherlands.

Seedlings from 15 crosses made at Svalov, Sweden were tested in the greenhouse for resistance to entrance and to invasion of foliage and tubers. The number of seedlings per family that exceeded their parents in resistance to entrance ranged from 0 to 49.4 percent (mean 17.2 percent). Number of seedlings exceeding their parents in resistance to invasion ranged from 1.5 to 29.6 percent. Analysis of variance showed significant variation between crosses in resistance to invasion. It is apparent that components of resistance to entrance and to invasion by hyphae of *Phytophthora infestans* can be separated and manipulated through selective breeding techniques.

Clones tested at Svalov for foliage resistance during 1977 were multiplied in the field and harvested in September 1978. Each population was tested together with its parents and with Bintje as a standard variety. It was established that tuber resistance is correlated with resistance to fungal entrance into the foliage but not to fungal invasion when calculations were based on the total material arising from diallel crosses. When crosses were analyzed separately, 3 populations had a significant correlation coefficient between tuber resistance and resistance to entrance, while in two populations (77042 and 77043) tuber resistance was correlated with resistance to invasion.

Wart (*Synchytrium endobioticum*)

A method has been developed to increase tuberization in 6 to 10-week-old seedlings by spraying plants at the five-week stage with Cycocel (chlorcholinchloride). The surfaces of JIFFY Pellets are dusted with dried, resting-stage sporangia of *S. endobioticum* derived from warty tubers. Symptoms begin to show on 8-week-old seedlings (Figures III - 1, 2). The time span is greatly reduced and relatively small amounts of inoculum are required.

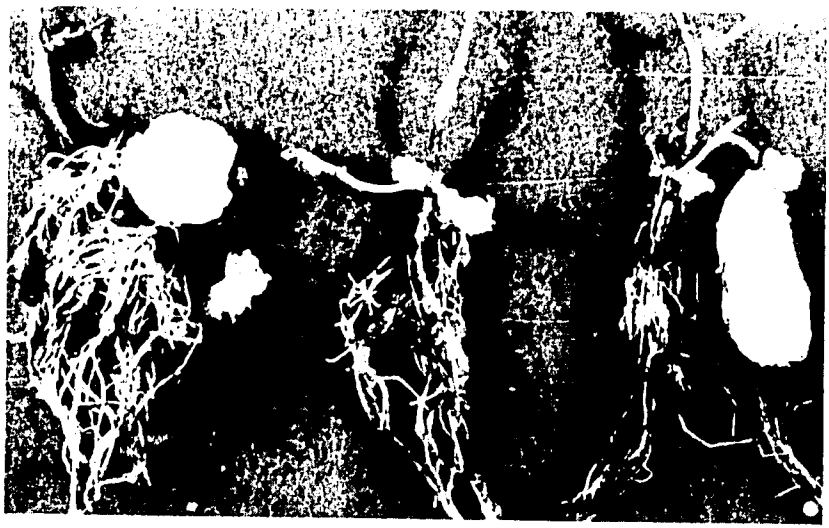


Figure III - 1. Symptoms of Wart (*Synchytrium endobioticum*) on 8-week-old potato seedlings.

Figure III - 2. Symptoms of Wart (*Synchytrium endobioticum*) on 12-week-old transplanted seedlings.

Seedlings from 120 crosses between clones resistant to *S. endobioticum* and clones selected for resistance to certain other diseases and pests were screened. Of a total of 1,156 clones, 77 percent showed no macroscopically visible symptoms, thus being either resistant or escapes. The tubers from clones showing no symptoms are to be retested using the Glynne-Lemmerzahl method.

The Glynne-Lemmerzahl method of inoculating tubers with the wart organism, in a comparison with the Spiekermann method, saves time and space, requires less inoculum, and offers the possibility to rate degrees of resistance with the Pratt rating scale with six steps from resistant through intermediate to susceptible reaction (Table III-2).

Clones with 0 to 4 ratings were maintained for further evaluation while susceptible material (degree 5

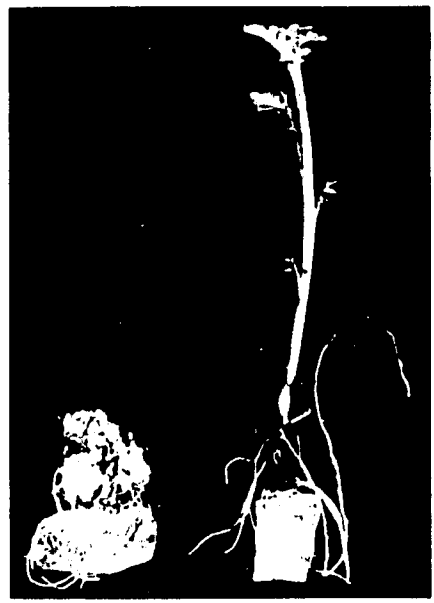


Figure III-3. Glynne-Lemmerzahl Test: Susceptible variety "Yungay" (left) compared to resistant (degree 3) variety "Mariva." Note symptoms of late necrosis at base of sprout of "Mariva" caused by *Synchytrium endobioticum.*

Table III - 2. Percent of clones rated by the Pratt scale for resistance to *Synchytrium endobioticum.*

Scale	Disease rating		Percent of clones
0	No symtoms resistant or escape		12
1 2	Early necrosis) Late necrosis)	resistant	18
3 4	Very late necrosis) Slight reaction)	intermediate	22
5 6	Strong reaction) Very strong reaction)	susceptible	50

and 6) was discarded. The Peruvian varieties Molinera, Chata Blanca, Collata, Huayro, Ticahuasi, Tarmeña, Yungay, and Tomasa Condemayta were susceptible while Mariva showed "very late necrosis" and can be considered to be intermediate in resistance (Figure III-3).

Six cultivars from Newfoundland, Canada, were resistant to the pathovar collected in Carpapata (Central Andes, South of Huancayo) which is used in all screening tests. The varieties with their resistance rating (in parenthesis): Mirton Pearl (1), Pink Pearl (0), N 170-261 (0), N 620-2 (0), N 227-15 (2) and N 433-21 (2).

Wart-infected tubers from about 40 locations in Perú were collected to determine presence and prevalence of biotypes of *S. endobioticum*.

Smut (*Angiosorus solani*)

So far 336 clones in the Germ Plasm Collection showed symptoms of smut, *Angiosorus solani*. These clones belong to seven species or subspecies of *Solanum: ajanhuiri*, spp. *andigena*, *curtilobum*, *chaucha*, *goniocalyx*, *phureja* and *stenotonum*.

Smut symptoms were observed at the lower end of the stem, in the stolons and tubers. Under the microscope, mycelium with typical septums and clamp connections is visible (Figure III - 4).

Greenhouse experiments using the fungicides Bayleton, Vitavax and Benlate did not control the disease when susceptible plants were grown in naturally infested soil.

Pink Rot (*Phytophthora erythroseptica*)

Pink rot has become increasingly important in highland fields in the Mantaro Valley, Perú. Soil fumigation studies have shown the effectiveness of Dazomet 98 which retards and reduces infection by *P. erythroseptica*. Diploid clones as a group are more susceptible to pink rot than tetraploid clones. Preliminary experiments suggest that tuber greening in-

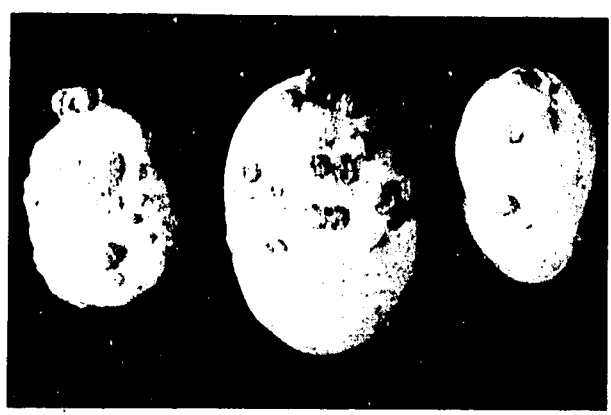


Figure III - 4. Tubers of the "Antarqui" variety showing protuberances resulting from infection by *Angiosorus solani*.

creases resistance to pink rot. This will be studied in relation to storage of seed in diffuse light.

Other Fungal Pathogens

Careful records are maintained of indigenous soil fungi infecting clones in the Germ Plasm Collection and in other CIP field plots in Perú. These records serve to select sites for field screening for resistance to specific fungal pathogens as well as to indicate where control measures may be necessary to reduce disease incidence. The fungi which are common in the Andean region are readily eliminated through normal greenhouse practices. In addition, only material isolated by meristem culture or grown from true seed is exported.

Thrust IV

Control of Important Bacterial Diseases of Potatoes

Breeding and screening for resistance received major emphasis in bacterial research in 1978. Although research emphasis continued on bacterial wilt of potatoes caused by *Pseudomonas solanacearum*, research on *Erwinia* diseases was increased. The development of clones derived from *S. phureja* with resistance to bacterial wilt, the identification in the Germ Plasm Collection of new sources of resistance and the characterization of new isolates of *P. solanacearum* were some of the principal achievements in bacterial wilt research. Two *Erwinia* subspecies and a new species affecting potatoes in Perú were characterized and, in addition, extensive screening for resistance to soft rot was conducted.

Bacterial Wilt

Field plots were established in Huánuco, Perú (2,300 meters) where bacterial wilt and late blight are endemic problems, to retest the dual resistance of earlier selections. Following initial screening of 66 clones for late blight resistance, 16 clones having a blight rating of four or less (1 - 9 scale) with yields of 0.5 - 1.2 kg/plant, were combined with five additional new clones and screened for bacterial wilt resistance. Thirteen of the 21 clones did not show wilt symptoms. Some of these same clones tested by the Colombian Potato Program also have appeared promising; nine have been selected for increase.

The impact of the "Molinera" variety, selected for wilt resistance in Perú, has been instrumental in lifting the quarantine imposed on seed potatoes from the Department of Huánuco. (Figure IV-1).

In another trial, 136 selected clones were planted at El Asesor near Lima to study their adaptation to irrigated desert conditions. Thirty-six clones, including 12 MB clones recently developed at CIP, yielded more than 1.0 kg/plant; six yielded more than the control variety "Ticahuasi" (Table IV - 1).

Fifty-one clones from 16 tuber families, derived from crosses of superior wilt resistant *phureja* and late blight resistant *demissum* sources, were selected for more extensive testing. A total of 115 accessions from 58 species were tested in another study against

a race 3 isolate of *P. solanacearum* (CIP-013) in an attempt to identify broader sources of resistance to wilt. Twelve accessions from nine species had 90 percent or more resistant plants (Table IV - 2).

Table IV - 1. High yielding bacterial wilt and late blight resistant clones adapted to irrigated desert winter conditions at El Asesor, Perú.

Clone	Yield kg/plant
MS 27A.3	1.39
MB 5.49	1.40
MS 82.60	1.50
MB 6.11	1.60
MB 6.25	1.70
MB 5.24	1.75
"Ticahuasi" (control)	1.38

The CIP collection of isolates of *P. solanacearum* includes a total of 159 from various host sources (Table IV - 3).

A total of 425 clones from the University of Wisconsin contract with combined resistance to bacterial wilt, late blight and virus Y

Table IV - 3. Number of isolates of *Pseudomonas solanacearum* classified according to biovar and host origin.

	Biovars				
Origin	1	2	3	4	Total
Potato	23	55	6	3	87
Solanaceous plants and weeds	10	5	21	10	46
Musa spp.	21	2	3	0	26
Total	54	62	30	13	159

Table IV - 2. Selected *Solanum* spp. resistant to *Pseudomonas solanacearum* isolate 013, race 3, under greenhouse conditions (25-31°C).

Solanum spp.	Accession no.	Number plants tested	Percent resistant plants
bulbocastanum	PI 243511	40	72.5
chacoense	CIP 760917.1	32	81.3
demissum	PI 160221	9	77.8
jamesii	CIP 760476 *	41	92.7
jamesii	PI 275266	14	78.6
polytrichon	PI 275241	64	82.9
stenotomum	OCH 3520	7	85.8
stenotomum	OCH 3571	13	92.4
stoloniferum	PI 161178	16	75.0
stoloniferum	PI 161170	38	84.3
sogarandium	PI 230510	20	70.0
sparsipilum	CIP 760147.7	11	91.0

* Previously reported, CIP Annual Report 1976, to be resistant to race 1 isolates 052 and 060 of *P. solanacearum*.

were received in Perú and Costa Rica for field evaluation. The 375 clones at CIP-Lima were screened for resistance against race "0" of *Phytophthora infestans*. Forty-seven clones were immune or showed a hypersensitive reaction, 103 were resistant and 208 clones were susceptible to late blight. Thirty of 150 clones sent to Costa Rica for field tests for blight resistance (some were duplicates of

Figure IV-1. Two farmers of Chaglla, Huánuco, Perú and a CIP scientist observe the yield of one plant of the variety "Molinera" in a potato seed field (right) and extensive plantings (below) of this variety, which was selected for wilt resistance, growing in Huánuco (3,200 m) where it is replacing the susceptible, long season potato crop.

those tested in Perú) were selected for further evaluation because of resistance and superior yield.

Field screening for bacterial wilt resistance in Turrialba, Costa Rica (600 meters elevation), under severe wilt conditions, yielded one clone, CRUZA 148, which has not wilted in three consecutive plantings and which has generally good agronomic characteristics.

In Turrialba field trials to determine influence of maize and bean rotations on the persistence of high indigenous levels of *P. solanacearum* race 1 in the soil, no significant difference in survival of the bacterium was observed (Figure IV - 2). A clear difference in the general susceptibility of the three varieties used in the study is shown in Figure IV - 3.

Fifty-seven *S. sparsipilum* x *S. phureja* clones were tested for resistance to race 1 (isolate LB-6) of *P. solanacearum* at Cornell University using a leaf clipping method of inoculation developed by A. Tschanz. Scissors were dipped in inoculum and used to cut three leaves per stem. One-half to one-third of each leaflet was cut off. Symptoms appeared in 3-5 days at 30°C. Fifteen of the 57 clones had high levels of resistance. These resistant clones are to be used in the Cornell Contract breeding program in crosses with clones having general or field resistance to *Phytophthora infestans.*

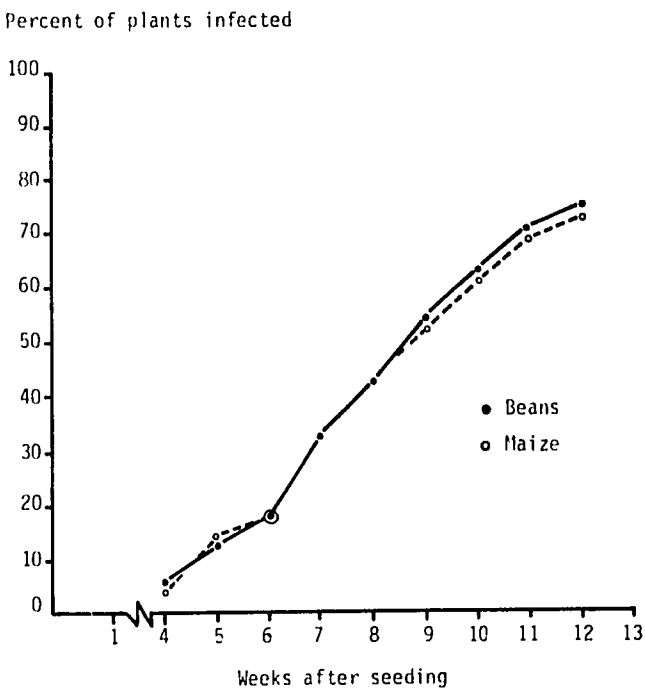


Figure IV-2. Influence of crop rotation on subsequent development of bacterial wilt.

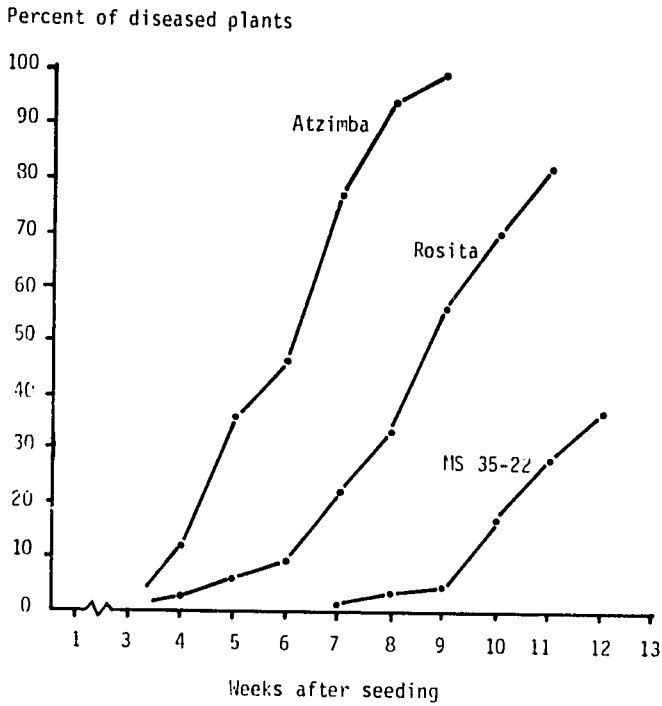
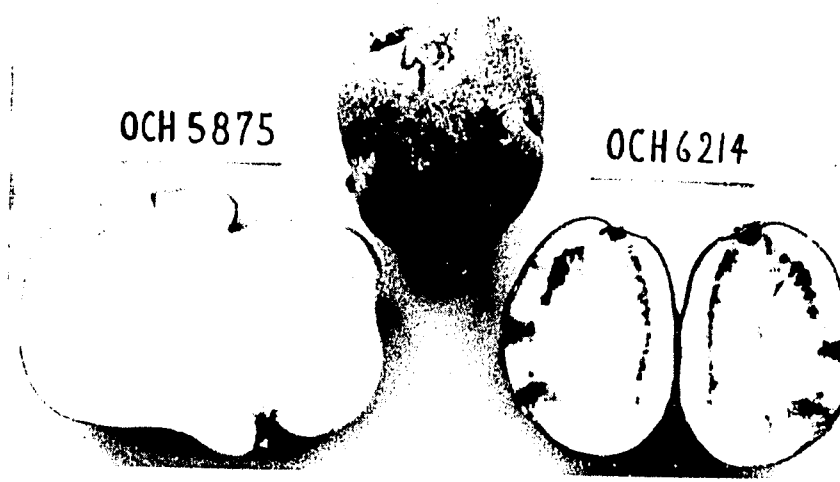


Figure IV-3. Increase of bacterial wilt in three clones following either beans or maize in rotation.

Erwinia Diseases

Clones previously reported to be resistant following inoculation with one level of inoculum, together with some accessions from the Germ Plasm Collection, were

Figure IV - 4. Infectivity titration with five levels of inoculum of *Erwinia chrysanthemi* (levels 3, 4 and 5 can be seen on central uncut tuber). Tuber half on left is resistant clone OCH 5875 and the cut tuber on right is susceptible clone OCH 6214.



tested for resistance with an aggressive soft rotting isolate of *Erwinia chrysanthemi* using an infectivity titration inoculation procedure. Inoculation was by injection with a microsyringe inserted 5 mm into the tubers. After incubation under low oxygen for 3 days at 25°C, tubers were cut through and the lesions and the diameter of the rotted tissue recorded (Figure IV - 4).

Two clones appeared to be either immune or very resistant, 13 were resistant, 11 moderately susceptible and 41 were susceptible. Those recorded as resistant are being increased to confirm these results in expanded tests with tubers and for examination for the development of "blackleg" symptoms.

Continuing the characterization of isolates of *Erwinia*, 28 isolates from the central and southern highlands, coast and jungle of Perú have now been classified: 17 are *E. caratovora* var. *caratovora*, 5 var. *atroseptica* and 6 *E. chrysanthemi*. These three types were found in the three regions causing both tuber rots and "blackleg" stem symptoms. Five of each type were inoculated into plants producing "blackleg" symptoms at 30°C but not at 20°C in the case of *caratovora* and *chrysanthemi* isolates, whereas *atroseptica* isolates caused symptoms at 20°C but not at 30°C.

Plant pathologist William J. Hooker of Michigan State University studies potato disease symptoms in preparation for publication of a compendium which is jointly sponsored by the American Phytopathological Society, the Potato Association of America and the International Potato Center.

Thrust V

Control of Important Virus Diseases of Potatoes

The discovery of potato spindle tuber viroid (PSTV) in some clones maintained at CIP necessitated a temporary reallocation of priorities in virus research. Modifications of methods which permit detection of PSTV infections with increased reliability were tested while established electrophoretic and indicator host detection methods were used in routine screening. The addition of a breeder-virologist resulted in some shift in emphasis in research on virus resistance. A labor- and time-saving seedling screening method for potato leaf roll virus (PSTV) was introduced into routine use. The successful adaptation of a spray gun method for mass inoculation of PVX and PVY and the development of a practical PSTV-free seed program increased the general efficiency of virus control.

Potato Leaf Roll Virus (PLRV)

Resistance to PLRV continued to receive high priority in virus research. Seedling screening techniques have been improved by several modifications. To ensure uniform germination of seeds from different families, all seeds are now treated with freshly prepared gibberellic acid before sowing. Seeds are germinated in a sterile sand and "Jiffy" mix amended with Cupravit to prevent algal growth. Infective aphids are transferred to each seedling when it is 2-4 cm high or, alternatively, shoots from PLRV-infected plants heavily colonized by aphids are shaken over seedling trays to distribute the aphids uniformly. The results shown in Experiment 3 of Table V - 1 indicate a reasonable agreement in PLRV symptom development with those obtained by the labor-intensive individual transfer of aphids (Expts. 1 and 2), except with family 700039. Because distinct symptoms develop in seedlings grown in trays, and because results are relatively consistent from one experiment to the next, only healthy seedlings require transplanting if there is a need to harvest tubers.

For screening of clonal materials, inoculation with aphids placed onto sprouts on tubers produced only low levels of PLRV infection. As a more efficient alternative sprouts were removed

from tubers, rooted and the small sprout cuttings exposed to infective aphids. Exposure of sprout cuttings seems more promising than exposure of stem cuttings because their use makes possible exposure of very small plants.

Further experiments with *S. brevidens* PI 218228 (see 1977 Annual Report) have shown that when it was challenged with PLRV by graft inoculation the virus multiplied at a low level in the grafted plants. Presence of the virus was confirmed in all instances by grafting to *Datura stramonium* and/or the variety "Ticahuasi." Symptomless infection was also detected in grafted *S. brevidens* PI 245763, on which aphids failed to survive, indicating resistance to *Myzus persicae*. This has been confirmed at Rothamsted Experimental Station, England, in research that found this resistance to function against *M. persicae* but not against *Macrosiphon euphorbiae*.

An international regional trial for testing PLRV resistance in clonal material was started during the report year. Field books supplied to cooperators provided full details of procedures, experimental designs, as well as data sheets. Tubers of some of the best breeding lines with resistance to PLRV were sent to the CIP regional programs from the Scottish Plant Breeding Station and the Max-Plank Institute. Many lines also had single gene resistance to PVY and/or PVX. Countries participating in the trials are Argentina, Chile, Colombia, India, Korea, Mexico, Pakistan, Philippines, Sri Lanka, Tunisia, Turkey and Zambia.

Table V - 1. Potato leaf roll virus symptom expression in seedling families following individual aphid transfer (Expts. 1 and 2) and by shaking distribution (Expt. 3).

	Percent of seedlings with PLRV symptoms *		
Family	Expt. 1	Expt. 2	Expt. 3
700921	5.2	1.4	2.7
700031	–	5.9	3.3
703256	6.5	8.4	15.0
701028	21.1	14.0	11.2
720031	–	23.0	13.8
700042	36.5	20.9	23.6
700039	56.6	58.5	21.5
701520	87.8	84.3	69.3
720027	86.9	74.8	84.2
"Renacimiento"	100	100	100

* Percentage of seedlings equated to the control variety "Renacimiento" = 100.

Potato Spindle Tuber Viroid (PSTV)

Efforts were directed to improving diagnostic techniques suitable for rapid, accurate detection of PSTV. The use of *Scopolia sinensis* as an indicator host was not reliable under test conditions at CIP, Lima. Electrophoresis was found to be more reliable than the Yang and Hooker tomato test, although a combination of electrophoresis and the tomato test are in routine use. Generally it was essential to grow both potato and tomato plants at temperatures above 25°C to ensure adequate concentration of viroid for screening purposes.

A modification of the original method of Morris and Smith to extract RNA from samples has substantially increased the efficiency of electrophoresis. This modification eliminates the need for dialyzing an RNA suspension after fractionation with lithium chloride. As a result, extraction time requires only 4 to 5 hours and the risk of RNA degradation by contaminating nucleases is reduced.

An antiserum produced in 1967 in Canada was tested at CIP. In double diffusion in gel the antiserum produced an extra precipitation line with sap from PSTV-infected plants. Unfortunately its titer was very low. Initial attempts to produce an antiserum at CIP by injecting PSTV-RNA and semi-purified extracts from infected plants resulted in an antiserum containing a low titer of an antibody which reacted with infected plants.

In cooperative research thermotherapy following meristem excision was not successful in viroid eradication. However, preliminary results in which meristems were excised from secondarily PSTV-infected plants cold treated at 5°C to 8°C *in vivo* and *in vitro*, and then maintained at 25°C until plantlets were regenerated, eradicated PSTV.

PVY and PVX

The adaptation of a spray gun technique for mass inoculation of seedlings has greatly speeded screening for PVY and PVX resistance. Carborumdum is mixed with strained inoculum and sprayed on seedlings. Infection rates are comparable to labor-intensive hand inoculation methods. As outlined in CIP Circular Volume VII, No. 1, 1979, up to 90 percent of susceptible seedlings can be eliminated while still growing in seedling trays. Resistant seedlings may be transplanted and then hand inoculated to verify results as well as to detect escapes.

A total of 118 clones were retested for immunity or extreme resistance to PVY using ELISA and latex serological techniques before and after grafting to *Nicotiana occidentalis* infected with PVY. One hundred and twelve clones were confirmed to be immune or

to have extreme resistance to PVY while the other six clones had field immunity or hypersensitivity. An additional 77 clones were identified having immunity or extreme resistance and eight with field immunity or hypersensitivity.

Novel Viruses

A virus coded UC was isolated from potato plants showing calico symptoms in a field in the highlands of Perú. The virus was not transmitted by *Myzus persicae*. It has isometric particles ca. 26 nm in diameter and was not related to tobacco ringspot, tomato black ring, Andean potato latent and Andean potato mottle viruses. The UC virus has a wide host range, infecting species of seven plant families.

A virus coded Pep. MV, pepino mosaic virus, was found in *S. muricatum* (pepino) in the Cañete Valley, Perú. The virus is ca. 525nm long; it failed to react with antiserum to PVX but caused a hypersensitive reaction in *S. stoloniferum* PI 230557, and the cultivars "Revolución" and "Merpata." Pep. MV was transmitted by contact but not with *M. persicae*. It was not detected in 100 clones examined in CIP's Germ Plasm Collection.

Studies on the wild potato mosaic virus (WPMV) and the X_{HB} strain of PVX were terminated. Of special interest is the fact that the X_{HB} strain showed a wide host range and infected clones USDA 41956 and the variety "Saco" previously considered immune to PVX.

Eleven isolates of PVS from the Andean region were compared with a European strain. Host range studies showed considerable differences in symptom expression between isolates. Segregation for hypersensitivity to PVS was found in seedlings of *S. chacoense* PI 275136 and *S. megistacrolobum* PI 265879. The resistant cultivar "Saco" was not infected by mechanical inoculation. Efficiency of *M. persicae* to transmit PVS and spread by contact varied greatly with the isolates.

Antisera, Serology and Electron Microscopy

The distribution of antisera to national potato programs increased during 1978 to 81 samples sent to 21 countries, in contrast to 86 samples sent to only 16 countries during the 1975-1977 period. Antisera samples distributed included: PVX (17), PVS (19), PVY (17), TRSV (4), APLV (12) and APMV (12). In addition to use for virus identification in developing countries, antisera was also used extensively: (a) for screening the CIP Germ Plasm Collection for different viruses, (b) to determine suitability of the ELISA technique for use at CIP, and (c) to develop the latex test as a routine technique both for CIP and for potato programs in developing countries.

Table V - 2. Virus detection in leaf and tuber sap by latex serology. (+ indicates a positive reaction, – a negative reaction).

Virus	Maximum infected sap dilution that gave a + reaction	Virus dilution end-point (by infectivity assay)	Detection in tubers
APLV (Hu)	1:2,000,000	10^{-6} to 10^{-7}	+
PVX (X_c)	1:2,000,000	10^{-6} to 10^{-7}	+
APMV (type)	1:32,000	10^{-6} to 10^{-7}	+
PVS (Andean strain)	1:32,000	10^{-5} to 10^{-6}	+
PVY (ordinary strain)	1:512	10^{-3} to 10^{-4}	--

The original latex test was modified to use plastic petri plates as carriers and the addition of a dispersant (Tween 20) to the Tri-HCl buffer. The dispersant avoids the need of centrifugation of samples. The latex procedure as now routinely used at CIP has given sensitive results with most viruses tested. The tests also are effective in detecting viruses in tuber tissue although the detection of PVY by latex is rather low, possibly due to the quality of PVY antisera used (Table V - 2).

The possibility of producing polivalent latex has been explored and found promising. Results indicate that it is possible to produce polivalent latex sensitized with several antisera which gives reliable results. In fact, in most instances the polivalent latex detected viruses at higher sap dilution than did the univalent latex (Table V - 3).

The enzyme-linked immunosorbent assay (ELISA) has been adopted for routine testing of potato viruses in leaf samples, tubers and plantlets derived from meristem culture. At present PVX, PVY, PVS, PVT, APLV, APMV, tobacco mosaic and 14 R viruses

Table V - 3. Detection of potato viruses with univalent and polivalent latex.

Latex	PVX	PVS	APLV	APMV
univalent PVX	16,000 *	–	–	–
univalent PVS	–	1,000	–	–
univalent APLV	–	–	64,000	–
univalent APMV	–	–	–	1,000
polivalent PVX + PVS + APLV + APMV	256,000	16,000	128,000	64,000

* Reciprocals of maximum infected sap dilutions that gave positive reactions.

can be detected by the ELISA technique described in more detail in CIP Circular Volume VI, No. 9, 1978. ELISA has been useful in detecting single and multiple infections in either leaf samples or tubers (Table V - 4).

Although ELISA was more sensitive than other serological techniques in detecting potato viruses, the latex technique is more simple to use. A combination of both techniques are used routinely for serological testing for viruses in CIP's seed program.

The electron microscopy laboratory opened for operation during 1978. The subsequent addition of a vacuum evaporator now permits preparation of strong, high contrast carbon films. About 2,000 samples, primarily from the clean seed program and for virus identification, were processed and observed. Several viruses were identified using a modification of leaf dip serology.

Table V - 4. ELISA values (OD_{405}) for tests on multiple detection of potato viruses.

Viruses	Experiment *		
	A	B	C
PVX	>2.0	>2.0	1.8
PVY	1.25	>2.0	1.3
PVS	1.60	>2.0	1.1
APMV	2.0	>2.0	–
PVX + PVY + PVS + APMV	>2.0	>2.0	–

* In Expt. A, viruses were cultured in separate propagation hosts and final dilution of all viruses was 1:40. In Expt. B, virus samples from leaves of the variety "Renacimiento" infected with one or more viruses were diluted 1:10 (W:V). In Expt. C, viruses were obtained from 0.2 g of infected tuber tissue of different cultivars diluted to a final concentration of 1:40.

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 emphasis during 1978. Sources of resistance have been identified for both nematode and insect pests and are being utilized in integrated control programs.

NEMATOLOGY

Potato Cyst Nematodes

A total of 2,395 clones from various sources were tested for resistance to four populations of *Globodera* spp. Of this total, 860 clones showed resistance to one or more nematode populations collected from the regions of Otuzco, Huancayo, Cuzco and Puno in Perú. Two clones of *S. juzepczukii* (702626 and 701323) were resistant to nematode populations from Huancayo, Cuzco and Puno. In addition, clones from the Netherlands had good resistance to the Huancayo population of cyst nematodes used in the screening trials. As well, some root-knot nematode resistant clones of *S. sparsipilum* and *S. chacoense* had wide resistance to Peruvian *Globodera* populations. Of 2,116 clones from 25 families from the Cornell Contract, including intercrosses of *S. sanctae-rosae*, *S. chacoense*, *S. multidissectum* and *S. vernei*, most were susceptible; none were resistant to all four cyst nematode populations.

In screening seedlings for *Globodera* resistance, crushed cysts (eggs) were added to soil one week after transplanting seedlings into 4-ounce plastic cups. Susceptible seedlings were discarded after 6-8 weeks while remaining plants were transplanted to 10 cm clay pots for tuber production. Of 19,435 seedlings screened since 1974, 1,157 were retained through 1978 since they showed some level of resistance to cyst nematodes. Several seedlings yielded about 2 kg of tubers per plant in *andigena* parental material having considerable in-breeding.

In tolerance studies of selected clones to *G. pallida*, a total of 219 clones were planted in a severely infested field (134 eggs/gm of soil) near Chocón, Perú. Sixty-one clones

were considered to be tolerant, yielding more than the control variety, "Renacimiento." In another field study with 14 varieties commonly grown in Perú, only the variety "Ticahuasi" appeared to be tolerant. Based on yield comparisons of varieties grown in untreated and nematicide-treated soil, "Ticahuasi" had a yield increase of less than 30 percent, which, under the experimental conditions, would not offset the cost of nematicide. Yield of "Ticahuasi" in untreated soil ranked second of the 14 varieties in the experiment.

Influences of N-P-K fertilizer levels were observed on the yield of the common *andigena* variety "Renacimiento" grown in a cyst nematode infested field (Table VI - 1).

The results of different levels of N-P-K indicate that, in spite of a uniform nematode infestation, there was a significant yield response to fertilizer, especially phosphorus. Results are to be analyzed to determine possible correlation between fertilizer and nematode multiplication rate.

Table VI - 1. Effect of N-P-K fertilizer on the yield of "Renacimiento" grown in a field infested with *Globodera pallida*.

Treatments (kg/ha)			Yield
N	P	K	kg/ha
160	400	200	29,680
160	200	400	26,950
320	400	400	26,580
320	400	200	24,680
0	0	400	9,080
0	400	0	17,480
320	0	0	8,390
0	0	0	8,910

Two-hundred and fifty-two cultures of potato cyst nematode were maintained at CIP during 1978. Of these, 35 were collected in Bolivia, 11 in Colombia, 16 in Ecuador, 112 in Perú, while 78 samples were obtained from 23 other countries.

Frequency of pathotype distribution in the Andean region is shown in Table VI - 2. More than 60 percent of the pathotypes identified belong to the races P_4 A and P_5 A. Two *andigena* clones, 702535 and 702698 used as progenitors of crosses made in 1978, were highly resistant to P_4 A and P_5 A.

Center of origin of the potato cyst nematodes was believed to be the Peruvian and Bolivian Andes with *G. rostochiensis* generally distributed south of Lake Titicaca and *G. pallida* predominant north of the Lake. In a joint CIP-Rothamsted expedition, potato cyst nematodes were collected from central and southern Perú and throughout Bolivia.

Fifty-two sites at altitudes between 3,000 and 4,500 meters were inspected. Ten of 24 sites in north and central Perú yielded *G. pallida* in contrast to one site in which *G. rostochiensis* was found. Six of 28 sites in Bolivia were infected with *G. pallida* while

Table VI - 2. Frequency of pathotype distribution in the Andes.

Pathotype	Differential clones	Frequency No.	Frequency %
P_1B *	*S. multidissectum*	1	1.9
P_2A *	*S. kurtzianum*	6	11.5
P_3A *	*S. vernei* GLKS	1	1.9
P_4A (P_a2)	*S. vernei* (VT)^2 62.33.3	13	25.0
P_5S (P_a3)	None	20	38.5
R_1A (R_01)	*S. tub* ssp. *andigena*	1	1.9
R_1B (R_04)	*S. tub* ssp. *andigena*	1	1.9
R_2A (R_02)	*S. kurtzianum*	3	5.8
R_3A (R_03)	*S. vernei* GLKS	6	11.5
		52	100.0

* No equivalence in European classification.

G. rostochiensis was found at three locations. This pattern of distribution is at variance with previously held concepts.

New *Globodera* species attacking *Oxalis tuberosa*, *Tropacolum tuberosum*, *Ullucus tuberosus* and *Chenopodium quinoa* were found near Lake Titicaca, Puno.

Root-knot Nematodes

A total of 105 families consisting of crosses between *S. sparsipilum*, *S. chacoense*, *S. phureja* and selected lines of the tetraploid, *S. tuberosum* ssp. *andigena*, were tested for resistance to *Meloidogyne incognita acrita*. The 6,482 seedlings from these crosses were each inoculated with 4,000 eggs of *M. incognita acrita*. Two months later, roots were removed and evaluated for nematode infection. Crosses involving *S. sparsipilum* clones as the female parent had the highest segregating immune-and-resistant progenies followed by crosses of *S. phureja*, *S. chacoense* and tetraploid *andigena* lines (maternal average). Paternal averages showed highest immune-and-resistant progenies in crosses of *S. chacoense* followed by *S. sparsipilum*, *S. phureja* and tetraploid *andigena* lines (Table VI - 3). Crosses between *S. chacoense* clones as male parents and either *S. chacoense* or *S. phureja* as females were limited, so definite inferences cannot be made about inheritance of immunity or resistance in this group. Crosses involving *S. sparsipilum* as either female or male parents had the highest immune segregating progenies in all the crosses tested. Apparently immunity is a recessive character and cytoplasmic effects are impor-

Table VI - 3. Percent immunity and resistance to *Meloidogyne incognita acrita* of inter- and intra-specific crosses of diploid and tetraploid and *Solanum* species.

Female parents	Male parents				
	S. sparsipilum	*S. chacoense*	*S. phureja*	Tetraploids	Maternal $\bar{x}$
S. sparsipilum	96.8	59.4	57.4	–	71.2
S. chacoense	34.8	0.8 *	–	–	24.0
S. phureja	28.9	100.0 *	6.0	–	44.9
Tetraploids	–	–	–	1.7	1.7
Paternal $\bar{x}$	53.5	77.0	30.4	1.7	

* Results of only one test cross.

tant, especially in the case of crosses with *S. sparsipilum* as a female (Table VI - 4).

All 25 *andigena* clones, selected in the Cornell University Contract program as being resistant to five species of the root-knot nematodes, were susceptible to a Peruvian population of *M. incognita acrita*. This implies occurrence of races in this group of nematodes, indicating need to study race distribution.

False Root-knot Nematodes

Influence of soil moisture on persistence of *Nacobbus aberrans* was part of the continuing study on biology of this nematode.

A soil sample from a heavily infested field was air dried on a laboratory bench and maintained in that condition for a year. Relative humidity of the soil sample during this period was 7 to 9 percent. Periodically, young tomato seedlings were transplanted in 4-ounce plastic cups containing this air dried soil. After 2 months, roots were washed and rated for nematode infection. Egg masses

Table VI - 4. Reaction of various diploid inter-specific crosses to *Meloidogyne incognita acrita*.

Cross ♀ x ♂	No. of families	Percent root galling index *					No. of seedlings
		0	1	2	3	4	
Res x Res	20	51	11	35	2	0	1058
Res x Sus	12	28	10	51	10	0	768
Sus x Res	21	4	10	66	19	<1	1370
Sus x Sus	9	<1	<1	44	51	3	819

* 0 = immune; 1 = resistant; 2 = moderately susceptible; 3 = susceptible; 4 = very susceptible.

Table VI - 5. Survival of *Nacobbus aberrans* in air dried soil.

Source of inoculum	Root galling index *		
	1 month	5 months	8 months
Moist infested soil	2.5	2.8	2.4
Dried infested soil	2.2	2.3	2.0
Uninfested soil	0.0	0.0	0.0

* 0 = no root galling to 4 = severe root galling.

and vermiform nematodes were extracted from parallel air dried soil samples at time of transplanting. Data (Table VI - 5) indicate that *N. aberrans* can withstand dessication for at least 8 months. Both viable egg masses and immature adult females were recovered suggesting that these two stages are the means of survival of this species under adverse moisture conditions.

Because both *Meloidogyne* spp. and *N. aberrans* often occur together, it is difficult to obtain monocultures of *N. aberrans*. Air drying infested soil for 2 to 4 weeks prior to planting susceptible hosts provided an efficient method of obtaining monocultures of *N. aberrans*.

Biological Control of Nematodes

In searching for natural biological agents that might limit establishment of *Globodera* nematodes in the Andes, 38 soil samples were collected from diverse habitats. These samples were inoculated with clean cysts of *G. pallida* and planted with tubers of "Mariva" and "Renacimiento" cultivars. Plants were periodically checked and soil samples were examined for the presence of fungus-infected developing female nematodes. Eggs of the first generation cysts were also examined for fungal infection.

A total of 37 fungi were isolated from infected eggs and developing females. Isolates of these fungi have now been inoculated onto plants infected with cyst nematodes to determine their possible eradication effect.

A fungus attacking mature females and eggs of *M. incognita acrita* populations was collected near Huánuco. The fungus is pathogenic to eggs as a large number of infected first generation eggs was found when root-knot nematode-infected plants were inoculated with the fungus (Figure VI - 1). Pathogenicity tests indicated a valuable potential use of this fungus in controlling root-knot and the potato cyst nematodes.

ENTOMOLOGY

Experiments at Rothamsted, Cornell and CIP confirmed that

glandular hairs on foliage of certain wild potato species help protect the plants against several small insect and mite pests. Emphasis was placed on studying the role of glandular hairs.

The wild potato species *S. polyadenium* and *S. tarijense* have numerous four-lobed glandular hairs on their leaves and have resistance to flea beetle, *Epitrix harilana rubia*, attack (Table VI - 6).

Resistance to damage by the mite, *Polyphagotarsonemus latus*, was found in *S. polyadenium* and in the seedlings *S. tarijense* and *S. berthaultii*. Leaves of these plants possessed sticky tip simple glandular hairs (Table VI - 7).

The leaf miner fly, *Liriomyza huidobrensis*, was trapped by the four-lobed hairs. Accessions of *S. berthaultii* and *S. tarijense* were resistant to feeding and ovipositing by this fly.

Inheritance of foliar hairs with sticky tips was investigated by crossing "seedlings" of *S.*

Figure VI - 1. Parasitized root-knot nematode eggs showing fungal hyphae completely replacing embryo. (Greatly enlarged)

Table VI - 6. Flea beetle feeding damage and glandular hair density on adaxial (upper) leaf surfaces of field plants.

Species	No. of clones	Feeding holes/plant	Glandular hairs/10 mm^2
S. berthaultii	9	9	75
S. tarijense	1	7	112
S. polyadenium	7	3	233
S. tuberosum	4	59	1

berthaultii and *S. tarijense* with and without sticky tips on hairs of mature leaves. Sticky tips were dominant in F_1 progeny. F_2 generations were obtained by crossing five plants within families, each family derived from each of the original crosses. Each family segregated in a 3:1 ratio, sticky tip : pointed tip (P = 0.05). A back-cross ratio of 1:1 confirmed that sticky tips are controlled by a single dominant gene.

Inheritance of foliar hairs with sticky tips was also studied

Table VI - 7. Mite damage to seedlings of *Solanum berthaultii* relative to the ocurrence of sticky tip hairs on the abaxial (under) surface of leaves.

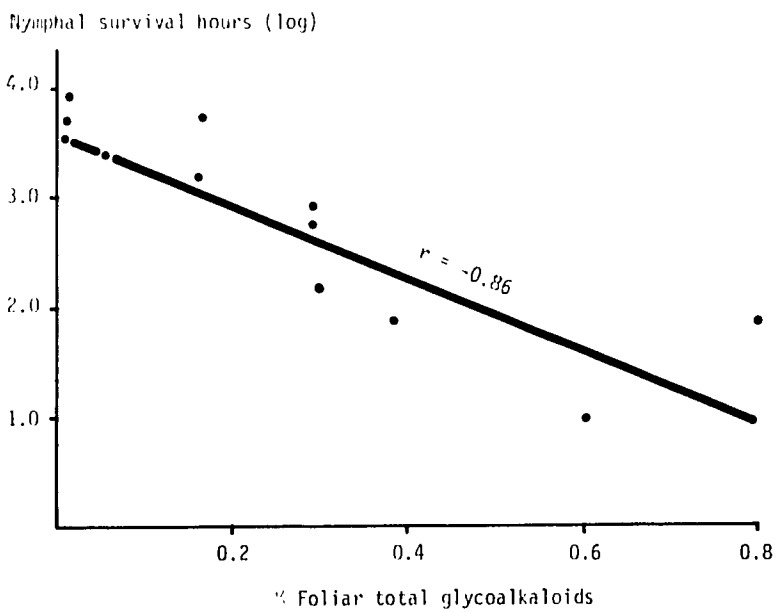
Seedling	Foliar hairs */mm^2	Percent leaf area damaged
Sticky tip		
PI 265857	11.6	3
PI 265858	10.5	6
PI 310926	14.0	8
PI 310927	35.4	0
HHC 4422	12.2	0
HHC 4531C	17.3	0
HHC 4574	15.1	18
HHC 4727	9.9	11
Non-glandular tip		
PI 283069	9.9	54
PI 310971	20.9	60
HHC 4538	14.3	4
HHC 4543	14.4	77
HHC 4562	11.6	34
HHC 4570	10.0	21

* Excluding the four-lobed hairs which appear to be ineffective against mites.

in *S. berthaultii* and *S. phureja* crosses. *S. berthaultii* PI 265858 has abundant sticky tipped foliar hairs and *S. phureja* has simple hairs without glandular tips on either young or mature leaves. All F_1 progeny had rudimentary glandular hairs but these were ineffective in trapping mites and insects. In the F_2 generation a ratio of approximately 4:9:3 (pointed:rudimentary glandular tip: sticky glandular tip) was observed. The simplest hypothesis that fits the results involves two gene loci, the full expression of the sticky glandular tip depending on the presence of two recessive genes at one locus and at least one dominant gene at the other. The presence of the glandular tip, rudimentary or otherwise, is thus controlled by the presence of only the dominant gene and accounts for the occurrence of the glandular tip in all F_1 progeny and three out of four F_2 progeny. While two back-crosses of F_1 progeny to *S. phureja* confirmed the above hypothesis, in a third back-cross there were significantly more progeny with pointed tips than expected in a back-cross ratio. More crosses will be made to clarify the two gene loci hypothesis.

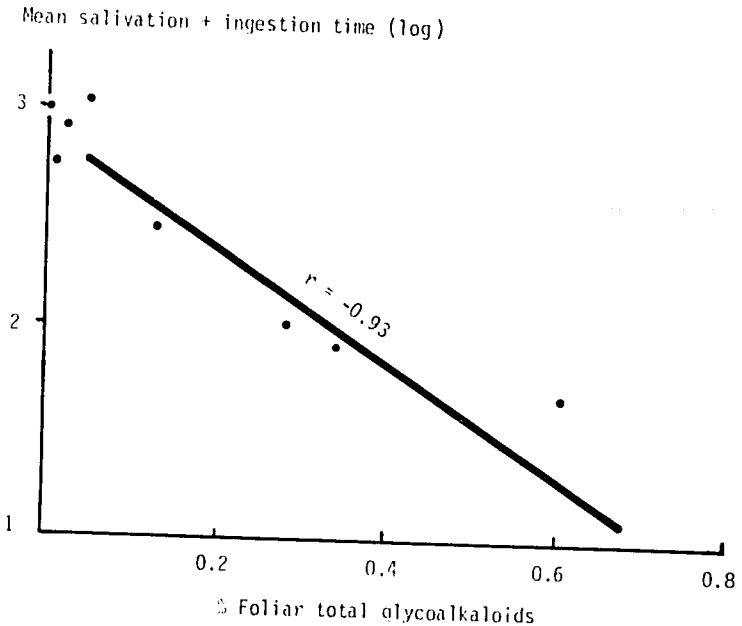
Total glycoalkaloid (TGA) fractions extracted from the foliage of 10 different-resistant *Solanum* species were fed to potato leafhopper nymphs in studies conducted at Cornell University to determine effects of TGA extracts

Figure VI - 2. Relationship between nymphal survival of the potato leafhopper and concentration of foliar total glycoalkaloids from 12 *Solanum* accessions in artificial diet.



fed at concentrations equivalent to levels in fresh foliage. Nymphal survival, Figure VI - 2, and duration of settling, salivation-ingestion (Figure VI - 3) and non-feeding were significantly correlated with TGA concentration (r = -0.86, -0.79, -0.93 and 0.82). As measured by suppression of salivation-ingestion, the threshold concentration for the glycoalkaloid, tomatine, was between 0.01 and 0.05 percent. These findings provide further evidence of a causal role for potato glycoalkaloids in leafhopper resistance.

Figure VI - 3. Relationship between duration of salivation and ingestion for potato leafhopper nymphs and concentration of foliar total glycoalkaloids from 8 *Solanum* accessions in artificial diet.



Thrust VII

Physiological and Agronomic Management of Potatoes Adapted to Environmental Stress

Tuber seed is the costliest potato production input in developing countries and use of poor quality seed is a major production constraint. Small farmers of the tropic and subtropic regions are especially vulnerable to this situation. A new approach to the potato seed problem is being investigated at CIP: the use of true seed for production of consumer potatoes.

Consumer Potatoes from True Seed

Use of true seed could reduce potato production costs to a level similar to that of the cereals: 5 percent or less as compared to as much as 60 percent of total production cost with conventional tuber seed. Few diseases of potatoes are carried in true seed. Large amounts of energy could be conserved through use of true seed when considering transportation, harvesting and storing tuber seed from one season to another.

Use of true seed was demonstrated during the visit of a CIP mission to the People's Republic of China in August 1978. In Inner Mongolia, 2 1/2 tons of true seed were produced in 1977 and shipped to the southern hill provinces to be hand carried to highland farmers for both multiplication of tuber seed and direct production of consumer potatoes.

Research at CIP for development of agronomic technology to produce consumer potatoes from true seed has followed two approaches: (a) direct field seeding of the true seed, and, (b) transplanting seedlings from nurseries.

True seed from two open pollinated progenies, 575031 and M-1295-29, was planted directly into the field in El Asesor near Lima, Perú to study various methods of covering the seed at planting. Five seeds per hill were planted and an average of three plants per hill was obtained (Figure VII - 1). Although both progenies segregated for tuber color and shape, yields were remarkably good. Some treatment yields approached those of a standard potato variety (Table VII - 1).

Broad temperature fluctuations severely limited true seed germina-

tion of 54 cross-pollinated progenies in research at Huancayo (3,300 m).

Several progenies from the University of Wisconsin, Cornell and CIP potato breeding programs were evaluated for yield and haulm and tuber uniformity during the winter at Lima (coastal desert), the summer at San Ramón (high jungle, 800 m) in Perú, and in the spring at Waynesville, N.C., USA. Five-week-old seedlings of each progeny were transplanted with nursery soil covering the roots or with bare roots to test performance under field conditions. Evaluation of yield and haulm and tuber uniformity (Tables VII - 2; Figure VII - 2) indicates increased plant vigor when roots are adequately covered with soil at time of transplanting. In addition, when direct seeding true seed, or transplanting seedlings to the field, good weed control and water management to maintain optimum soil moisture were important factors to obtain vigorous productive plants.

Agronomic Studies

Fertility studies continued in 1978 under coastal, mountain and high jungle conditions in Perú. Several sources of non-soluble and soluble phosphate were studied under field and greenhouse conditions (Table VII - 3). In low phosphate soils in the mountains and high jungle, response to phosphate fertilizer increased regardless of level of soluble phosphate. However, above soil pH 6.5 soluble sources were superior to insoluble at levels of 80 kg/ha of P_2O_5. At 160 and 240 kg/ha of P_2O_5, both phosphate sources were equally efficient. In the coastal region a

Table VII - 1. Yields of open pollinated progenies directly seeded with true seed under field conditions (El Asesor).

Treatments *	575031		M-1295-29	
	kg/plot	ton/ha	kg/plot	ton/ha
True Seed (0.15m spacing)				
1. Seed covered with soil	26.10	24.85	29.10	27.70
2. Seed covered with sand	34.30	32.60	27.00	26.00
3. Seed covered with peat moss	28.80	27.50	23.50	22.40
4. Seed covered with peat moss and sand	22.60	21.50	23.60	22.40
Tuber Seed				
"Renacimiento" (0.30m spacing)	35.80	34.10	35.10	37.40

* True and tuber seed were planted on dry soil. Furrow irrigation was applied immediately after seeding. Fertilizer was applied at the rate of 160:160:100 kg of NPK and 15 tons of dry cow manure per ha.

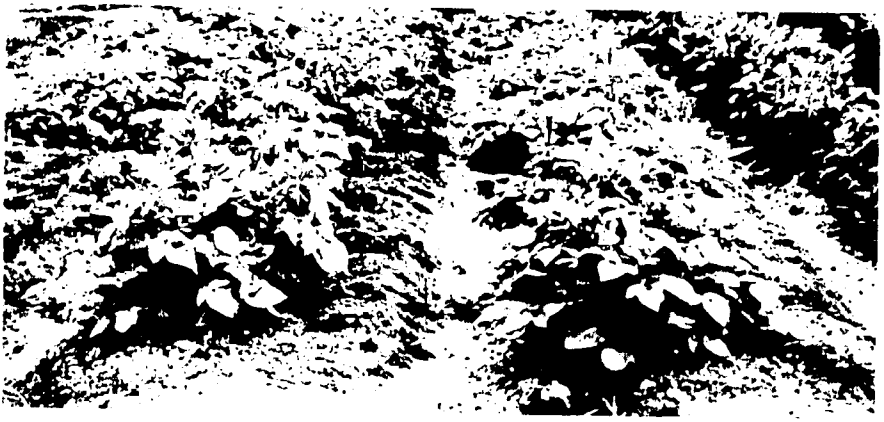


Figure VII - 1. Plants arising from direct seeding of true seed, El Asesor, at time of fertilizer application prior to hilling.

Table VII - 2. Yield and uniformity of selected progenies grown from true seed and transplanted to field with soil-covered or bare roots.

	Yield (t/ha)						Uniformity *	
	Lima		San Ramon		Waynesville			
Progeny **	C	B	C	B	C	B	Haulm	Tubers
w726 x w5295.7	14.91	12.64			16.58	8.50	3	3
w729 x w5295.7			6.35	7.73	21.42	12.17	3	3
w231 x w5295.7	16.92	9.92					2	2
A 44	15.06	7.28	8.03	6.24	12.50	12.92	2	3.5
A 33			11.21	7.74	10.50	11.25	2	2
A 38					22.08	7.25	3	4
U 252	25.67	12.10			11.75	11.25	2	3
U 254	23.78	15.35					2	2
374050.1 op	17.56	10.21					2	3
378158	29.87	18.95					3	3.5
378140	42.34	12.64					3	3
378175			10.91	9.14			3	3
R 13.7 x R 165.4	45.62	26.38					3	3
R 18.2 x R 245.2	37.20	31.20					3.5	3
R 140.2 x R 57.8			13.45	6.14			3	3
R 126.5 x R 142.1			17.28	5.85			2	2
Tuber Seed Varieties								
"Kennebec"					22.83		4	3.5
"Renacimiento"	30.34						4	3.5
"Mi Perú"			20.75				4	3.5

* Uniformity code: 1 = non-uniform; 2 = semi uniform; 3 = acceptable uniformity; 4 = clonal uniformity.

** C = covered; B = bare.

Figure VII - 2. Aggregate sample yield showing general uniformity of tubers produced by transplants developed from a true seed progeny, El Asesor.

similar situation was found at pH 7 or above on soils with moderate to high availability of phosphate. When sulphur was applied above a level of 200 kg/ha, yields were reduced 20-30 percent in both mountain and jungle soils when pH was between 5.5 and 6.5 regardless of the source of sulphur.

Huancayo mulching experiments clearly demonstrated that soil erosion and water runoff could be reduced (Table VII - 4).

In San Ramón (high jungle) several rotations and practices influenced yield and soil and water losses when compared with bare soil (Table VII - 5).

A field experiment studied effects of irrigating all or alternate furrows as well as frequency of irrigation during the winter season in El Asesor. Yields were reduced due to poor soil aeration and increased incidence of late blight when irrigation frequency was at 7-10 day intervals. Smaller yield

Table VII - 3. Yield of potatoes in tons/ha in mountain and jungle soils in Perú with 160:160:80 kg/ha of N:P:K.

Locations	Controls w/out NPK	Controls w/out P	Bayovar phosphate	Phosphate and superphosphate	Superphosphate	Triple superphosphate	Ammonium phosphate
JUNIN							
Yanahallpa, pH 4.9	4.9	9.4	14.2	16.6	15.1	–	–
LA LIBERTAD							
pH 4.9	5.3	9.9	17.2	19.9	20.8	–	–
Huanchar, pH 7.2	9.5	15.1	25.6	33.6	32.1	32.2	–
Sta. Rosa, pH 6.7	9.9	13.3	25.8	31.6	33.9	31.6	–
Las Cruces, pH 5.7	9.4	15.8	26.9	30.8	32.2	32.7	30.0
CUZCO							
Zurite, pH 6.2	3.2	10.8	13.1	14.8	15.1	14.4	–
Andenes, pH 6.7	6.4	16.0	19.8	17.7	21.0	17.0	18.9
CHANCHAMAYO							
San Ramón	0.6	0.3	13.1	12.4	15.8	–	–

Table VII - 4. Potato yield, water and soil losses in Huancayo at 25% slope (rainfall 400 mm).

Treatments	Yield ton/ha "Revolución"	Runoff % rainfall	Erosion ton/ha
Bare soil	–	9.4	5
Potato + fallow (rows with 25% slope)	29	14.6	12
Potato + fallow (rows contoured)	32	8.4	6
Potato + fallow (green org. matter incorporated)	38	14.8	10
Potato + fallow with mulch	36	5.7	2

reductions resulted when alternate furrows were irrigated at 20-day intervals. The alternate furrow treatment provided the highest water use efficiency.

Heat Tolerance

Experiments compared plants grown in San Ramón with those grown in La Molina. Number of main stems was reduced by up to 80 percent while the number of axillary branches increased by up to 10-fold in San Ramón. In general, leaf area, chlorophyll content and total dry matter was reduced under heat stress conditions at San Ramón. Reduction in number of main stems is of special

Table VII - 5. Crop rotation yields, water and soil losses in San Ramón (with 30% slope, rainfall, 1,405 mm).

Treatments	Yield ton/ha			Runoff	Erosion
	Corn	Soybean	Potato	% rainfall	ton/ha
Bare soil	–	–	–	14.5	68
Corn + soybean + potato (fallowed, burned)	7.9	0.3	8.6	12.4	29
Forage + soybean + potato (fallowed w/out burning)	–	0.8	12.1	3.0	1
Corn + soybean + potato	10.5	0.2	10.6	4.5	1
Pineapple + potato	–	–	17.7	11.3	3

importance because of a close correlation between number of main stems and number of tubers formed. However, using material from the CIP breeding program for adaptation to lowland tropics resulted in the number of main stems remaining almost unchanged while the increase of axillary branches was even higher than for non-adapted material. This also results in significantly increased leaf area and, in some cases, increased total dry matter.

Physiological Studies

Previous research indicated a high endogenous gibberellin (GA) content results from high temperature. This may be responsible for delay or inhibition of tuberization caused by high temperatures. Further research indicates that the root system may play a key role in GA metabolism. Accordingly, increased tuber yield may be possible by lowering the endogenous GA content through use of a plant growth regulator such as Cycocel (CCC).

Results in San Ramón, La Molina and Yurimaguas support this hypothesis. While CCC caused yield increases in both San Ramón and Yurimaguas under high heat stress, almost no effect was observed under cooler conditions in La Molina. Although varieties differed, all cases showed greater yield following treatment in Yurimaguas than in the somewhat cooler San Ramón site. In both locations the lowest yielding, non-treated control varieties when treated with CCC showed the highest increase in yield.

Figure VII - 3. Effect of two temperature regimes, 20°C day, 15°C night, and 30°C day and 20°C night, on leaf area and net assimilation rate of DTO-28, a clone adapted to high temperatures and "Merpata," a non-adapted clone. The arrow indicates tuber initiation.

Although tuber growth is commonly inhibited in the lowland tropics, in the case of adapted material an increase in tuber yield may occur under San Ramón conditions compared to La Molina in the winter. It was suggested that low net photosynthesis due to high respiratory losses may be responsible for inhibited tuber growth. In experiments with both adapted and non-adapted clones a decreased net assimilation occurs at high temperatures (Figure VII - 3). In general, less carbohydrate is available under high than under low temperatures.

The percentage of total dry matter (DM) in tubers in contrast to the total plant DM under heat stress conditions in San Ramón, and at the relatively cool coastal location at El Asesor, is given in Table VII - 6. Total DM in tubers is much more influenced by San Ramón conditions than the total DM production. This supports somewhat the hypothesis that under high temperature conditions the potato is rather sink than source limited although heat adapted clones such as DTO-28,

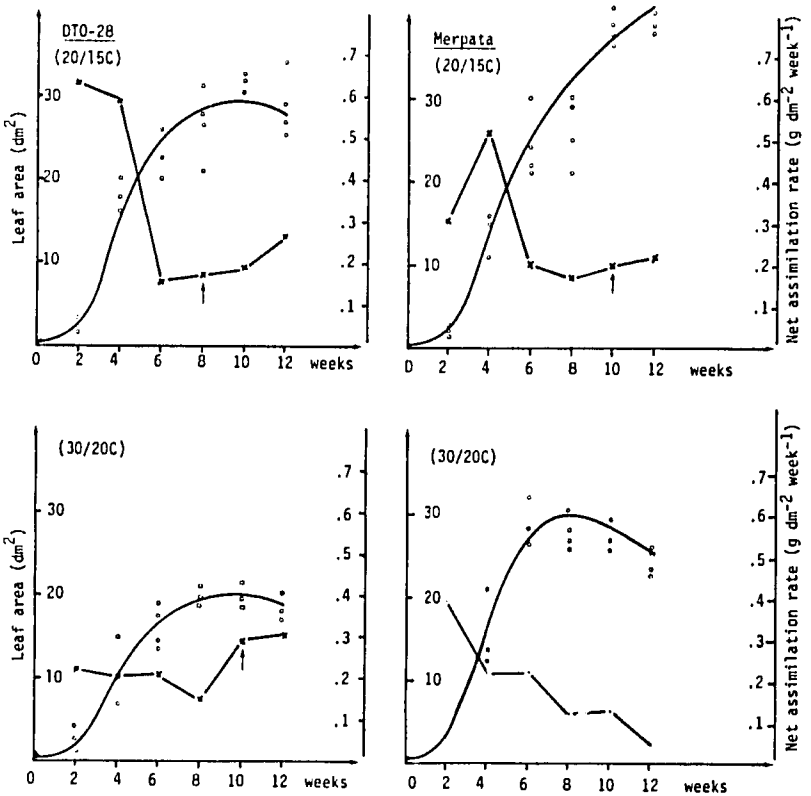


Table VII - 6. Total dry matter (DM) and percent of total DM in tuber in El Asesor and in San Ramón 2 months after planting. Data are the mean of four plants chosen at random.

Varieties	Total DM/plant (g)		% total DM in tuber	
	El Asesor	San Ramón	El Asesor	San Ramón
DTO-28	78	188	67	44
María Tropical	90	78	63	62
N-567.8	103	92	65	5
N-568.7	133	99	70	4
N-570.5	76	126	47	1
N-574.1	53	200	43	51
65-ZA-5	173	136	36	2
Ticahuasi	212	106	56	3
Antarqui	222	159	31	5
Mariva	234	152	38	7
Revolución	352	194	44	1
Sipeña	294	102	45	0
Merpata	188	304	34	0
Mi Perú	201	140	39	0
Renovación	104	89	15	0
Yungay	172	116	57	2

N-574.1 and the variety "María Tropical" are efficient in tuber DM accumulation.

Drought Tolerance

In summer and winter field experiments at La Molina, varieties and clones with varying genetic characteristics received two irrigation treatments, one that maintained optimal moisture level and the other with moisture stress. Under severe conditions in the summer experiment, relative yields (stress:optimal) varied from 0.05 to 0.5 for nine varieties tested. Material from the Huancayo germ plasm collection and wild species from the Sturgeon Bay collection performed poorly under stress with the exception of some clones belonging to the species *S. curtilobum*. Under mild winter conditions, relative yields of seven varieties varied from 0.65 to 0.9, while 12 of 40 clones of the Huancayo collection (5 adg, 4 cur, 1 phu, 1 ajh and 1 juz) and two of 16 clones of the frost resistance program had a relative yield of 0.8 or more. Performance of the wild species examined was disappointing. Results from leaf water potential and stomatal aperture measurements indicated these methods are limited in screening for drought tolerance.

An attempt to develop a laboratory method measuring drought tolerance is underway in the CIP Research Contract at the University of Minnesota. Excised potato leaflets were subjected to desiccation in a closed chamber maintained at 25 percent relative humidity. Humidity in the chamber was regulated by continuous air circulation through a glycerol solution. Desiccated leaflets were rehydrated (100 percent humidity) and their ability to recover completely from drought was determined.

Apparently *S. tuberosum* cultivars posses higher drought avoidance whereas species such as *S. acaule* and *S. commersonii* possess higher drought tolerance. Thus, at 25 percent relative humidity, 5°C, *S. acaule* was desiccated in 150 hours to the same degree as "Kennebec" in 300 hours.

Cold Tolerance

An increasing understanding of the anatomical and physiological basis of frost resistance is being obtained through research at the University of Minnesota supported in part by a contractual arrangement with CIP.

Anatomical differences related to frost hardiness (-2.5°C to -5.5°C) varied in selected *Solanum* species. Observations were made on 2-month-old plants of 26 wild species as well as seven cultivars of *S. tuberosum*.

Among the various anatomical parameters studied, the number of palisade parenchyma layers, the stomatal index on the upper surface of leaf and palisade thickness were found to be highly correlated to frost hardiness. All hardy species had two palisade layers. Three nonhardy (killing temperature -3.5°C)

plants had one palisade layer. Hardy species averaged a three-fold greater stomatal index (26.7 percent) than non-hardy species (8.8 percent) on the upper surface of the leaf. Palisade parenchyma occupied a larger portion of leaf cross section thickness in hardy species (62.8 percent) than in non-hardy species (51.2 percent). No significant differences in cell size and inter-cellular space could be detected among these two groups of species. Ploidy was not related to leaf anatomy or frost hardiness. From preliminary studies it appears that the two-palisade-layer character is inherited in the hardy hybrids.

The capacity of potatoes to acclimate to cold was examined in a number of tuber-bearing *Solanum* species (Table VII - 7).

Results suggest that cold resistance is controlled by one mechanism and cold acclimation by another. In related studies at the University of Minnesota, frost susceptible potatoes such as *S. tuberosum* are more heat tolerant than potatoes which can be cold acclimated. However, heat resistance can be increased in

Table VII - 7. Classification of tuber-bearing *Solanum* potatoes in terms of frost resistance and cold acclimation.

Categories	Species (examples)	Killing temp (C)	
		Before Treatment *	After Treatment **
Group I: frost resistance and able to cold harden	*S. acaule* (Oka 3885) ***	– 6.0	– 9.0
	S. commersonii (Oka 5040)	– 4.5	– 11.5
Group II: frost resistance but unable to cold harden	*S. sanctae-rosae* (Oka 5697)	– 5.5	– 5.5
	S. megistacrolobum (Oka 3914)	– 5.0	– 5.0
Group III: frost sensitive but able to cold harden	*S. oplocense* (Oka 4500)	– 3.0	– 8.0
	S. polytrichon (PI 184773)	– 3.0	– 6.5
Group IV: frost sensitive and unable to cold harden	*S. tuberosum*	– 3.0	– 3.0
	S. stenotomum (PI 195188)	– 3.0	– 3.0

* Plants were grown in a regime of 20/15°C day/night, 14 hrs.
** Plants were grown in a regime of 2°C day/night, 14 hrs, for 20 days.
*** Identification number at Potato Introduction Station, Sturgeon Bay, WI. USA.

S. acaule and *S. commersonii* following cold acclimation.

The natural distribution pattern of many hardy and non-hardy *Solanum* species was studied to explain these anatomical differences. A distinguishable difference in the geographical distribution of hardy and non-hardy wild species was found. Among species studied, the hardy species (except *S. commersonii*) are found in the high Andes of southern Perú, central and southern Bolivia, northern Chile, and northwestern Argentina. Non-hardy wild species, on the other hand, are mainly distributed in México, Guatemala, Venezuela, Colombia, Ecuador and northern and central coastal Perú. From data in the literature a close relationship was found between altitude of collection and frost resistance.

Apparently anatomical features of hardy species are the result of adaptation to environmental stress, mainly low temperature and in some cases together with water stress. These anatomical features have a potential as "markers" for identifying hardy potato plants.

Improving Potato Productivity

Methods are being developed for identifying major farm-level production constraints and evaluation of technology on farms. A new manual, "Maximizing Potato Productivity in Developing Countries," provides a uniform format for agro-economic research at both experiment station and farm levels.

Special project funding (IDRC) provided resources for testing the methodology on a larger scale in the Mantaro Valley of Perú and included additional components. Experience in this project is being used to improve the manual.

A joint program of on-farm trials integrating CIP and national program scientists in Huancayo was developed to evaluate agronomic technology to improve productivity.

Thrust VIII

Development of Post-Harvest Technology and Improvement of Nutritional Quality

Post-Harvest Technology

A study of the influence of storage on potatoes of different quality indicated that neither the type of store nor the condition of tubers entering the stores increased the average net loss (Table VIII - 1). The investigation compared nine seed potato stores and three types of selection practices. Three replications each of 27 treatments were stored for 140 days and then evaluated for evaporation, sprouting, and disease losses.

A formula devised for measuring the economic dimension of storage losses substantiated that good selection practices at time of entering storage returned the greatest net profit to farmers. Simple modifications to existing structures such as houses and stables represent an economical storage alternative for farmers.

The first storage course using CIP facilities at Huancayo in May included students from Perú, Ecuador, Bolivia, México, Guate-

Table VIII - 1. Quality of potatoes leaving storage after 140 days as influenced by the quality entering storage.

	Percent defective entering storage		
	0	25	50
Type of storage	Percent defective after 140 days		
Adobe *	15.0	46.3	66.3
Wood	14.7	44.4	61.8
Plastic	16.6	42.0	62.7
Screen	15.7	39.7	64.5
Open stable	13.7	40.9	63.2
Room in adobe house *	17.4	42.9	67.9
Mean loss	15.5	42.7	64.4
Net loss	15.5	17.7	14.4

* Mean of two adobe storages and rooms in three adobe houses.

mala, Turkey and Sri Lanka. The course to be presented again in 1979 will be modified as the result of a follow-up evaluation.

Following a single-visit survey of 250 farmers in the Mantaro Valley of Perú, a second multiple-visit survey of 45 potato producers assessed production and distribution systems. While all producers store for home consumption, the absolute amount (but not the percentage of total production) destined for home consumption increases with increased scale of production (Table VIII - 2).

Small-scale producers tend to sell their potatoes at harvest only upon passing a certain threshold of production estimated by survey to be about 350 kilos per family member. Below this figure potatoes are kept for home consumption, seed and for a financial reserve for household emergencies. Growers with more than two hectares in potatoes can obtain credit and government help in the production of certified seed. This enables them to use capital-intensive inputs and to obtain higher yields.

A three-season farm storage study completed in Kenya investigated: (1) improved pit storage; (2) box storage in farm houses; and, (3) back storage in farm houses. Pit

Table VIII - 2. Distribution of potato production according to ecological zone and amount of land planted to potatoes on 45 farms.

No. and category of producer	Percentage / kilos						
	Home			Sale			
	Seed	Consumption	Processing	Seed	Ware	Other	Total
Valley floor							
6 Small-scale	23.4 *	76.6	–	–	–	–	100.0
0.5 ha	167 **	545	–	–	–	–	712
12 Medium-scale	15.4	21.1	1.1	13.5	45.6	3.3	100.0
0.5 - 2.0 ha	1,157	1,576	83	1,008	3,412	247	7,483
12 Large-scale	14.5	1.8	–	39.5	41.4	2.8	100.0
2.0 ha	12,414	2,375	–	33,765	35,386	2,325	86,265
Intermediate and high zones							
3 Small-scale	9.7	33.6	26.2	–	26.6	3.9	100.0
0.5 ha	260	895	698	–	710	105	2,668
8 Medium-scale	14.0	25.2	7.3	2.9	47.4	3.2	100.0
0.5 - 2.0 ha	748	1,346	392	154	2,529	164	5,333
4 Large-scale	24.1	15.7	2.7	0.3	50.0	7.2	100.0
2.0 ha	3,565	2,325	398	50	7,395	1,080	14,813

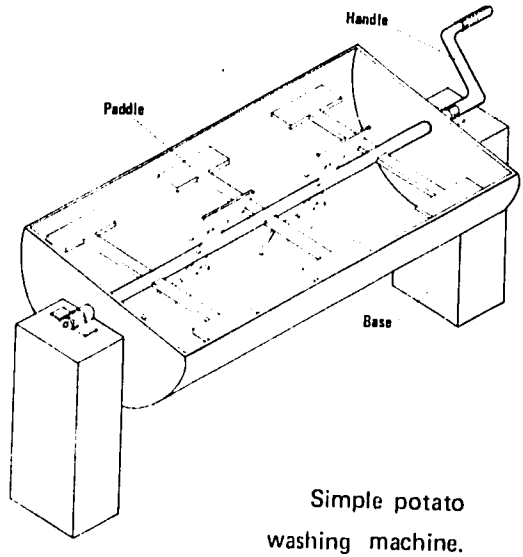
* Percentage of harvest. ** Kilos per producer.

storage was eliminated after one season due to unacceptable potato rotting as the consequence of ground water. The other two systems of storing indicated that most weight losses resulted from dehydration rather than rotting.

Processing

Based on preliminary experiments in small-scale processing of potatoes, a pilot system has been developed to fit the requirements for a simple type of processing. Efforts pointed to equipment design and operating conditions for obtaining potato flour from dried potato and white chuño. Maximum capacity envisioned is for 1,000 kg per day of fresh potatoes. Facilities and equipment have been developed for the following steps in processing: storage, washing, cooking, peeling, cutting and drying.

A 2,500 kg capacity storage was built at CIP's La Victoria farm in the Mantaro Valley. Locally available material was used including eucalyptus wood, straw and thin wire. About 200 kg each of five varieties of potatoes were used to assay effect of storage time on reducing sugar content and processing quality. When reducing sugars were below 0.3 gm/100 gm fresh weight, browning did not develop in either the final dried potato product or in white chuño. After about 4 months storage at ambient temperatures, reducing sugars increased to 0.9 gm/100 gm, and sprouting and greening started in addition to deterioration in quality of the product.



Simple potato washing machine.

A potato washing machine was made by cutting away a third of the diameter of a 55-gallon drum in a longitudinal direction. Three sets of paddles attached to a central shaft running the length of the open drum end in an exterior crank handle for operating the device. Its capacity was 50 kg per minute.

Although cooking in vapor at atmospheric pressure resulted in better conditioning for peeling, the relative nutritive value of the product was superior following cooking in water at 95° C for 35 minutes. After cooking, the tubers were placed in a simple peeling machine with a capacity of 5 kg per minute and operated at a speed of 70 rpm. The peeled potatoes were then

cut into strips or ovals with a locally-designed and constructed cutting machine.

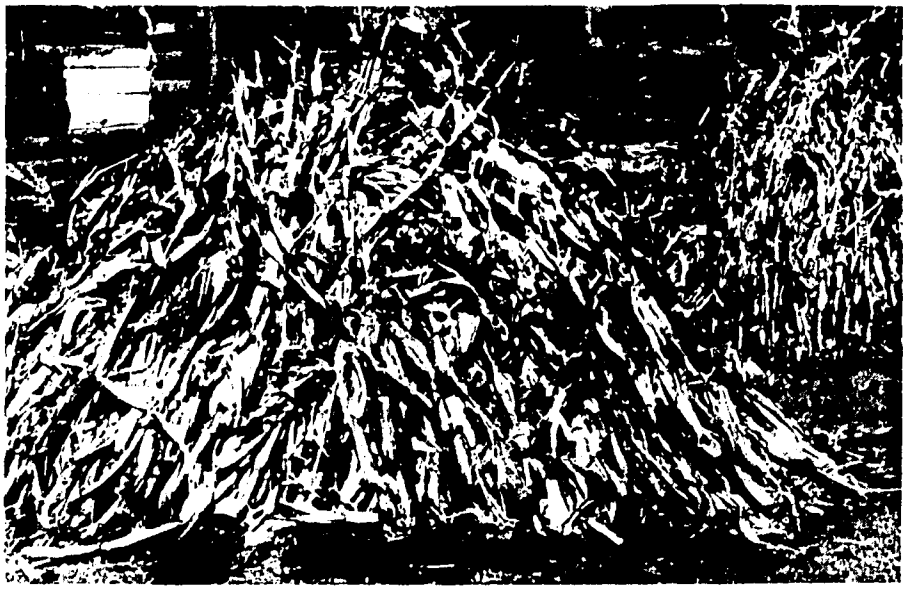
Drying was done in wooden, black matte-painted trays of 1.125 m^2 and 8 kg capacity fresh weight. The trays were inside a thin plastic covered semi-circular shelter. Average radiant energy under the experimental conditions at 3,300 meters was 5,210 kg/cal/m^2/8 hr. Other conditions for drying included wind speed of 0.25 - 0.60 m/sec and an air temperature range of 17-55°C.

Nutrition

Various analyses were made as a service for numerous research activities. Additionally, a wide range of analytical determinations were made in support of solar dehydration and village scale processing. Analyses included: nitrogen (3,900), total sugars (372), reducing sugars (208), starch (120), total glycoalkaloids (194), and dry matter (2,150).

Simple experimental rustic potato store for use by small highland farmers. Constructed of low-cost local materials, the demonstration/experimental unit is designed to hold 750 kg of seed tubers in the upper portion exposed to indirect light and 800 to 1,000 kg of tubers for consumption in the lower dark portion.

Rustic seed store using indirect light to control sprout growth. This sample unit has a capacity of 1,500 kg and has been used successfully for up to 6 months in the Peruvian highlands. It is also giving encouraging results for 3-4 months under high temperature lowland tropical conditions. Similar structures show promise in hill potato producing areas of the Philippines and Central Africa.



Simple experimental clamps for storage of seed or consumption potatoes. These circular units hold 500 kg, but for larger amounts elongate structures should be examined. CIP experimental work in the Peruvian highlands includes an evaluation of different covering materials, such as straw and corn stalks (above) and straw and soil (below). Different ventilation systems are also being investigated for use during both dry and rainy storage seasons. Generally, storage life of potatoes in such very simple structures is limited by sprouting, thus such units are likely to be most successful in cooler regions.

Thrust IX

Seed Production Research for Developing Countries

Seed Production

Through a network of research contracts, planning conferences and direct contacts, CIP scientists keep abreast of modern techniques in disease detection and eradication. When potato spindle tuber viroid (PSTV) was suspected in the CIP collection, meristem plantlets were sent to Canada and the United States for confirmation. As a result, a detection and eradication program was initiated. This program now ensures that within limits of modern techniques, all CIP export material is free of PSTV and other diseases. The regular program of testing for well-known and novel viruses is continually being improved.

Maintenance and Multiplication

Maintenance and multiplication of pathogen-tested potatoes proceeds through a sequence of five generations:

Generation I: maintained as pathogen-tested *in vitro* multi-meristems (MM).

Generation II: production of pathogen-tested seed tubers in a quarantined screenhouse for export to National Programs.

Generation III, IV and V: the field increase and production of low-virus seed tubers for use by CIP scientists.

Segregated tuber families produced from true seed are grown in the quarantined screenhouse for distribution to national programs. Thirty-six tuber families were harvested for export and 182 other families were in various stages of production. These included resistance to: heat, frost, *P. infestans*, *P. solanacearum*, PLRV, viruses and various combinations of resistance.

Limited amounts of generation I and II were produced in 1978 pending testing for PSTV on all materials. Export of MM resumed in October and Generation II plants were planted in November. Some 10.7 tons of low-virus seed tubers were harvested for use by CIP scientists and 1.5 ha were replanted in La Molina and Huancayo for the 1978 - 79 crop.

A cooperative project involving CIP Thrusts II, VII and IX started to evaluate advanced clones prior

to inclusion in generations III - V. Rapid multiplication method using stem cuttings was refined and work began on other methods such as leaf-node cuttings (MS thesis at UNA, Lima) and sprout cuttings (University of Sydney, Australia).

Thrust IX is responsible for testing parental lines used by Thrust II for freedom from APLV, PVT and PSTV, all of which can be transmitted sexually through true seed. By year's end, 140 parental lines were being virus-tested. Lines free of these viruses, although infected with non-sexually transmitted viruses, are maintained as multi-meristems plantlets for distribution to CIP's breeding programs.

A contract with the Department of Agriculture, Victoria (Australia) is multiplying cultivars and advanced clones for re-distribution to national programs of South East Asia and the Pacific (Region VII) in quantities sufficient for replicated trials. Some cultivars are being distributed and advanced CIP clones are in early stages of multiplication.

Tissue Culture Research

Routine virus elimination work involving thermotherapy and meristem excision were temporarily suspended in early 1978 pending testing for PSTV. Six new cultivars and clones were passed to Generation I. At year end, 255 pathogen-tested MM plantlets had been distributed to Thrust IX, 350 to Thrust II and 222 for international transfer (Table IX - 1).

Low-temperature storage of MM plantlets *in vitro* at 8°C has been an efficient method for maintaining the pathogen-tested cultivars with only one transfer per year. Extension of the storage interval at controlled room temperature (25°C) by using a medium which permits very slow growth offers a promising alternative for maintaining a large germ plasm collection and can be easily adopted by developing countries. Further research on germ plasm storage *in vitro* is being continued using both virus-free and virus-infected cultivars.

Attempts to eradicate PSTV by meristem isolation and thermother-

Table IX - 1. Shipments of *in vitro* MM in 1978 from CIP, Lima.

Receiving country	No. of cultivars	No. of samples	Days en route *
USA	3	6	–
Kenya	9	18	15
"	6	12	6
Brasil	10	18	28
"	11	11	–
Mauritius	6	12	25
Turkey	7	14	11
"	4	8	6
Germany	6	12	8
India	18	27	–
Bolivia	1	2	–
France	10	18	8
Ecuador	3	5	–
Spain	3	6	15
China	31	51	–

* Indicates cultures were hand carried or travel time unknown.

apy were ineffective. Encouraging results were obtained through low-temperature treatment of *in vivo* and *in vitro* plants and later excising meristems from these plants. Because of early success with cold therapy, research into protoplast and suspension culture techniques to eliminate PSTV were discontinued. However, the experience gained in successful establishment of growing colonies from protoplasts has opened interesting possibilities for selection of variant clones. Plating of suspension cultures derived from friable callus growths to a range of culture media is underway.

Socioeconomic Aspects

During the last year, studies in Perú, Ecuador and Colombia identified and evaluated socioeconomic and agronomic factors that have the greatest impact on production and use of improved planting material at farm level.

Farm level experiments in the Cañete Valley of Perú's Central Coast indicate that quality of tuber-seed available in the Central Highlands is variable and the farmer's choice of seed source is important in determining subsequent yield and profitability of his crop.

In the Machachi region of Ecuador a survey of 80 farmers

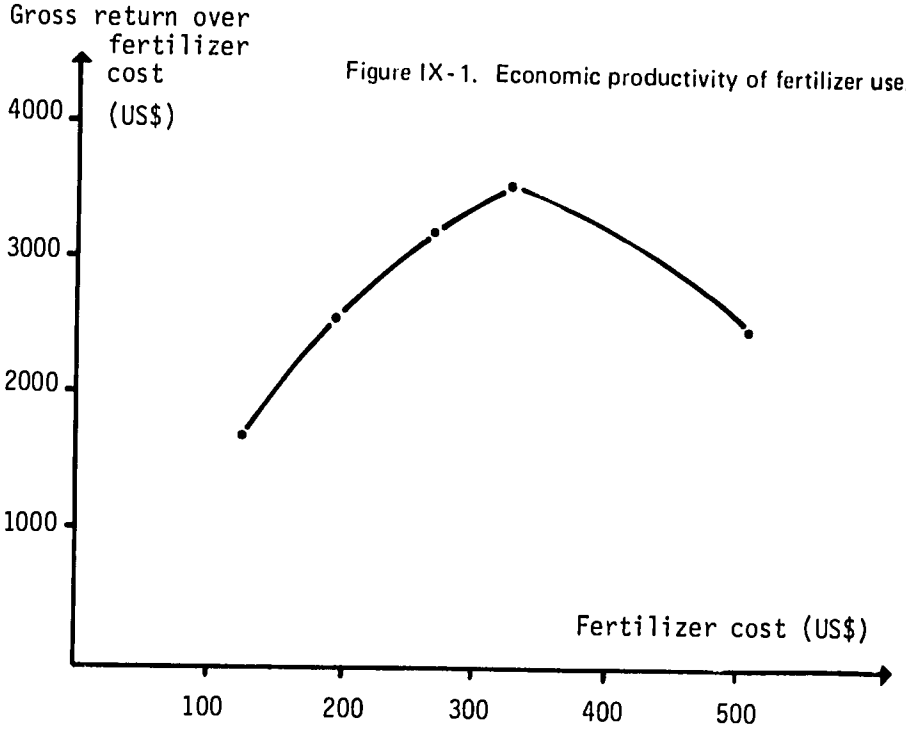


Figure IX-1. Economic productivity of fertilizer use.

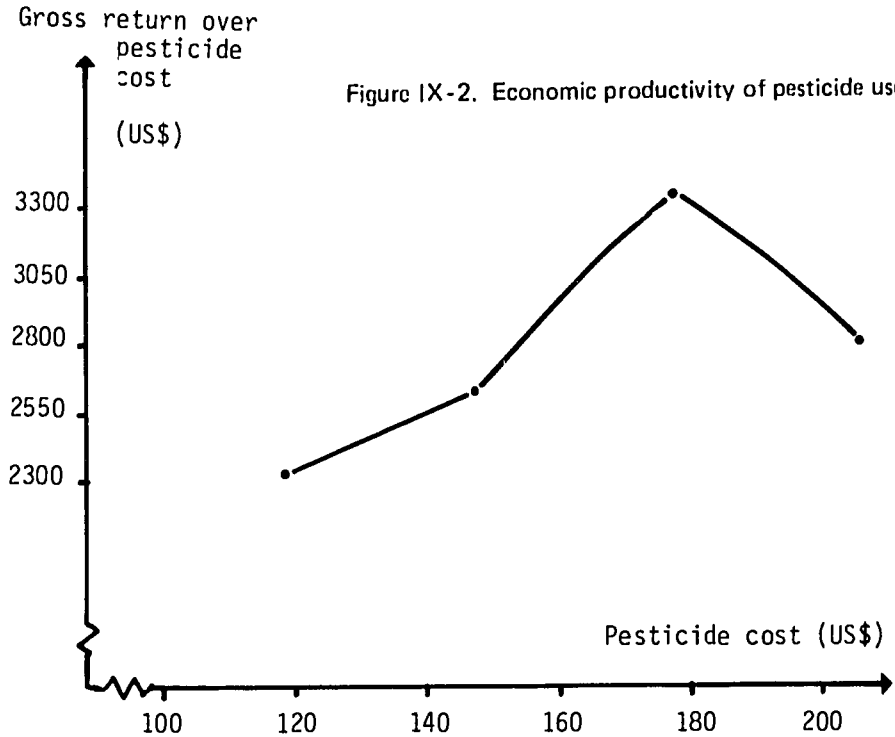


Figure IX-2. Economic productivity of pesticide use.

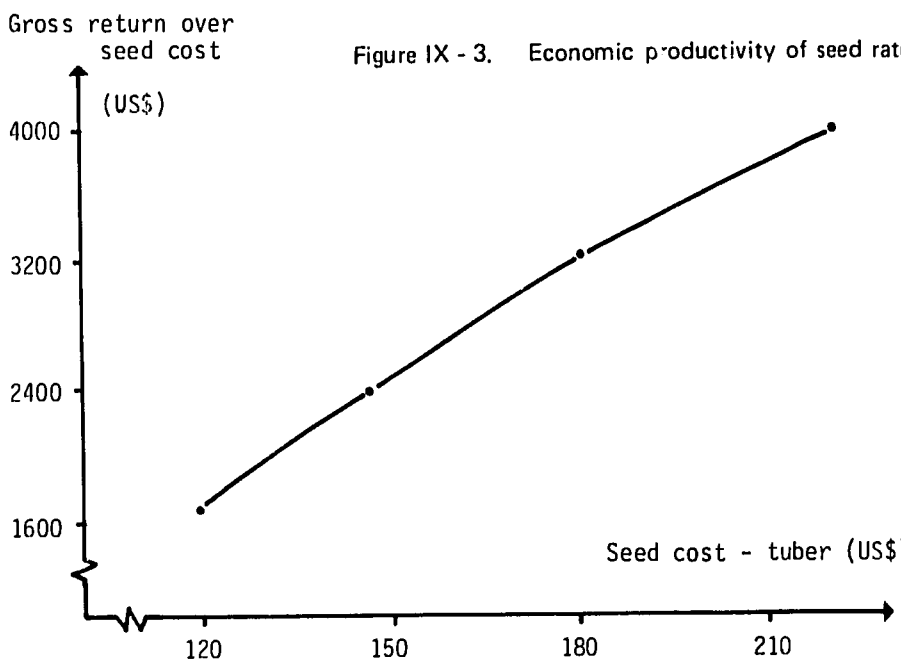


Figure IX - 3. Economic productivity of seed rate.

growing 554 hectares of potatoes showed:

(1) 93% use their own tuber-seed.

(2) 30% are unaware of the existence of certified tuber-seed.

(3) 50% do not purchase certified tuber-seed for economic reasons such as high costs of scarcity of cash.

(4) 94% cultivate the improved cultivar Santa Catalina.

(5) 14% use excessive levels of fertilizers and pesticides.

(6) 45% use less than one ton of tuber-seed per hectare, and increases in the tuber-seed rate appear to be highly profitable.

In conclusion, apparently there is an opportunity to increase productivity and profits with no additional costs by reducing fertilizer and pesticide applications and increasing the seeding rate (Figures IX-1, IX-2, IX-3).

Regional Research & Training

1978 Program Development

Regional scientists have concentrated on improving the quantity and quality of their research programs. Because of the diversity in conditions among regions it has been impossible to develop research equally in all areas. Some regions concentrated on training, although the general production type training course is assuming less importance and more specialized training is normal. Development of research programs still takes considerable time but emphasis is changing to collaborative projects between countries wherever possible. This regional transfer of technology will eventually lessen the consultative and advisory load of CIP scientists.

The research component of RR&T is noted in the associated Thrust reports. Training is reported separately by Regions.

Region I

CIP research Thrusts have strong links with many institutions in Region I countries.

A FAO associate scientist began work with the CIP regional scientist. Several technical advisory visits to Argentina resulted in plans for storage and industrial processing of potatoes. Development of a southern, subregional zone (Brazil, Argentina, Uruguay and Chile) was pursued and a training course held in November.

In Brazil, visits were made to advise on problems such as nematodes, bacterial wilt, seed production and storage. The former leader of the Peruvian Potato Program was named coordinator for the EMBRAPA Potato Program. Arrangements were made for training of two Brazilian scientists in Lima and for the 1979 meeting of ALAP (Asociación Latinoamericana de Papa).

In Chile, support was given to the potato seed multiplication scheme in the south and a visit made by the seed specialist and the regional scientist to Punta Arenas in the far south with the object of investigating the potential for high quality seed production. Two economists were given training with the Social Science Unit in CIP headquarters.

In Bolivia, assistance was provided to plan for bilateral technical assistance in developing a strong seed production program. This proposal has been accepted in principle by the donor government and should be implemented in 1979. Two Bolivian M.S. trainees returned to strengthen the research program.

In Colombia and Ecuador, the principal work has been to implement the seed production program financed by the Ford Foundation. In Colombia the former leader of the Colombian Potato Program took charge of field investigations and socioeconomic inputs were organized by the CIP/Lima Social Science Unit. After the first year of agronomic trials the economic component will increase. In addition to basic field studies, in Ecuador a program of investigations at farmers' level under CIP's "Optimizing Productivity Project" was organized.

In Perú, support has been given to the national program in developing the Perú/BID proposal which covers production and training in seed technology.

Region II

Regional headquarters were transferred from México to Turrialba, Costa Rica in January. The field staff was retained in México for CIP's routine research program.

Regional program development mainly centered around a cooperative project among six countries of the area. PRECODEPA, or Programa Regional de Cooperación en Desarrollo de la Papa, is a joint project between México, Guatemala, Honduras, Costa Rica, Panamá, Dominican Republic and CIP. Each country has selected a major field of study and will develop a research program for the mutual benefit of other participants. The entire region will have access to all components of a complete potato program. CIP will continue to investigate some specific components, such as frost resistance, in which the countries themselves only have a minor interest. A preliminary advance of funds to coordinate this project was disbursed by the donor and funds for a 5-year program were promised.

Region III

The regional headquarters in Nairobi, Kenya was changed to operate from a sister center — ILRAD. An agreement was signed with the University of Nairobi to collaborate in potato research with the Faculty of Agriculture.

In addition to successful development of regional germ plasm projects with the plant quarantine station at Muguga, the staff cooperated with the Kenya Seed Inspection Service and the Kenya Seed Company to develop a commercial seed production scheme. The scheme will use the Agricultural Development Corporation high altitude farms for multiplication and the KSC marketing organization for sales.

In Rwanda and Burundi new agreements permit CIP to place two scientists in Rwanda to help organize a strong potato research program. In northern Rwanda, an extremely populated area, potatoes are the staple diet. Soils are rich there and the crop grows well. Good seed is essential and a seed production scheme will have high priority. A similar situation exists in parts of Burundi.

In other countries of the Region activity concentrated on training, at both the general and individual level. Germ plasm was supplied for testing from the clones cleared by the Kenya Quarantine Station. Malagasy urgently needs seed multiplication because seed is of poor quality and, until recently, was extremely difficult to import. Agreement has now been obtained to import clones from Kenya.

Region IV

In Turkey, shortage of trained Turkish scientists at the regional headquarters in Menemen was remedied by transferring staff members from some of the provincial stations. A second deficiency, the lack of field transport and equipment, was rectified by a donation of equipment from German Technical Assistance. Another proposal has been prepared for financing a seed production and multiplication scheme in Erzurum, which is the principal seed area situated in northeastern Turkey. This will be part of the overall seed production project for the country and is designed to supply 20 percent of national requirements.

The principal CIP efforts in Menemen, Izmir, have been to develop and train local staff in techniques of rapid multiplication by stem cuttings and virus testing. These will form the nucleus of the future seed production team. The development and screening of large quantities of germ plasm from a variety of sources progressed satisfactorily. Suitable clones were multiplied for the regional germ plasm bank and distributed to other countries of the region.

In Egypt, cooperation continued with the storage and tuber moth project. A consultant, provided through the regional program, advised on improvements to traditional storage.

In Jordan and Syria proposals for seed production schemes which will be submitted to different bilateral agencies for funding were prepared. Agreements were signed with both Algeria and Morocco to formalize the relationship with CIP as a result of which the consultancies given by CIP to these countries will substantially increase in 1979.

In Tunisia, a renewal of the CIP/Tunisia/CIDA Special Project was signed and the project is now in its third year with two more remaining. This year, 170 tons of improved seed were produced.

Execution of this scheme was planned so that next year it will become routine. This will allow more time for the CIP scientist to concentrate on investigating physiological and agronomic problems in the preparation and utilization of this seed. It is apparent that improved technology is being adopted by the seed farmers. In 1977 the average yield was only 11 tons per hectare with 54 percent of seed quality, compared with 17.3 tons per hectare with 65 percent of seed quality in 1978.

Collaborative agronomic trials showed that high salinity of normal irrigation water depressed yields by 18 percent but this could be offset by yield increases of approximately 20 percent by using better management practices in water application.

Region V

In Pakistan several collaborative research projects have been organized with national staff in the different provinces. Leaf roll screening projects and testing of frost resistant germ plasm were done in Baluchistan. Assistance was given to develop a low virus-content "certified" seed scheme in the Punjab Plains. In Sind Province, heat tolerant clones were tested and a number of agronomic germ plasm trials were organized in the North West frontier province near Peschawar. Agroeconomic studies were started in Punjab Province.

The CIP team was instrumental in activating a virology session in Faisalabad, Punjab from which a program of aphid trapping to gather information on the feasibility for a seed production scheme in the Punjab Plains was started.

Region VI

Collaborative research links with active potato scientists in the various institutes, universities and state organizations in India were established. Visits to problem sites in India have identified the need for CIP germ plasm resistant to nematodes and bacterial wilt. As a result of interest at the International Seminar in Jullundur, research on the use of botanical seed will now be strongly featured in the basic research program of India.

Bangladesh is one of the countries in Asia which is rapidly expanding its potato production and a firm government commitment has been made to build a strong national research and extension program.

The regional scientist assessed the possibility of cooperation in Bhutan. Although the crop is still very small it is achieving considerable importance and is also a potential export crop. Training and the supply of a range of germ plasm are the most immediate objectives. Training in the basic maintenance of good seed has been started.

In Nepal clones from imported germ plasm which are most suitable

for the hill climate have been selected. Several are outstanding for disease resistance and other desirable characteristics. Multiplication is in progress in spite of setbacks caused by the discovery of wart disease on the seed multiplication farm. The stem cutting technique for rapid multiplication has been introduced and rooted cuttings have been successfully transplanted after being transported long distances, sometimes on a porter's back. A Swiss bilateral team arrived to support the national program thus giving the regional scientist time to investigate other research problems. An experimental store was built and financed by CIP.

Region VII

Major emphasis was placed on developing a coordinated potato program in the Philippines. The different institutions involved include the Bureau of Plant Industry together with the German Bilateral Technical Assistance team, the University of Los Baños, Mountain State Agricultural College and Philippines Council of Agricultural Research. A detailed program of research in which CIP participates has been produced.

A Philippine scientist was appointed to assist the regional scientist in developing a comprehensive agronomic and germ plasm testing program in the Philippines. He will collaborate with scientists of the national program in developing studies such as the optimization of potato productivity and the agronomic requirements of growing the potato in high temperature conditions.

Scientists from Sri Lanka attended various training courses organized in the region. One scientist contributed lectures at the Seminar/Workshop on bacterial wilt in Manila.

The development of the seed production program contract at the Plant Research Institute in Victoria, Australia has continued and it is expected that in 1979 quantities of seed will be available for distribution and testing.

Training Program

Training courses, specialized individual training, workshops, seminars, and advanced degree studies have been part of CIP's Regional Research and Training Program since 1972. The scope and importance of training activities, in association with CIP's research activities in Perú and in the regions, has continued to increase. A Training Department was organized in March of 1978.

The Training Department includes the Head of Training, a Senior Training Officer and a Training and Communications Specialist, involved part-time with preparation of training materials. The Training Department is the central coordinating point for CIP training activities wherever these activities occur.

Primary emphasis of CIP's Training Program is non-degree training at the regional level, conducted in association with national programs. In 1978, the use of national program scientists as instructors in CIP courses was expanded. Scientists from developed countries also traveled to each of CIP's regions to reinforce CIP's own training efforts.

In August a "Training Review" evaluated the status of CIP's Training Program. CIP's own Research and Training Staff and the Heads of Training from the International Agricultural Centre, Wageningen, Holland, and the International Agricultural Development Service, New York, participated as consultants in the one-week "Training Review." The consultants made recommendations to accelerate development of CIP's Training Program.

Most CIP training activities are associated with Regional Research Programs, although need for training at the advanced level for leaders and scientists of national potato programs continues. In response to this need, CIP has expanded its support of scholarships for advanced degrees studies at local and foreign universities. Scholarships in 1978 for advanced degrees are shown in Table TR-1. A scholarship for a Ph.D. represents a commitment of about US$ 50,000 over a 3-year period. The number of these

scholarships that CIP can support is few and uses a large part of available training funds. Alternative sources of scholarship funds are needed to meet the demand for advanced training for scientists from developing countries.

REGION I
South America

The number of scientists participating in CIP training activities in South America more than doubled in 1978 as compared with the previous year. Eighty-five scientists and technicians from nine countries of Region I, participated in intensive short courses, in-service training at CIP/Lima and in conferences and professional meetings. Not all the training activities were in Perú. A major emphasis was on "subregional" courses in association with strong national potato programs in South America.

Professional meetings for planning research priorities and scientific meetings and seminars involved 20 participants from South American countries. They were partially supported by CIP to attend a FAO Conference, a Tropical Root Crops Symposium, the annual meeting of the Potato Association of America, a meeting to evaluate the Andean Zone Potato Project, a meeting of South American economists, a Symposium on Bacterial Wilt and a National Entomology Convention.

In addition to group training activities in Region I, 27 students from South American countries studied for advanced degrees through CIP scholarships. Twenty of these graduate students were from Perú and most were registered at the National Agrarian University (UNA) at La Molina while conducting thesis research under direct supervision of a CIP scientist.

REGION II
México, Central America and the Caribbean

In-service training was emphasized although some formal courses were held. Trainees from México and the Dominican Republic participated in a 16-week in-service training program in potato production, conducted by the Instituto Nacional de Investigaciones Agrícolas and Centro de Investigación de Agricultura y Ganadería del Estado de México in Toluca, México. One trainee from México and another from the Dominican Republic were financed by CIP, while others were financed by institutes of their own countries. Each trainee pursued a particular aspect of potato production with facilities provided at other Mexican institutes.

One Mexican and one Guatemalan participated in the CIP/Lima Potato Storage Course during April. In March a CIP scientist conducted a seed production short course for extension agents and farmers, which was organized by Instituto de Ciencia y Tecnología Agrícolas in the "altiplano" region of Guatemala. In October, the German Government, Panamanian institu-

tions and CIP, sponsored a seminar on potato production at Cerro Punta, Panamá. Participants from México, Guatemala, Honduras, Costa Rica, Panamá and the Dominican Republic, took part.

REGION III
Tropical Africa

A total of 43 scientists, including national program leaders from several countries of Tropical Africa, participated in CIP-sponsored training. An in-country course conducted by the Ministry of Agriculture, Malagasy, included several instructors provided by CIP. Region III scientists participated in the 7th International Potato Course sponsored by the International Agriculture Centre at Wageningen, the Netherlands; in the UNESCO/ICRO course on tissue culture in Brasil; in the Francophone Production course in Tunisia, and in CIP/Lima for in-service training in seed production.

REGION IV
Middle East and North Africa

One hundred and three trainees from nine different countries of the Middle East and North Africa participated in 10 different training courses or activities during the year. In Tunisia, a general production course was offered for the second consecutive year for scientists from the French-speaking African countries. In Turkey, short-term training was on general agronomic practices, seed inspection and aphid identification. Regional scientists were also in Belgium, Pakistan and Lima for specialized training in various aspects of potato technology. One scientist from the Turkish National Potato Program began M.S. studies at Reading University.

REGION V
Southwest Asia

A two-week general production course organized in cooperation with the Pakistan Agriculture Research Council was attended by 22 graduate trainees from Pakistan, and two from Iran. A plant physiologist from Stuttgart University assisted with the training, and Pakistani scientists participated as instructors.

An inter-regional one-week seminar on post-harvest technology at Islamabad, Pakistan, included a 3-day visit to the Kaghan Valley during harvest of the summer crop. Fifteen potato scientists from Pakistan, two from Afghanistan and one each from Egypt, Syria, Turkey, Bangladesh and Nepal attended. The "Institute for Research on Storage and Processing of Agriculture Produce," Wageningen, the Netherlands, provided a storage consultant. The seminar included position papers and country papers to highlight the problems of harvesting, handling, storage and marketing. Several scientists from the countries of Region V participated in training activities and seminars in other countries.

A plant pathologist from Afghanistan attended the regional

CIP TRAINING SCHOLARSHIPS IN 1978

CODES	NAME	COUNTRY	DEGREE	UNIVERSITY	DATE START/END	SUPERVISING SCIENTIST	NOTES
	Breeding & Genetics						
A (a)	Amoros, Walter	Peru	MS	U N A	11-76/09-78	Mendoza	Heterosis
A (a)	Alarcon, Carlos	Bolivia	MS	U N A	05-76/12-78	Huaman/Jatala	Nacobbus Resistance
A (a)	Calua, Luis A.	Peru	MS	U N A	10-78/10-80	Mendoza	Inheritance of Earliness in Tetrapoloid Potato
S (a)	Landeo, Juan	Peru	PH. D	Wisconsin	07-76/07-79	Hanemann	Potential of Andigena in Breeding
S (a)	Lazin, Michael	USA	MS/PH.D	Cornell	04-76/05-79	Ewing	Head & Photoperiod Interaction
A (a)	Lecaros, Jose M.	Peru	MS	U N A	08-77/08-79	Mendoza	Combining Ability of Andigena
S (a)	Muñoz, Francisco	Ecuador	PH. D	Cornell	01-77/12-79	Plaisted	Andigena Populations
S (a)	Vasquez, Victor	Peru	MS	U N A	10-78/09-80	Estrada	Late Blight Resistance
	Nematology/Entomology						
A (a)	Alcazar, Jesus	Peru	MS	U N A	06-78/06-80	Jatala	Andean Potato Weevil Biology
A (a)	Astocaza, Evelio	Peru	MS	U N A	11-78/11-80	Franco	New Globodera Spp
S (a)	Canto, Manuel	Peru	PH. D	Cornell	06-78/06-81	Brodie	Meloidogyne Resistance
A (a)	Lazaro, Monica	Peru	MS	U N A	02-77/03-79	Franco	Biology Control of Globodera
S (a)	Valencia, Luis	Peru	PH. D	Queensland	08-78/08-81	Blood	Biology of Tuber Moth
	Pathology						
A (a)	Abad, Jorge	Peru	MS	U N A	03-76/10-79	Fribourg	Virus Studies
A (a)	Beltran, Vilma	Peru	MS	U N A	03-76/12-78	French	Erwinia Spp Tuber Resistance
S (c)	Camacho, Jesus	Mexico	MS	Chapingo	01-77/07-78	French	Chemical Control of Heterodera
S (c)	Cartin, Luis	Costa Rica	MS	Chapingo	01-77/07-78	French	Bacterial Wilt
S (a)	Ciampi, Luigi	Chile	PH. D	Wisconsin	10-78/12-78	French	Bacterial Wilt
S (a)	Granada, Gustavo	Colombia	PH. D	Wisconsin	08-78/09-81	Sequeira	Bacterial Wilt
S (a)	Hidalgo, Oscar	Peru	PH. D	N C S U	01-78/12-80	Echandi	Pathology
A (a)	Mandujano, Juan	Peru	MS	U N A	01-77/12-78	French	Soil Survial of P. Solanacearum
S (a)	Moreira, Arturo	Bolivia	MS	U N A	04-76/08-78	Jones/Fribourg	Bolivian Viruses

S (d)	Santillan, Franklin	Ecuador	MS	U N A	06-77/06-79	Fribourg	Ecuadorian Viruses
S (a)	Untiveros, Demetrio	Peru	MS	U N A	01-77/07-78	Turkensteen	Thecaphora Resistance
S (a)	Velupillai, Malarmagal	Sri Lanka	MS	Florida	04-78/08-80	A. A. Cook	Bacterial Wilt
	Physiology						
A (a)	Bedoya, Ana María	Peru	MS	U N A	10-78/01-79	Booth	Storage
A (b)	Bernal, Miguel	Peru	MS	U N C P	07-78/06-79	Shaw	Processing
A (a)	Cabello, Rolando	Peru	MS	U N A	07-78/12-78	Villagarcia	Fertilization
A (a)	Egoavil, Carlos	Peru	MS	U N A	01-76/12-79	Glas	Drought Resistance
A (b)	Gerra, Cayo	Peru	MS	U N C P	09-78/08-79	Shaw	Processing
P (a)	Glas, Tjaart	Holland	Post-Doc	C I P	09-77/02-79	Accatino	Physiology of Drought Resistance
A (a)	La Torre, Braulio	Peru	MS	U N A	01-78/12-79	Felipe/Morales	Erosion
A (a)	Maguiña, Ana María	Peru	MS	U N A	01-78/06-79	Shaw	Nutrition
S (a)	Manrique, Luis	Peru	PH. D	Hawaii	09-77/12-80	Meyer	Tropical Soils
A (a)	Quevedo, Juan Miguel	Peru	MS	U N A	09-78/06-80	Bryan	Seed Production
A (a)	Risi, Juan José	Peru	MS	U N A	09-78/12-78	Villagarcia	Fertilization
A (a)	Rodriguez, Mario	Peru	MS	U N A	01-77/12-78	Glas	Salinity
P (a)	Sattelmacher, Burkhard	Germany	Post-Doc	C I P	01-77/06-81	Accatino	Hormone Control of Tuberization
S (a)	Vega, Ulises	Peru	MS	U N A	04-77/12-78	Villagarcia	Phosphate Fertilization
A (a)	Villagarcia, Margarita	Peru	MS	U N A	02-78/12-79	Villagarcia	Fertilization
	Social Science Unit						
A (a)	Achata, Adolfo	Peru	MS	U N A	08-78/09-80	Monares/ Malamud	Agro-Economic Studies on Seed Production
S (a)	Tardieu, Francois	France	PH. D	I N A F	01-78/08-80	Horton/ Accatino	Optimizing Potato Production
S (b)	Vargas, David	Peru	MS	U N A	01-78/12-79	Monares	Agro-Economic
	Taxonomy						
S (a)	Cheng Song Tay	Taiwan	PH. D	Birmingham	04-77/09-79	Ochoa	Taxonomy of Cultivated Diploid Species

SCHOLARSHIP TYPE: A - Student Asst.; S - Full; P - Post-Doc

FUNDING: (a) Core; (b) IDRC; (c) BID/Core; (d) German

symposium on "Pathogens and Pests of the Potato in the Tropics" in the Philippines. The Head of Potato Research of Iran visited CIP/Lima and the Potato Coordinator, Pakistan, attended an International Seminar at Jullundur, that was organized by the Indian Potato Association.

REGION VI
India, Nepal and Bangladesh

This Regional Program established in mid-1977 developed a range of training activities in cooperation with the national programs of India and Nepal. A production and seed certification course at the Central Potato Research Station at Jullundur, was attended by 24 scientists from India, two from Nepal and three from Bangladesh. The main International Training Course on Potato Production is conducted annually by the Central Potato Research Institute at Simla, India. CIP sponsored four CPRI trainees in 1978, one from Bangladesh and three from Bhutan.

In addition to regional courses, a scientist from Jullundur, India, participated in CIP's "Workshop on Bacterial Wilt" and the "Second Symposium on Pathogens and Pests of the Potato" in the Philippines. Bhutan became the fourth country in CIP's Region VI Program in 1978.

REGION VII
Southeast Asia

One hundred and thirty-five scientists and technicians from nine countries of Region VII and from three countries of other CIP regions participated in training in the Philippines. Philippine scientists received advanced training in Australia and CIP/Lima. One national program scientist from Sri Lanka began M.S. studies in pathology at the University of Florida.

The short-term regional and in-country training activities in the Philippines in 1978 included: Second Regional Symposium and Bacterial Wilt Workshop; First and Second Potato Production School (in-country); Rapid Multiplication workshop; and Statistics Workshop. Regional scientists also received specialized training in virology, and tissue culture techniques at CIP/Lima.

Social Science Unit

Farm-level research dealt with three main interrelated topics: (1) constraints to potato production, (2) seed production, distribution and use, and, (3) post-harvest technology and marketing. Research continued on the potential of the potato in developing countries.

Farm-level research was in conjunction with CIP thrusts VII, VIII and IX, and with national scientists. Most fieldwork was in the Mantaro Valley of Perú's Central Highlands. Research on potato seed production and use also centered in the Cañete Valley of Perú's Central Coast and in the Machachi region of Ecuador.

Production Constraints

Research on production constraints concentrated on identification and analysis of technical and socioeconomic factors limiting potato production in the Mantaro Valley. The first step was identification of agro-ecological zones with distinct patterns of potato production and use (Figure SSU-1): Valley Floor (3,200-3,450 meters above sea level); Eastern Slopes (3,450-3,950 meters); Western Slopes (3,450-3,950 meters); and, High Zone (above 3,950 meters).

The Valley Floor is a relatively flat riverine plain that includes the most favorable crop production conditions in the entire area. It has the highest human population density of the four zones. Its cropping systems are highly diversified and a substantial part of the land is irrigated. Potato production and use patterns differ sharply between small and large farms. To date, most research on crop production has been on the Mantaro Valley Floor. Not all results are directly applicable to the other zones.

Land slope increases and number of crops diminishes above 3,450 meters. Maize is seldom grown above this altitude. Cropping systems, tillage and cultural practices and yields differ between the eastern and western slopes of the valley between 3,450-3,950 meter altitudes. Potatoes are most important on the eastern slopes. In the High Zone, above 3,950 meters, crop production is extremely hazardous and nearly all cropland

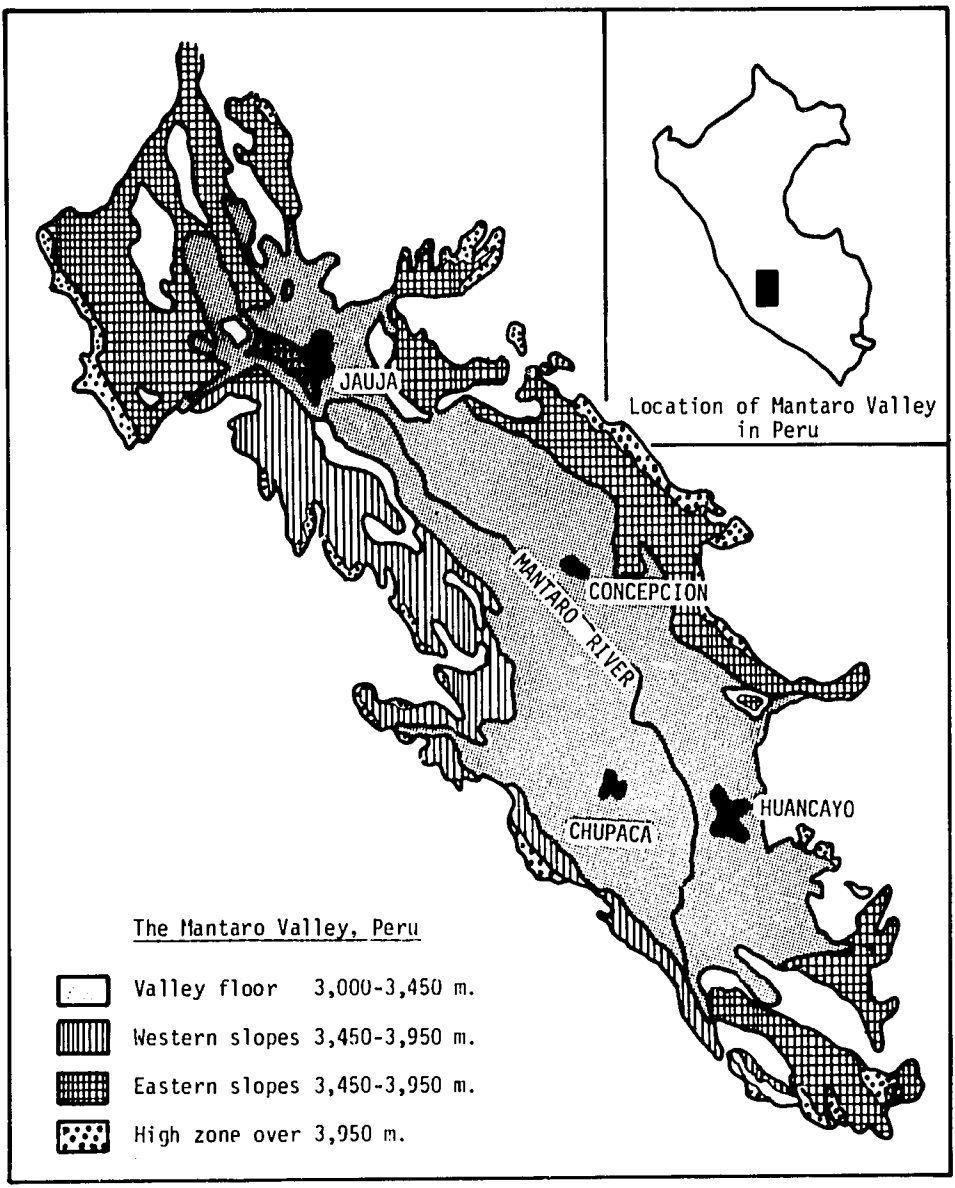


Figure SSU - 1. Agro-ecological zones of the Mantaro Valley, Perú.

is in potatoes, barley and forages (Figure SSU-2).

The Valley Floor includes three distinct farm types: small, subsistence-oriented producers (less than 0.5 ha potatoes); medium-sized commercial producers of ware potatoes (0.5 - 2.0 ha); and large commercial producers of seed potatoes for sale on the Coast (some with more than 10 ha in potatoes).

Intermediate and High Zones have few seed growers, and the size range of farms is smaller, with no distinct farm types.

Survey Results

Farming is a part-time activity for nearly 70 percent of the potato producers in the Mantaro Valley (Table SSU-1). Most farms are diversified, producing both crops and livestock. Livestock production increases in importance with altitude.

Potatoes, the major crop in the valley, are grown on nearly all farms. While the size of potato producing enterprise is quite small, a few large seed producers account for a substantial share of potato production in the valley.

The importance of fallow in rotation cycles is closely linked to

Figure SSU - 2. Land use by agro-ecological zone.

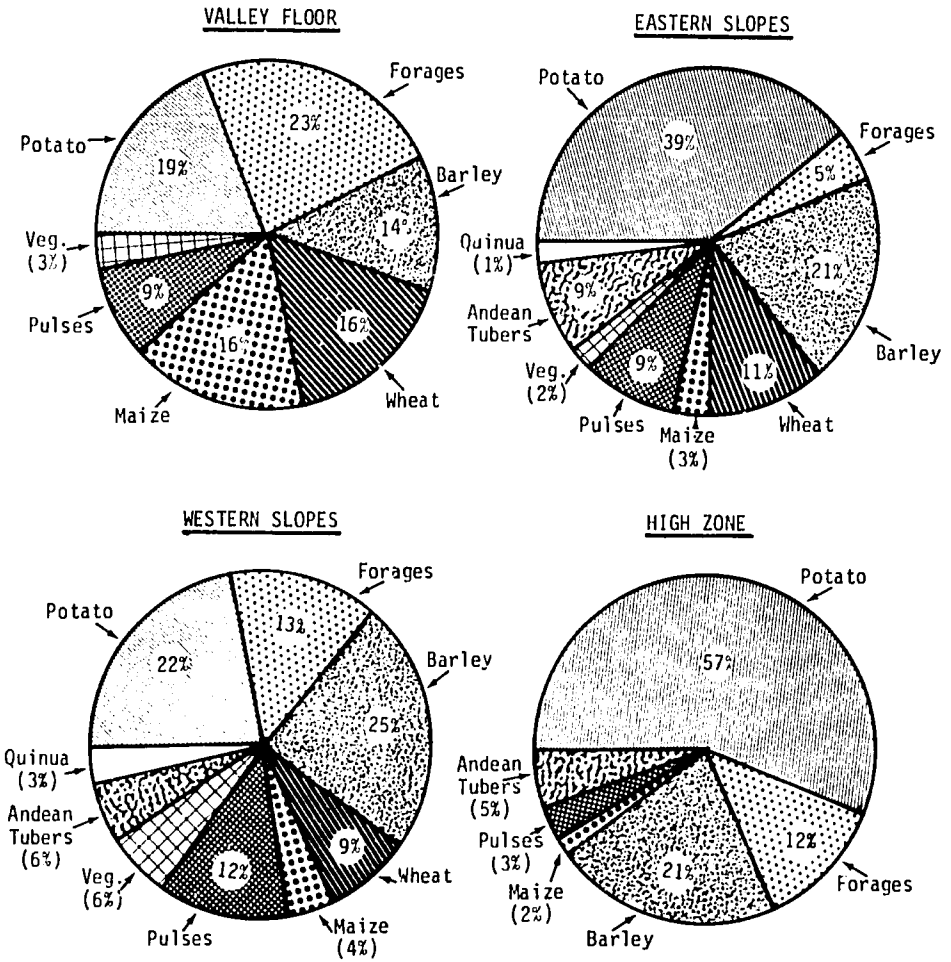


Table SSU - 1. Summary information on potato producers in Mantaro Valley.

	Valley Floor		Intermediate		High Zone	Total Mantaro Valley *
	Small Farms	Medium Farms	Eastern Slopes	Western Slopes		
Percent farmers with non-farm employment	80	46	61	59	63	67
Percent farmland in potatoes	24	17	39	22	57	25
Average farm size (ha)						
Cropland	1.0	10.9	1.9	1.8	1.4	2.3
Potatoes	0.2	1.9	0.7	0.4	0.6	0.6
Use of selected inputs (percent fields)						
Improved varieties	87	87	52	47	21	63
Improved seed	8	13	6	2	0	7
Chemical fertilizer	83	95	74	36	28	67
Average potato yields (mt/ha)						
Improved varieties	4.4	6.4	4.9	3.1	4.4	5.2
Traditional varieties	2.1	4.7	5.2	2.0	2.9	3.9
Percent harvest sold						
Improved varieties	11	74	60	21	56	57
Traditional varieties	8	3	44	3	7	30

* Excludes seed producers.

Table SSU - 2. Principal constraints as a percent of total potato production as perceived by farmers in Mantaro Valley.

	Valley Floor		Intermediate		High Zone	Total Mantaro Valley *
	Small Farms	Medium Farms	Eastern Slopes	Western Slopes		
No problem reported	33	35	31	34	37	33
Technical problems						
Frost	13	9	19	22	26	16
Drought	14	14	5	6	6	10
Pests	11	7	8	9	8	9
Diseases	8	7	12	7	2	8
Hail	5	4	9	12	16	8
Others	2	7	–	1	–	3
Socioeconomic problems						
Lack cash	8	7	9	3	4	7
Others	5	8	8	7	2	6
Total	100	100	100	100	100	100

* Excludes seed producers.

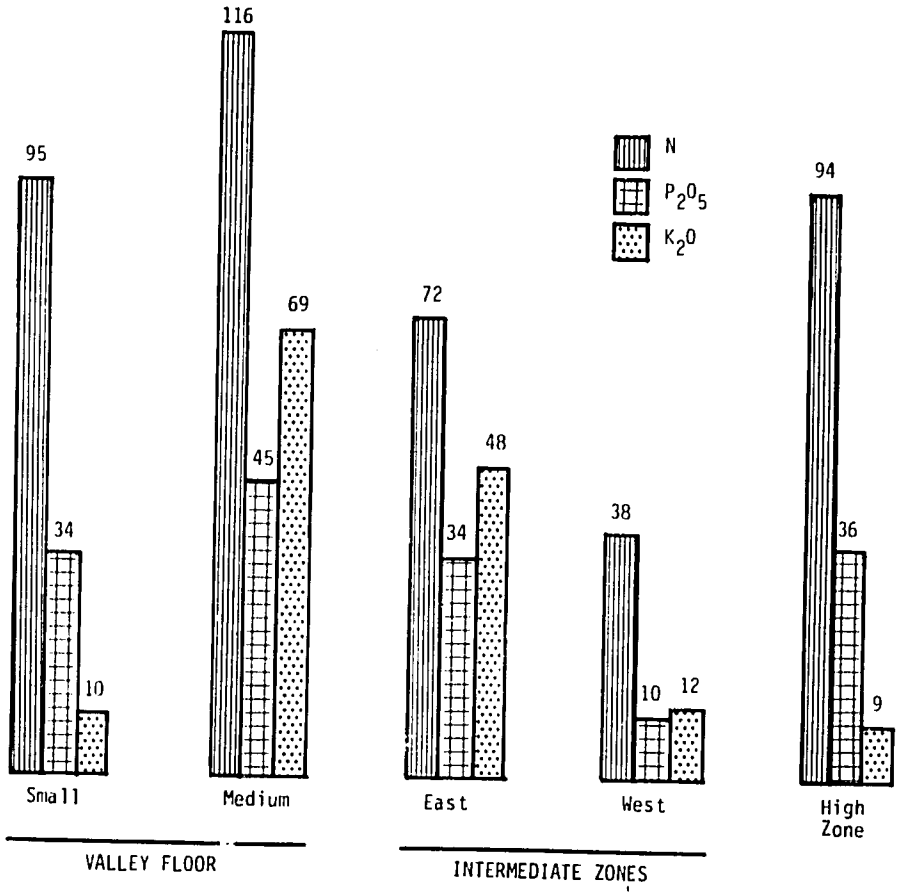
altitude. In the Intermediate and High Zones, where fallowing is common, potatoes are generally planted as the first crop after fallow. When potatoes are repeated a second or third year after fallow, yields fall off sharply (by about 50 percent in the Eastern Slopes and in the High Zone).

The use of improved varieties of potatoes introduced in the Mantaro Valley, is not evenly distributed. On the Valley Floor improved varieties account for nearly 90 percent of production, in the Intermediate Zones 50 percent and in High Zone 20 percent.

Chemical fertilizers and pesticides are commonly used throughout the valley. Many farmers seem to over-emphasize nitrogen fertilization, in relation to phosphorous and potash (Figure SSU-3). Pest control is often ineffective because of improper management and low rates of pesticide application.

Potato growers list their major production constraints (in descending order of importance) as: frost, drought, pests, diseases and hail (Table SSU-2). An agronomic

Figure SSU-3. Average chemical fertilizer application by agro-ecological zone and farm type (kg/ha).



survey in 1978 confirmed the importance of these factors, and documented management problems in seed potato selection, storage and planting, fertilization, and pest control.

During the 1978/79 crop year, on-farm trials are evaluating technical solutions to major production constraints. A socioeconomic analysis of trial results is to evaluate the "adoption potential" of new technologies. (See also section of Optimizing Potato Productivity, under Thrust VII).

Seed Potato Production, Use

Seed quality is one of the most critical factors in raising potato productivity in developing countries. Yet, farmers in many areas do not purchase improved seed when available.

Weighing a tuber seed sample during an agroeconomic survey, Mantaro Valley.

Breaking clods of soil with a sledge hammer prior to planting, Mantaro Valley.

Socioeconomic research on seed production and use, addressed two questions:

1. What are the most important socioeconomic factors limiting production and use of improved seed in developing countries?

2. How can these limiting factors be removed?

This research is in conjunction with Thrust IX and with National Program scientists in two areas of Perú (Mantaro and Cañete Valleys), in Ecuador (Machachi region) and in Colombia (Cundinamarca).

Highland Seed in Coastal Valley

A randomized block design, with 40 m^2 per plot and three replications was used in two Cañete Valley experiments.

Main findings from these experiments on fertilization and seed sources:

1. Statistical analysis indicates no significant differences in yield resulting from use of farmer seed and basic seed in either experiment. Farmer and recommended fertilization levels did not yield significantly different results. Moreover, no factor interactions were found in either experiment.

2. Significant statistical differences (at the 1 percent and 10 percent level) emerged among yields from different commercial seed sources at the two locations.

Results support the hypothesis that, under management conditions of medium-sized farmers in the Cañete Valley, basic seed produces yields similar to those obtained by

Checking fertilizer and seed for an agro-economic experiment, Mantaro Valley.

using seed of many good farmers from the Central Highland. Also, these farmers are getting, through their own fertilizing practices, yields similar to those obtained from using recommended levels, although they use different product combinations and face different cost levels.

Another important conclusion is that commercial seed from the Central Highland is of highly variable quality, when expressed in terms of yield. Since Perú's commercial potato seed has a fixed price, this yield variability means that seed users can get different rates of profit from similar investments in seed, depending upon sources of purchase in the Central Highlands. Because the official system delivers at a fixed official

Maize and seed potatoes stored in a farm house in the Mantaro Valley.

price, an input with such variability in quality, the use of government inspected seed potatoes can be expected to be limited.

The above analysis throws light on two interrelated problems facing potato programs of developing countries: the reason many farmers prefer not to buy certified or improved seed, and one reason that national seed programs often do not grow beyond a small size.

Seed Distribution

The use of specific production inputs varies greatly between agro-ecological zones and types of farmers (Table SSU-3).

1. Substantial differences between seed growers and ware potato producers within the same agro-ecological zone (Mantaro Valley, low zone), regarding total variable cost and average yield.

2. Seed and fertilizer costs are similar, in relative terms, across agro-ecological zones within the Mantaro Valley, seed representing about 35 percent and fertilizer 9 percent of total variable cost.

3. Relative importance of seed and pesticide costs is greater in Cañete than in the Mantaro Valley.

4. Within the Mantaro Valley, relative importance of mechanization decreases with altitude, while the relative importance of labor increases.

5. Percentage of seed purchased decreases with altitude in the

Table SSU - 3. Variable cost and relative importance of inputs for potato producers in the Mantaro and Cañete Valleys.

Inputs	Mantaro Valley				Cañete Valley
	Valley Floor		Intermediate zone	High zone	
	Seed	Ware			Ware producers
Total variable cost (US$) *	1,421	915	732	786	1,178
Percent purchased inputs	75	61	31	25	96
Average yield (t/ha)	21.8	8	6.9	11	23
Percent of inputs in total variable cost					
Seed	34	35	34	36	44
Fertilizer	10	9	12	4	7
Manure	7	10	4	12	–
Pesticide	8	5	6	3	22
Labor	23	25	35	44	8
Mechanization	16	9	–	–	19
Animal source of energy	2	7	9	1	–
Total	100	100	100	100	100

* Exchange rate at planting time : US$ 1 = 98.24 soles (October 1977, Mantaro Valley)
US$ 1 = 151 soles (June 1978, Cañete Valley)

CIP personnel interviewing a potato farmer on the eastern slopes of the Mantaro Valley.

Mantaro Valley, indicating farmers tend to rely upon their own seed in the higher zones.

One striking feature of the seed distribution pattern of Perú's Central Region is that most commercial seed produced in the Central Highlands is sold on the Coast. For example, seed potato producers in the Mantaro Valley shipped about 1,000 tons of seed to Cañete in 1978, but sold practically no seed in the Highlands. For main season planting in Cañete, all coastal producers plant seed from the Highlands (for a variety of reasons including higher disease incidence, storage problems and price differential between the regions).

Table SSU-4 indicates how economic factors influence this interregional distribution pattern. No estimates are available for farm-level yield losses from virus infected seed potatoes in Perú. In Table SSU-4, it is assumed that by using improved seed with low virus levels, yields increase by 25 percent in each region (from 8 to 10 t/ha in Mantaro Valley, and from 20 to 25 t/ha in Cañete Valley).

Two main conclusions from Table SSU-4:

1. Given assumed yield differential of 25 percent, the change in net returns from using improved seed varies directly with initial yield

level and gross return and inversely with seed rate and price of seed; hence, additional net return (over seed cost) obtained by farmers in Cañete is more than twice the additional net return obtained by farmers in the Mantaro Valley.

2. Farmers in the Mantaro Valley buy only about 40 percent of their seed each year, whereas farmers in Cañete purchase nearly all their seed each year. Hence, farmers in the Mantaro Valley would need to increase their cash expenditure greatly to purchase improved seed for their entire planting.

Concepts illustrated in this example can be used to predict what types of potato producing regions and what types of farmers are most likely to buy improved seed. The demand for improved seed is likely to be greater in regions with high initial potato yields, high ware potato prices, and serious seed-borne disease problems. At the farm level, demand for improved seed will be greatest by farmers with high potato yields, currently using seed with high level of virus infection and with cash available at planting time (see also Thrust IX).

Post-Harvest Technology

The Social Science Unit collaborated with Thrust VIII in a

Table SSU-4. Estimated profitability of using improved seed in two regions of Perú.*

	Mantaro Valley (highlands)	Cañete Valley (coast)
1. Seed rate/ha	0.9 t	2.0 t
Percent seed purchased	40	100
2. Seed cost/ha		
a. traditional	$ 64.4	$ 184.0
b. improved	$ 110.4	$ 286.0
3. Yield/ha		
a. traditional seed	4.8 t	16 t
b. improved seed	6.0 t	20 t
4. Gross return		
a. traditional seed	$ 245.3	$ 980.8
b. improved seed	$ 306.6	$ 1,226.0
5. Additional seed cost (2a-2b)	$ 46.0	$ 102.0
6. Additional gross income (4b-4a)	$ 61.3	$ 245.2
7. Change in net return (6-5)	$ 15.3	$ 143.2
8. Benefit/cost ratio (6/5)	$ 1.3	$ 2.4

* Exchange rate: US$ 1 = 195.73 Soles (January 1, 1978).

Using an Andean foot plow (chaquitaclla) to prepare land for planting potatoes in the Mantaro Valley.

A team of oxen plowing potato land on the floor of the Mantaro Valley.

short course on storage, organizing on-farm trials for new storage techniques and collecting price data for evaluation of ware storage experiments. Additionally, farmer marketing strategies were studied and a seminar held on potato marketing problems.

The Storage Short Course involved socioeconomic and agronomic research and trained participants in specific skills to aid them to design, test and transfer low-cost storage techniques to farmers. The course emphasized the need for defining farm-level storage problems, the execution of on-farm experiments in conjunction with on-station experimental work, and the need for understanding management and marketing practices along with improved storage techniques. Four course participants from Latin America were visited later for evaluation. All participants had used their experience in terms of reports and seminars in their home countries and two of the four were ready to implement further storage work along the lines suggested by the course. A further follow-up is planned in early 1979.

Throughout 1978, potato price information in the Mantaro Valley was collected to evaluate ware potato storage experiments measuring profitability of holding potatoes off the market for periods of 3 to 6 months.

Potato Potential

Bibliography surveys and analyses of published statistics by CIP, Cornell University and the Technical University of Berlin provide the information base for this research project. A "Country Questionnaire" was sent via CIP Regional Scientists to National Potato Program Leaders, requesting information on potato production and use, major production constraints, prices of major foodstuffs, and other aspects of the potato industry. Completed questionnaires from 22 developing countries provide information to complement published material in an analysis of the potato's current and potential contribution to human nutrition in the developing world.

Communications

The Communications Department is a Center Support activity which includes personnel and facilities for artwork, audio-visuals, photography, printing and binding, duplicating, cold type setting, editing/writing, distribution of communications production, preparation of training lessons, and projection of slides/movies/overheads.

The Department is production oriented to provide needed or requested materials and assistance to scientists, technicians, administration or others.

A reconstructed darkroom for black and white photography was completed during the year and operations on a limited scale began. Other facilities available are a studio and small projection room, where meetings or slide shows for groups of no more than 20 persons are held. The small projection room was in use virtually every day.

Communications Department photographers took some 1,200 black and white and 1,500 color slides during the year. Approximately 500 colored slides were added to bring the total now in CIP files to 4,000. These slides are used for publications, for slide series, for illustrated lectures and for loan to other institutions. About 1,800 duplicated copies of slides were made. Black and white photo files were augmented by some 500 negatives. Considerable more use was made of high contrast slides for presentations and for publications during the year with 1,200 slides being made.

The offset press section printed in excess of 1,055,000 impressions during a one-year period. These included forms for administration or other CIP departments, Annual Reports, Planning Conference Reports, bulletins, circulars, completion of printing a potato cook book and miscellaneous items.

Addition of a larger wire spool-type stapler increased both flexibility and speed in the section's bindery operations. A new offset plate burner enabled the section to turn out better quality printing in a minimum of time. Although the plate burner was in operation for less than half the year, 186 plates were processed with it.

A new composing machine was added to the Department's facilities to take place of a rental machine. The composing machine is used for preparing the text for various publications -- this 1978 Annual Report is one example -- and for designing forms, tables/charts and for making copy to produce special slides from high contrast film.

The art/drafting section was especially active, first with getting the Annual Report ready for plate burning and at the end of the year in preparation of materials for the annual review. Addition of a draftsman resulted in potential for higher production. CIP's artwork requirements vary considerably for publications, reports, maps, and slide series. A special display of CIP activities was prepared and shown during a special event at the Lima Civic Center (CONACITA).

CIP's duplicating and distribution section, which is part of the Communications Department, produced nearly 190,000 impressions by mimeograph, 34,100 by ditto machine and 159,000 with a copying machine. This section was also in charge of sending out CIP publications to fill specific requests as well as maintaining and updating mailing lists for regular distribution.

Twelve numbers of the CIP Circular were issued. This is a monthly publication containing articles on CIP research. Nearly 2,500 copies in both English and Spanish are sent to a regular mailing list. The format of the Circular has been changed, more photos are being used and production methods have been altered to better fit Communications Department facilities. A Spanish Writer/Editor was hired at year's end to aid with the Circular as well as with other publications and news releases in Spanish. A new Head of Communications Department was named during the year and began work in May.

The first, or pilot, training lesson was prepared, designed and printed. Most evaluations of the concept of the training lessons were highly favorable. The concept is to produce a small, handy-to-carry "pocket" size lesson packet. It includes extra writing space for notes, it will be highly readable, and contain illustrations that can be easily redrawn or reproduced in developing countries. Lessons are to be in loose-leaf form for ease in inserting updates or new materials. A slide series using some of the same lesson art work is suitable for use in conjunction with each training lesson. Although the lessons are prepared for use at the Ingeniero Agrónomo level, the form of presentation aims indirectly at application at the farmer level.

Library

The library continued to add selected items of interest to its specialized collection. The book collection was augmented by 1,700 volumes bringing the total to 3,500. This figure includes the theses

collection which holds 190 titles, nearly all on potato research. Journals by subscriptions were revised and reduced to 78 titles. Journals by subscription, donation and exchange total 450 titles. A new journal display system was also started.

Initial steps were taken in the acquisition of available journal subscriptions in both microfiche and paper copies for the gradual substitution of back copies of these journals in fiche, for space-saving and efficiency in document storage and retrieval. Although the library will not be producing its own fiche, resources of microfiche publications in CIP's field of interest are being tapped. A special room in the library's basement will house the fiche collection and its accessories.

Emphasis on the reprint collection has continued due to the needs of CIP scientists for current information gathered through journal scanning and bibliographies.

Daily screening of books and journals continues to provide references for "Potato Analitics." Author and subject cards of these potato articles are filed in the card catalogs.

Library contacts at the national and international levels continued including inter-library loans, photocopying services and exchange. At the national level, contacts were maintained with neighbouring libraries BAN (National Agricultural Library), CRIA (Regional Centers for Agricultural Research), IIA (Agro-Industrial Institute) and others. In the near future BAN (Coordinating Center of AGRINTER for Perú), will be supplied input sheets of CIP publication data. Searches and bibliographies were also prepared for courses taught by CIP scientists at the Universidad Nacional Agraria.

At the international level, contacts continued mainly through photocopying services and exchange. In late 1978 mailing list up-date cards were also sent in order to maintain a constant flow of publications with those institutions with which we have exchange agreements.

Weekly lists of new acquisitions continued to be published in CIP's Internal Bulletin and will be distributed externally as of next year.

At year's end, the Head Librarian resumed work after completing a Master's degree in Information Studies in England with the dissertation "Survey of Agricultural Library and Information Services in England." Contacts with various well known European Centers in the field of agriculture and related disciplines (FAO, EEC, IAEA, IRAT, libraries of the Agricultural University in Wageningen, PUDOC, RTI, UN and UNESCO) were also made by the librarian.

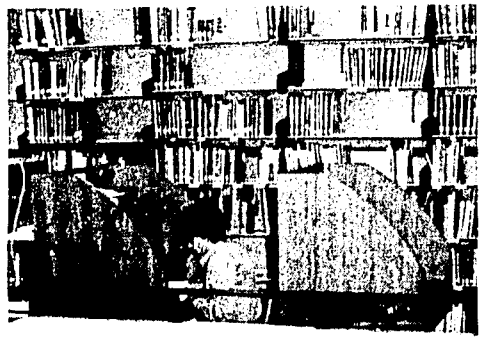
Language Instruction

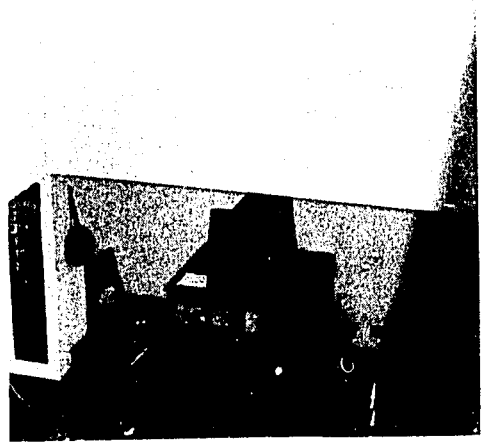
Individual Spanish lessons for CIP's scientists and their wives

continued in 1978. Taking the classes from CIP's language instructor were 19 English-speaking men and 12 wives, 3 German-speaking men and 3 wives, and 1 French-speaking man.

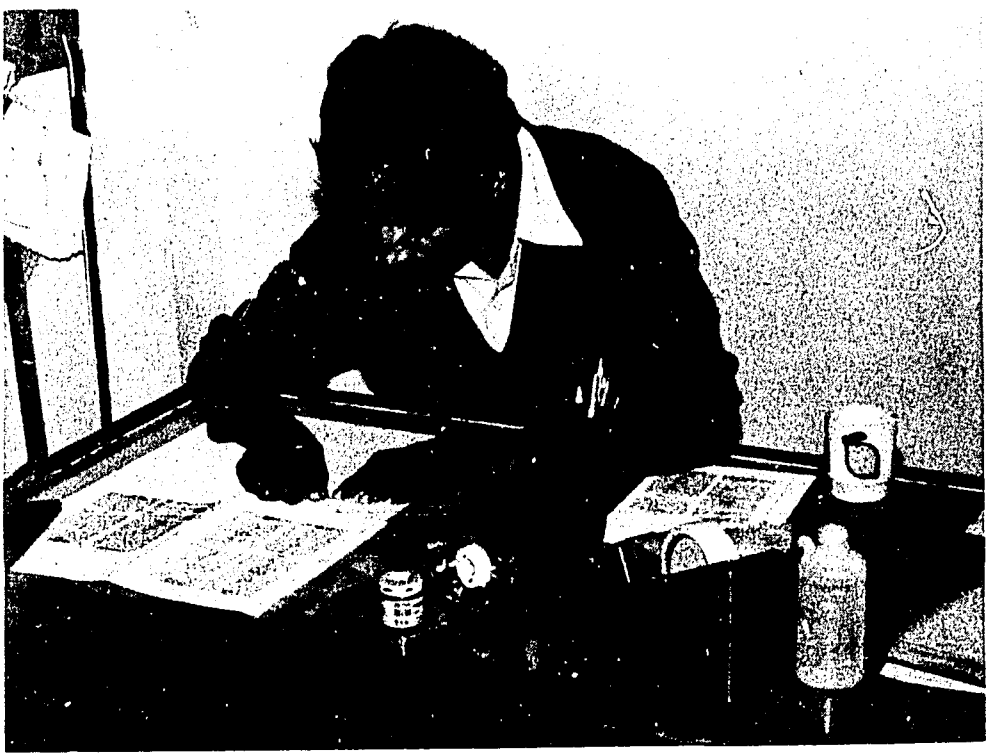
Visitors

The number of visitors at CIP continues to increase. In 1978 a total of 632 visitors of 45 different nationalities toured CIP facilities. This was 218 persons more from 42 different nations as recorded in 1977.





Two floors of CIP's library (right) and camera-ready copy being prepared in the Communications art section for the 1978 annual report (below).



Publications by CIP Scientists

(Reprints should be requested directly from the authors).

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2. **Augustin, J., S. R. Johnson, C. Teitzel, R. A. True, J. M. Hogan, R. B. Toma, R. L. Shaw** and **R. M. Deutsch.** 1978. Changes in nutrient composition of potatoes during home preparation. II. Vitamins. Am. Potato J. 55:653-662.

3. **Augustin, J., S. R. Johnson, C. Teitzel, R. B. Toma, R. L. Shaw, R. H. True, J. M. Hogan** and **R. M. Deutsch.** 1978. Vitamin composition of freshly harvested and stored potatoes. J. Food Science 43(5):1566-1571.

4. **Brown, C. R., H. Hauptli,** and **S. K. Jain.** 1978. Variation in *Limnonthes alba*: A biosystematic survey of germ plasm resources. Economic Botany (In press).

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6. **Estrada, R. N.** 1978. Breeding frost-resistant potatoes for the tropical highlands. *In* Plant Cold Hardiness and Freezing Stress. Edited by P. H. Li and A. Sakai. N. Y. Academic Press. pp. 333-341.

7. **Estrada, R. N.** 1978. Behavior of *Solanum curtilobum* Juz. et Buk. in crosses to tetraploid cultivated potatoes. Am. Potato J. 55:374 (abstr.).

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14. **Franco, J.** and **K. Evans.** 1978. Restoration of morphological features of *Globodera pallida* after storage in formalin. Journal of Nematology 10(4):370-372.

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17. **Frey, F.** 1978. Effects of the herbicide aminotraizole on the nematode *Acrobeloides buetschlii* (de Man 1884). Steiner and Buchrer 1933 in culture. Nematologica: (Accepted for publication).

18. **Gibson, R. W.** and **L. Valencia.** 1978. A survey of potato species for resistance to the mite *Polyphagotarsonemus latus*, with particular reference to the protection of *Solanum berthaultii* and *S. tarijense* by glandular hairs. Potato Res. 21:217-223.

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53. **Westcott R. J., G. G. Henshaw** and **W. M. Roca.** 1977. Tissue culture storage of potato germ plasm: Culture initiation and plant regeneration. Plant Science Letters. 9:309-315.

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Research and Consultancy Contracts

CIP's research program is strongly supported by contract research at institutions with existing expertise and facilities. Research contracts are normally for a 3-year period and are reviewed annually when progress reports are submitted. The objectives and other details of research are clearly defined in each contract with appropriate budget specifications.

Selected information derived from the following contracts has been incorporated into various Thrust reports.

Research Contracts

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

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

3. The Swedish Seed Association, Svalov, Sweden.— "Development of Late Blight Resistance of Cultivated Potatoes." V.R. Umaerus.

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

5. Research Station for Arable Farming, Wageningen.— "Water Stress Tolerance." C.D. van Loon.

6. Foundation for Agricultural Plant Breeding, Wageningen.— "Resistance Breeding Against the Potato Eelworm, *Heterodera rostochiensis*." C.A. Huijsman.

7. Centro Regional de Investigación Agraria, La Molina, Perú.— "Utilización de las Especies Cultivadas Diploides para Mejoramiento en Calidad Culinaria y Nutricional de Papa." F. de la Puente.

8. University of Wisconsin.— "Developing Potato Clones with Resistance to Bacterial Wilt and Improved Adaptation to Tropical Conditions." L. Sequeira.

9. Universidad Nacional Agraria, La Molina, Perú.— "Fertility and Mineral Nutrition of the Potato." S. Villagarcía.

10. Universidad Nacional Agraria, La Molina, Perú.— "Effect of Various Systems of Potato Production on Yield, Pathogens, Fertility and Soil Erosion." Carmen Felipe Morales.

11. University of Wisconsin.— "Potato Breeding Methods with Species, Haploids and 2n Gametes." S.J. Peloquin.

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

13. University of Minnesota.— "Environmental Stress Physiology in Tuber-bearing Solanum Species." P. Li.

14. Universidad de Costa Rica.— "La Epifitiología y Control de la Marchitez Bacteriana de la Papa." L. Gonzáles.

15. Instituto Colombiano Agropecuario, Colombia.— "Evaluation of the Resistance of Potato Genetic Material to *Pseudomonas solanacearum*." G. Granada.

16. Centro para el Desarrollo Rural y Cooperativo, Chile.— "Socioeconomic Study of the Production and Utilization of the Potato; Chile." G. Fu Alvarez.

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

18. Institut für Biochemie Biologische Bundesanstalt, Braunschweig, Germany.— "Use of Electrophoresis Techniques to Determine Clonal Variation in the CIP Germ Plasm Bank and the Evaluation of Gene-markers for Polygenetic Properties." H. Stegeman.

19. Victoria Dept. of Agriculture, Australia.— "Potato Seed Multiplication of Germ Plasm for Southeast Asian and Pacific Countries." P. T. Jenkins.

20. University Hohenheim (LH) Stuttgart, Germany.— "Physiological Studies on Tuberization and Growth in Potatoes." A. Krauss.

21. Technical University of Berlin.— Socioeconomics of Agricultural Development. "Socioeconomic Research and Training on Potatoes." G. Lorenzl.

22. University of Birmingham, England.— "Tissue culture studies with potatoes." G. G. Henshaw.

Consultancy Contracts

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

2. Centro Regional de Investigación Agraria I - La Molina, Perú.— "Consultancy on the Advanced Testing of Breeding Stocks for the Lowland Tropics." F. de la Puente.

3. Universidad Nacional Agraria - La Molina, Perú.— "Consultancy on Experimental Design, Statistical Analyses and Computer Programming and Processing." W.S. Salhuana.

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

5. Rothamsted Experimental Station, England.— "Consultancy on the Identification and Verification of the Resistance of Glandular Trichome-bearing *Solanum* Species to Selected Insects and Mites." R. Gibson.

6. Universidad Nacional Agraria - La Molina, Perú.— "Consultancy on the Production of Antisera Project in the Virus." C. Fribourg.

Staff

(as of December 31, 1978 or serving a major part of 1978)

Scientific Staff

Research

Orville Page, PhD . . . . . Director

Breeding and Genetics

Humberto Mendoza, PhD . . . . . Department Head
Charles Brown, PhD . . . . . Geneticist
Nelson Estrada, PhD . . . . . Breeder
Zosimo Huaman, PhD . . . . . Geneticist
Juan Landeo, MS . . . . . Geneticist (study leave)
Paul Thompson, PhD . . . . . Breeder

Nematology and Entomology

Parviz Jatala, PhD . . . . . Department Head
Javier Franco, PhD . . . . . Nematologist
K. V. Raman, PhD . . . . . Entomologist
Maria de Scurrah, PhD . . . . . Breeder/Nematologist
Luis Valencia, Ing. Agr. . . . . Entomologist (study leave)

Pathology

Edward French, PhD . . . . . Department Head
Franz Frey, PhD * . . . . . Mycologist
Roger Jones, PhD . . . . . Virologist
Carlos Martin, PhD . . . . . Bacteriologist
Anwar Rizvi, PhD . . . . . Virologist
Luis Salazar, PhD . . . . . Virologist
Lodewijk Turkensteen, PhD * . . . . . Mycologist

Physiology

Sidki Sadik, PhD . . . . . Department Head
Primo Accatino, PhD . . . . . Agronomist
Robert Booth, PhD . . . . . Physiologist
Tjaart Glas, PhD . . . . . Physiologist

Adolph Krauss, PhD . . . . . Physiologist
Raymond Meyer, PhD * . . . . . Agronomist
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. . . . . Field Supervisor - Lima
Enrique Grande . . . . . Field Foreman - San Ramon
Marco Soto, PhD . . . . . Superintendent - Huancayo

Regional Research and Training Headquarters - Lima, Peru

Kenneth Brown, PhD . . . . . Director
James Bryan, MS . . . . . Seed Production Specialist
Marciano Morales Bermudez, MS . . . . . Production Specialist
John Niederhauser, PhD . . . . . Consultant
Lyle Sikka . . . . . Seed Production Specialist

Social Science Unit, Lima

Douglas Horton, PhD . . . . . Head of Unit
Georg Durr, MS . . . . . Agricultural Economist
Anibal Monares, MS . . . . . Agricultural Economist
Luis Quintanilla, MS . . . . . Agricultural Economist
Robert Werge, PhD . . . . . Anthropologist

Training Department

Richard Wurster, PhD . . . . . Head of Training
Manuel Piña, PhD . . . . . Training Officer

Region I — South America

Oscar Malamud, PhD . . . . . Region Representative
Andre Devaux, Ing. Agr. . . . . Associate Expert (Peru)
Lauro Lujan, PhD . . . . . Seed Specialist (Colombia)

Region II — Central America, Mexico and the Caribbean

Michael Jackson, PhD . . . . . Region Representative

Region III – Tropical Africa

Sylvester Nganga, PhD . . . . . Region Representative
Dennis Goffinet, PhD . . . . . Research Scientist (Rwanda)
Eisse Luitjens, Ir. . . . . Associate Expert (Kenya)

Region IV – Middle East and North Africa

Patricio Malagamba, PhD . . . . . Region Representative
Brian Honess, MS . . . . . Seed Production Specialist (Turkey)
Roger Kortbaoui, PhD . . . . . Research Scientist (Tunisia)
William Schrage, Ir. . . . . Associate Expert (Turkey)

Region V – Southwest Asia

Gary Robertson, MS . . . . . Region Representative
Romke Wustman, Ir. . . . . Associate Expert (Pakistan)

Region VI – India, Nepal and Bangladesh

Hari Kishore, PhD . . . . . Region Representative
Peter Schmiediche, PhD . . . . . Research Scientist (Nepal)

Region VII – Southeast Asia

Lindsay Harmsworth, BS . . . . . Region Representative

Support Communications

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Rainer Zachmann, PhD . . . . . Communications Officer
Ayn Strattner, BA . . . . . Editor/Writer
Maria de Boisset, BA . . . . . Assistant Audio-visuals
Carmen de Podesta, MS . . . . . Librarian
Martha Crosby, BA . . . . . Assistant Librarian

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

Carmen Felipe Morales, PhD . . . . . Agronomist
Enrique Fernandez-Northcote, PhD . . . . Virologist
Cesar Fribourg, MS . . . . . Virologist
Isaias Herrera, Ing. Agr. . . . . Bacteriologist
Fermin de la Puente, PhD . . . . . Geneticist
Sven Villagarcia, PhD . . . . . Agronomist

Scientific Assistants

Breeding and Genetics

Juan Aguilar, Ing. Agr.
Edgar Alvarez, MS
Walter Amoros, MS
Saturnino Vargas, Ing. Agr.

Nematology and Entomology

Marcia Bocangel, BS
Renate Kaltenbach, BBA
Sila Llerena, Biol.

Pathology

Zoila de Abad, BS
Carlos Chuquillanqui, BS
Wilman Galindez, Ing. Agr.
Ana Maria de Lekeu, PhD
Lilian de Lindo, Ing. Agr.
Josefina de Nakashima, Biol.
Ursula Nydegger, Tech. Dip.
Hans Pinedo, Ing. Agr.
Soledad de Rodriguez, Biol.
Ernesto Velit, Biol.
Herbert Torres, MS

Physiology

Nilda Beltran, BS
Donald Berrios, Ing. Agr.
Nelson Espinoza, Q. F.
Rolando Estrada, Biol.
Nelly de Fong, Biol.
Norma Gonzalez, Q. F.
Rolando Lizarraga, Ing. Agr.
Rosa Mendez, Ing. Agr.
Jorge Roca, Biol.
Jose Luis Rueda, Ing. Agr.
Alberto Yupanqui Tupac, BS

Taxonomy

Jesus Amaya, Tech. Dip.
Matilde Orillo, Biol.
Alberto Salas, Ing. Agr.

Research Support

Lauro Gomez
Nelson Melendez, Tech. Dip.

Regional Research and Training

Richarte Acasio, MS., Philippines
Jorge Aguilar, Costa Rica

Social Science

Maria Isabel Benavides, BA
Hugo Fano
Cecilia Moreno, Ing. Zootc.

Social Science Special Project/(IDRC)

Jorge Alarcon, BS . . . . . Assistant
Elsa Bruno . . . . . Assistant
Efrain Franco, MS . . . . . Economist
Juan Perea, BS . . . . . Assistant
Marcelino Raymundo, BS . . . . . Assistant
Luis Tomassini, MS . . . . . Associate Agronomist
Ludy Ugarte, BA . . . . . Coordinator

Administration

Richard L. Sawyer, PhD . . . . . Director General
Roger Rowe, PhD . . . . . Deputy Director General

William Hamann, BS	Assistant to Director General
Carlos Bohl, Ing. Agr.	Executive Officer
Victor Barreto, BA	Assistant Executive Officer
Fernando Canalle, Ing. Civ.	Supervisor
Luis Palacios, Ing. Agr.	Supervisor
Leonardo Hussey	Controller
Oscar Gil, CPA	Senior Accountant
Jorge Bautista	Accountant
Blanca de Joo, CPA	Accountant
Guillermo Romero	Accountant

* Resigned during year.

COLERIDGE Y ASOCIADOS

THE INTERNATIONAL POTATO CENTER - CIP

FINANCIAL STATEMENTS AS OF DECEMBER 31, 1978 AND 1977

(Translated from the Spanish language)

I N D E X

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COLERIDGE Y ASOCIADOS
REPRESENTANTES DE
ARTHUR ANDERSEN & Co.
LIMA - PERU

Translated from the Spanish language

To the Board of Trustees of
The International Potato Center - CIP:

We have examined the balance sheet of THE INTERNATIONAL POTATO CENTER - CIP (a nonprofit organization established in Perú in accordance with the Agreement for Scientific Cooperation between the Government of Perú and the North Carolina State University of the United States of America) as of December 31, 1978 and 1977, and the related statements of sources and application of funds for the years then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying financial statements present fairly the financial position of The International Potato Center as of December 31, 1978 and 1977, and the source and application of its funds for the years then ended, in conformity with generally accepted accounting principles consistently applied during the periods.

Our examination has been made primarily for the purpose of forming the opinion stated in the preceding paragraph. The data contained in Exhibits 1 to 4 inclusive, although not considered necessary for a fair presentation of the financial position and source and application of funds of The International Potato Center, are presented as supplementary information and have been subjected to the audit procedures applied in the examination of the basic financial statements. In our opinion, these data are fairly stated in all material respects in relation to the basic financial statements, taken as a whole.

Countersigned by:

Coleridge y Asociados
Representantes de
Arthur Andersen & Co.

Luis Coleridge Alcántara
C.P.C. Matrícula No. 1234

Lima, Perú,
April 6, 1979.

COLERIDGE Y ASOCIADOS

THE INTERNATIONAL POTATO CENTER - CIP

BALANCE SHEET

(Stated in U.S. dollars)

(Translated from the Spanish language)

A S S E T S

	As of December 31 1978	1977
CURRENT ASSETS:		
Cash on hand in banks, includes US$1,000,000 in 1978 of short-term deposits	1,412,482	658,419
Accounts receivable -		
Donors	298,390	387,696
Advances -		
Principal and support staff	140,306	66,792
International agriculture centers and other organizations	132,790	35,906
Other	112,292	93,538
	683,778	583,932
Inventories of laboratory and other supplies	119,296	79,812
Vehicles and other fixed assets replaced to be sold	89,369	93,679
	208,665	173,491
Prepaid expenses and other assets	42,086	22,627
Total current assets	2,347,011	1,438,469
FIXED ASSETS:		
Buildings and construction in progress	1,467,092	1,359,842
Research equipment	554,826	497,555
Vehicles	612,171	503,938
Furniture, fixture and office equipment	326,478	276,912
Operating equipment	86,644	80,646
Installation and Site Development	631,518	558,582
Other	94,727	65,714
	3,773,456	3,343,189
	6,120,467	4,781,658

LIABILITIES, CAPITAL GRANTS AND UNEXPENDED FUNDS

	As of December 31 1978	1977
CURRENT LIABILITIES:		
Bank overdrafts	97,179	1,389
Accounts payable	213,750	423,902
Donors	255,550	66,000
Other	75,698	39,389
Total current liabilities	642,177	530,680
GRANTS RECEIVED IN ADVANCE	270,000	41,675
RESERVE FOR SEVERANCE INDEMNITIES (net of advances of US$10,766 in 1978 and US$3,374 in 1977)	72,854	63,509
CAPITAL GRANTS AND UNEXPENDED FUNDS:		
Capital grants -		
Fully expended in fixed assets	3,773,456	3,343,189
Working funds	488,000	362,000
	4,261,456	3,705,189
Unexpended funds -		
Capital grants	-	5,312
Core programs	717,092	220,485
Special projects	156,888	214,808
	873,980	440,605
	5,135,436	4,145,794
	6,120,467	4,781,658

The accompanying notes to the financial statements are an integral part of this statement.

THE INTERNATIONAL POTATO CENTER - CIP

STATEMENT OF SOURCE AND APPLICATION OF FUNDS

(Stated in U.S. dollars)

(Translated from the Spanish language)

	For the years ended December 31, 1978	1977
SOURCE OF FUNDS:		
Operating grants -		
Unrestricted	3,133,629	2,265,291
Restricted, net of US$255,550 in 1978 and US$66,000 in 1977 payable to donors	2,479,319	2,124,067
	5,612,948	4,389,358
Special projects grants, net of US$25,139 paid to donors in 1978	598,968	468,417
Capital grants	412,514	1,168,405
Working funds grants	-	22,000
Other income, net	195,430	279,062
	6,819,860	6,327,242
APPLICATION OF FUNDS:		
Operating costs -		
Core program:		
Potato research program	1,599,028	1,241,466
Research support	453,881	292,017
Regional research and training	1,611,061	1,341,638
Library, documentation and information service	174,133	198,151
General administration	486,990	451,375
General operating costs	640,193	683,477
Quinquennial review and five year celebration	-	98,903
	4,965,286	4,307,027
Special projects	442,080	330,922
	5,407,366	4,637,949
Capital -		
Additions to fixed assets	412,514	1,226,688
Working funds	126,000	22,000
	538,514	1,248,688
	5,945,880	5,886,637
UNEXPENDED FUNDS	873,980	440,605

The accompanying notes to the financial statements are an integral part of this statement.

COLERIDGE Y ASOCIADOS

THE INTERNATIONAL POTATO CENTER - CIP

NOTES TO FINANCIAL STATEMENTS

AS OF DECEMBER 31, 1978 AND 1977

(Translated from the Spanish language)

1. SUMMARY OF SIGNIFICANT ACCOUNTING PRINCIPLES AND PRACTICES

The CIP follows accounting principles and practices established by the Consultative Group on International Agriculture Research and similar non-profit organizations, which are summarized below:

a. The transactions are principally in U.S. dollars and the accounts are maintained in such currency, on an accrual basis. The balances representing cash and amounts owed by or to CIP that are denominated in currencies other than the U.S. dollar are adjusted to reflect the applicable current exchange rates at the balance sheet date. Exchange gains and losses are included in determining the source and application of funds for the period in which the exchange rates fluctuate.

b. Inventories of laboratory and other supplies are reported at estimated prices, which approximate the cost determined on a first-in, first-out basis.

   The fixed assets for sale included in inventories, are valued at acquisition cost.

c. Fixed assets are recorded at cost. No depreciation is accounted for in accordance with accepted accounting practices for non-profit entities. Retirements are charged fully to fixed assets capital account. Maintenance and repairs are reported as application of funds, as incurred.

d. In accordance with the Consultative Group on International Agriculture Research instructions, the unexpended balances for core operations at year-end are carried forward to the following period, except when prior arrangements to reimburse the amounts unexpended exist; in such cases the unexpended funds are reported as liabilities.

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Capital grants and special project grants unexpended at year-end are carried forward to the following period. Part of the operating grants and/or other income are used as working funds, according to the Consultative Group instructions.

2. AGREEMENT BETWEEN THE GOVERNMENT OF PERU AND NORTH CAROLINA STATE UNIVERSITY

The CIP was constituted on June 13, 1972, in accordance with an Agreement for Scientific Cooperation between the Government of Perú and the North Carolina State University signed on January 20, 1971. A summary of the significant provisions of the agreement follows:

a. The objective is to establish through common or cooperative efforts a non-profit organization of a scientific nature, dedicated to research and improvement of potatoes and tuberous roots and also to train people.

b. The CIP is a tax exempt entity established in Perú. Exemption includes income tax.

c. Non-Peruvian scientists working for the CIP are also tax exempt.

d. The agreement will be in effect for twenty years and will expire on January 20, 1991. This period may be extended.

e. If for any reason the existence of the CIP is terminated, the land, buildings, equipment, vehicles and other assets of the CIP are to be transferred to the Peruvian Government at no cost.

f. 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.

3. FIXED ASSETS

The acquisitions of fixed assets in transit at the balance sheet date are shown in the balance sheet and amount to US$98,850 (US$129,795 in 1977).

COLERIDGE Y ASOCIADOS

4. CONTINGENCIES

The CIP has filed a lawsuit against the constructor of its buildings, which is in process at December 31, 1978. The constructor, on the other hand, claims a payment of Peruvian soles 2,664,000 (US$13,639) from CIP, in excess of the amount recognized by CIP to settle its pending liability with the constructor. In addition, the latter is claiming the reimbursement of certain costs, which amount has not yet been defined.

In management's opinion as soon as judgement is pronounced the CIP will proceed to liquidate all items pending with the constructor which are not expected to result in any significant additional liability.

5. INCOME TAX

The CIP as a tax exempt non-profit organization, is registered in the Registro de Entidades Exoneradas of the Dirección General de Contribuciones. Registration should be renewed every three years. The CIP is at present renewing it.

COLERIDGE Y ASOCIADOS

SUPPLEMENTARY INFORMATION

EXHIBIT 1

THE INTERNATIONAL POTATO CENTER - CIP

ACCOUNTS RECEIVABLE FROM DONORS

AS OF DECEMBER 31, 1978

(Stated in U.S. dollars)

(Translated from the Spanish language)

Swiss Development Cooperation, Switzerland	75,000
Overseas Development Ministry, The United Kingdom	79,550
International Development Agency, Canada	49,800
International Technical Assistance, The Netherlands	94,040
	298,390

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EXHIBIT 2

THE INTERNATIONAL POTATO CENTER - CIP

FIXED ASSETS

FOR THE YEAR ENDED DECEMBER 31, 1978

(Stated in U.S. dollars)

(Translated from the Spanish language)

	Balances as of January 1, 1978	Additions	Replacements		Balances as of December 31, 1978
			Additions	Retirements	
Buildings and constructions in progress	1,359,842	107,250	-	-	1,467,092
Research equipment	497,555	57,271	-	-	554,826
Vehicles	503,938	79,827	77,268	48,862	612,171
Furniture, fixture and office equipment	276,912	53,768	8,137	12,339	326,478
Operating equipment	80,646	5,998	-	-	86,644
Installation and Site Development	558,582	78,841	2,163	8,068	631,518
Other	65,714	29,559	100	646	94,727
	3,343,189	412,514	87,668	69,915	3,773,456

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THE INTERNATIONAL POTATO CENTER - CIP

DETAIL OF SOURCE OF FUNDS

FOR THE YEAR ENDED DECEMBER 31, 1978

(Stated in U.S. dollars)

(Translated from the Spanish language)

CORE OPERATING GRANTS:		
Multi-purpose -		
Danish International Development Agency, Denmark	317,787	
Swiss Development Cooperation, Switzerland	200,000	
International Technical Assistance, The Netherlands	275,000	
	792,787	
Less:		
Applied to capital	105,892	
	686,895	
Core unrestricted grants -		
Swedish Agency for Research Cooperation	641,568	
Overseas Development Ministry, The United Kingdom	430,757	
International Development Agency, Canada	525,000	
Federal Germany Government	584,974	
Belgium Government	66,324	
	2,248,623	
Plus:		
Balance from previous years	198,111	
	2,446,734	3,133,629
Core restricted -		
Agency for International Development	1,600,000	
Australian Development Assistance Bureau	201,140	
Federal Germany Government	163,693	
Interamerican Development Bank	600,000	
Belgium Government	147,661	
	2,712,494	
Plus:		
Balance from previous years	22,375	
	2,734,869	
Less:		
Payable to Agency for International Development	255,550	2,479,319
		5,612,948

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THE INTERNATIONAL POTATO CENTER - CIP

DETAIL OF SOURCE OF FUNDS

FOR THE YEAR ENDED DECEMBER 31, 1978

(Stated in U.S. dollars)

(Translated from the Spanish language)

SPECIAL PROJECTS GRANTS:		
International Technical Assistance, The Netherlands	94,040	
Swiss Development Cooperation, Switzerland	178,500	
International Development Agency, Canada	49,800	
International Development Research Center	92,795	
Refrigeration Research Foundation	2,500	
Balance from prior years -		
Ford Foundation	2,739	
Federal Germany Government-Training and Socio Economics	4,773	
Interamerican Development Bank	43,868	
International Technical Assistance, The Netherlands	24,935	
Swiss Development Cooperation, Switzerland	37,252	
International Development Agency, Canada	26,766	
Ford Foundation, Training and Research in Colombia and Ecuador	41,000	598,968
CAPITAL GRANTS:		
Belgium Government	51,310	
International Development Association	150,000	
Interamerican Development Bank	100,000	
Transferred from multi-purpose funds	105,892	
	407,202	
Plus:		
Balance from previous years	5,312	412,514
OTHER INCOME, net		195,430
		6,819,860

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EXHIBIT 4

THE INTERNATIONAL POTATO CENTER - CIP

SPECIAL PROJECTS FUNDS PROVIDED AND COST

FOR THE YEAR ENDED DECEMBER 31, 1978

(Stated in U.S. dollars)

(Translated from the Spanish language)

	Funds provided	Disbursements: Prior years	Disbursements: This year	Disbursements: Total accumulated	Returns	Balance to date
Ford Foundation	127,300	124,561	134	124,695	-	2,605
Federal Germany Government	58,710	53,937	3,700	57,637	-	1,073
International Technical Assistance, The Netherlands	282,040	163,065	107,383	270,448	-	11,592
Swiss Development Cooperation, Switzerland	187,500	75,248	145,449	220,697	-	(33,197)
International Development Agency, Canada	167,671	91,105	39,483	130,588	-	37,083
Interamerican Development Bank	568,664	499,657	43,623	543,280	(25,139)	245
Ford Foundation	41,000	-	17,401	17,401	-	23,599
Refrigeration Research Foundation	2,500	-	2,310	2,310	-	190
International Development Research Center	92,795	-	82,597	82,597	-	10,198
Swiss Development Cooperation, Switzerland (PRECODEPA)	103,500	-	-	-	-	103,500
	1,631,680	1,007,573	442,080	1,449,653	(25,139)	156,888

COLERIDGE Y ASOCIADOS

THE INTERNATIONAL POTATO CENTER
Schedule 1: FUNDS PROVIDED AND COSTS
For the year ended December 31, 1978
(Expressed in thousand of U.S. dollars)

	Total Funds Available	PROGRAM COSTS						% of Gral. Adm. & Operat. to Direct	Unexpended-Balance	Payable to Donors
		Fixed Assets	Total Research	Reg.Res. & Training	Library Doc. & Inf.	General Administ.	General Operating			
Unrestricted Core	(1) 3,207.3		1,146.1	789.1	49.7	296.3	368.1	33	558.0	
Restricted Core										
USAID	1,600.0		555.9	436.3	47.1	131.8	173.4	29	-	255.5
ADAA	201.1		30.0	149.5					21.6	
Federal Germany	167.6			113.0			13.6	12	41.0	
IDB	600.0		309.2	77.3	77.3	58.9	77.3	29	-	
Belgium	150.6			44.6			6.2	14	99.8	
IDRC	11.3		11.7	1.3			1.6	15	(3.3)	
	2,730.6		906.8	822.0	124.4	190.7	272.1		159.1	255.5
Total Operating	5,937.9		2,052.9	1,611.1	174.1	487.0	640.2		717.1	255.5
Capital Grants										
IBRD/IDA	150.0	150.0							-	
IDB	100.0	100.0							-	
Belgium	51.3	51.3								
Unidentified Sources (multi-purpose)	105.9	105.9								
Balance from previous year	5.3	5.3								
Total Capital	412.5	412.5							-	
Special Projects										
Ford Foundation	2.7			.1					2.6	
Federal Germany	4.8			3.7					1.1	
Netherlands	119.0			107.4					11.6	
Swiss Development Cooperation	112.2			145.4					(33.2)	
CIDA	76.6			39.5					37.1	
IDB	69.0			43.6					.3	25.1
Ford Foundation	41.0			17.4					23.6	
Refrigeration Research Foundation	2.5			2.3					.2	
Int. Development Research Centre	92.8			82.6					10.2	
Swiss Development Cooperation	103.5			-					103.5	
Total Special Projects	624.1			442.0					157.0	25.1
Working Funds										
Earned Income	126.0								126.0	
Total Funds and Costs	7,100.5	412.5	2,052.9	2,053.1	174.1	487.0	640.2		1,000.1	280.6

(1) Includes $69,430 from earned income and $4,300 from 1977 unexpended restricted balance reclassified.

THE INTERNATIONAL POTATO CENTER

Schedule 2: EARNED INCOME AND APPLICATIONS

For the year ended December 31, 1978

(Expressed in thousand of U.S. dollars)

	Approved Budget	Actual
Sources of Earned Income		
Interests on Deposits	10.0	78.3
Sale of Crops & Materials	2.0	3.7
Sale of Fixed Assets	19.0	13.8
Indirect Costs charges on Special Projects & Current Accounts	59.0	65.6
Adjustment prior year	5.0	10.8
Rate of Exchange adjustment	20.0	23.5
Other	4.0	2.9
Sub-Total	119.0	198.6
Less: Auxiliary Services Deficit	(10.0)	(3.2)
TOTAL	109.0	195.4
Application of Earned Income		
Applied to Core Operations	82.0	69.4
Applied to Capital	27.0	-
Applied to Working Fund	-	126.0
Total	109.0	195.4

THE INTERNATIONAL POTATO CENTER

Schedule 3: COMPARATIVE STATEMENT OF ACTUAL EXPENSES
AND APPROVED BUDGET FOR THE YEAR ENDED DECEMBER 31, 1978
(Expressed in thousand of U.S. dollars)

	Operating Unrestricted		Operating Restricted		Capital	
	Budget	Actual	Budget	Actual	Budget	Actual
Programs						
Potato Research		1,146.1		906.8		
Regional Research & Training		789.1		822.0		
Library, Doc. & Infa. Services		49.7		124.4		
General Administration		296.3		190.7		
General Operating Costs		368.1		272.1		
Contingencies		-		-		
	3,077.7	2,649.3	2,730.6	2,316.0		
Capital						
Operating Equipment					20.5	6.0
Research Equipment					39.7	57.3
Installation & Utilities					24.0	71.7
Furnitures, Fixtures & Off. Equip.					44.1	53.8
Vehicles & Aircraft					50.0	79.8
Constructions & Buildings					111.6	107.2
Site Development					13.0	7.1
Communication Equipment					29.4	29.6
					332.3	412.5
Analysis of Variances						
Budget Surplus:						
- Budgeted surpluses	103.0					
- Unbudgeted Additional Income	26.6					
- Payable to Donors				255.5		
- Unexpended balance		558.0		159.1		
Deficits:						
- Reclassification from Core Operating Restricted to Capital					51.3	
- Unbudgeted Additional Income					28.9	
TOTAL BUDGET VS. EXPENSES AND APPLICATION OF VARIANCES	3,207.3	3,207.3	2,730.6	2,730.6	412.5	412.5

(COVERS... from inside front cover)

"Curiosity and enthusiasm for the beauty and variety of nature in forms and colors singular and perishable, led me to keeping them fixed in a painting just to make the pleasure more durable," says Frey. He is an amateur painter and has had no specific art training. He adds that time for such pleasure was always scarce because of other professional duties as a scientist in CIP's Thrust III, "Control of Important Fungal Diseases of Potatoes." It takes from a half to a full day for Frey to complete one of the paintings.

Birds were his first main painting subjects before he was associated with the International Potato Center. "Soon," he explains, "the wild potato collection drew my attention and Carlos Ochoa encouraged me to try some illustrations." The original painting of the new species, on the front cover, is to be presented to its discoverer.

Frey, a graduate of the University of Bonn, Germany, was with the German Technical Assistance program in Perú from 1973 through 1976. He has been with CIP since 1977. He will return to Germany in March 1979, "but will stay in contact with international technical assistance."

He and Ochoa plan to continue to add illustrations to the descriptions of newly-found wild potato species from South America.

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