BIBLIOGRAPHIC DATA SHEET

1. CONTROL NUMBER PN-AAN-957

2. SUBJECT CLASSIFICATION (695)
AF00-0200-0000

3. TITLE AND SUBTITLE (240)
Annual report, 1979

4. PERSONAL AUTHORS (100)

5. CORPORATE AUTHORS (101)
CIP

6. DOCUMENT DATE (110)
1980

7. NUMBER OF PAGES (120)
147p.

8. ARC NUMBER (170)
633.491.I61a - 1979

9. REFERENCE ORGANIZATION (130)
CIP

10. SUPPLEMENTARY NOTES (500)
(Research summary)

11. ABSTRACT (950)

12. DESCRIPTORS (920)
Potatoes
Yield

13. PROJECT NUMBER (150)
931097300

14. CONTRACT NO.(140)
AID/ta-G-1181

15. CONTRACT TYPE (140)
GTS

16. TYPE OF DOCUMENT (160)
52

AID 590-7 (10-79)

633.491
I61a
1979

PN-AAH-951

ANNUAL REPORT 1979

International Potato Center
Lima,
Peru

COVER PHOTO

Potatoes can be grown by either planting tubers or by planting "true" (botanical) seed, both shown in the comparison photograph on the cover.

Traditionally potatoes are grown by planting a tuber "seed." Few people are aware that potatoes also produce true seed in a small tomato-like berry growing on the plant above ground.

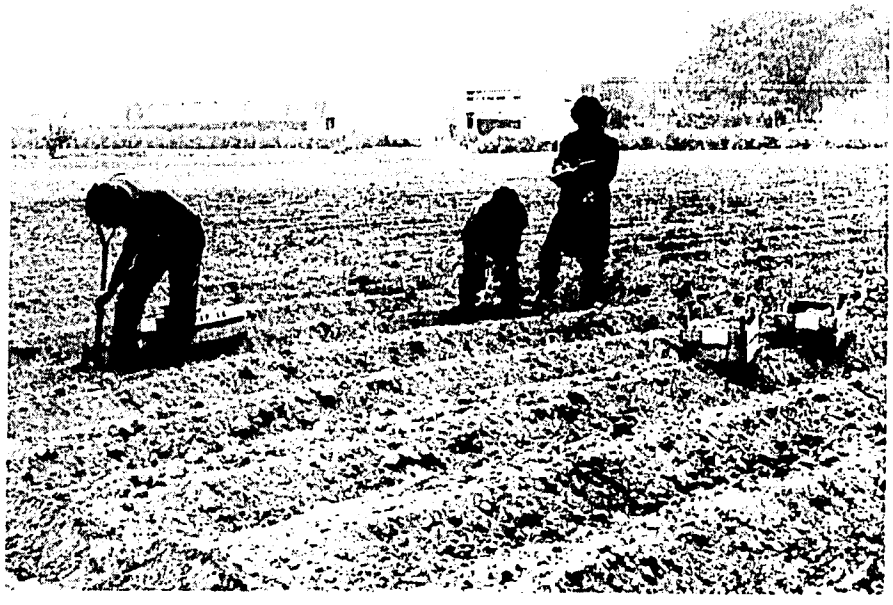
Wild potatoes usually perpetuate their kind by sexual propagation involving true seed. Cultivated potatoes are usually propagated vegetatively by planting a tuber. Vegetative propagation ensures purity of variety through cloning in which tubers of a variety produce plants and more tubers of the same variety.

True seed results from pollination of a potato flower followed by fertilization and production of a fruit containing up to several hundred seeds. Although these seeds genetically are not exactly the same, it is possible to select parental material to produce seed and plants that are relatively uniform.

Small scale farmers in developing countries face several potential problems in planting seed tubers. The major cost of producing potatoes under developing country conditions is the high price of seed tubers. This may exceed 60 percent of the total production cost.

(concluded, inside back cover)

ANNUAL REPORT 1979



Potato experiments adjacent to
CIP Headquarters.

The
International Potato Center
Apartado Postal 5969
Lima – Peru

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This is the eighth annual report published by the International Potato Center. Printed for worldwide distribution, the report covers the period of calendar 1979.

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, 1979. CIP Annual Report, 1979, Lima, Peru.

Entire production of this annual report was by CIP personnel using CIP facilities. Date of distribution: July 1, 1980 (English edition).

Director General's Report

International Centers of the CGIAR network are major crossroads for the international scientific world. The institutes provide a continuing meeting place for scientific exchange and collaboration in projects of mutual interest despite differences that may exist in political ideologies. The emergence of a peaceful world and combined efforts for food production depends to a great extent on the preservation and expansion of such crossroads.

Most of the senior scientists and administrators within the CGIAR Centers have to play dual roles. They have first to be competent, capable scientists with an international reputation in their field. Secondly, they must be astute diplomats with the ability to negotiate with senior ministry officials from widely different political backgrounds about agricultural development. Center scientists must have the ability to move through political differences without intervention in these matters or any hindrance to the objectives of the Center.

During the writing of this annual report there have been teams of senior scientists from both the Soviet Union and the People's Republic of China at CIP. During a social function at CIP which was attended by both groups, one of the scientists stated that CIP was not just a Center of expertise for developing countries but for the whole world.

The International Planning Conferences on each major phase of research activities are examples of the scientific exchanges that have taken place at CIP since its initiation. During the past 8 years 193 senior scientists from 31 countries have helped CIP develop 5-year plans for on-going projects, and collaborative efforts with other institutions. The latest planning conference was in the Philippines in September of 1979 on "Potato Production from True Seed." Scientists interested in and working on this subject participated from CIP, the People's Republic of China, Sri Lanka, South Korea, the Philippines, India, New Zealand, the Netherlands, Great Britain and the United States. Such exchanges and involvement of national scientists in common collaborative research must certainly be of some value in a world so widely fragmented at the political level.

The flow of relevant research continues to increase in volume from the CGIAR Centers. Many centers are much younger than CIP and have yet to reach their full productive capacity. Examples of the exciting advances at CIP are contained throughout the 1979 report and include research with true seed; the recovery of 16 wild

species in the living state which were previously only in herbarium collections; the rapid spread of tuber seed storage technology; the identification of biological field control of root-knot nematode, and the steady systematic day-to-day progress in a wide range of research such as antisera for potato spindle tuber virus, increasing viability of true seed and improvement in rapid and accurate seedling screening in breeding programs.

There must be a marked increase during the 1980's in the investment in national research programs and the development of national agricultural research and extension capabilities if the excellent relevant research coming from CIP and the other CGIAR Centers is to be utilized by developing countries. There is a general unawareness by recipients of Center technology of the restrictions imposed by funding that prevent the Centers from working directly in growers fields except in the few cases necessary to test material and make sure that the research results are relevant to the needs.

Indicative of this unawareness was a recent local news article castigating three Centers, IRRI, CIMMYT and CIP, for not moving more rapidly into growers fields and for not directly providing growers with the new varieties having superior resistance, adaptation, quality and yield. Most of the CGIAR Center advances involve better breeding material that must move through national seed multiplication schemes before any impact can be made on production. But the Centers cannot possibly move into seed production operations for growers in countries where this capacity is needed. This can only be done by national institutions with good seed producing capabilities.

During the 1970's, the Centers have developed new technology far faster than national programs have developed the ability to absorb it. These two segments must be brought into better balance during the decade of the 1980's.

Hopefully, the governments of developing countries and their interested bilateral agencies will stimulate the required investment in agriculture in the 1980's to permit the exciting relevant research coming from the International Centers to move through national programs into growers fields and make major advancements in agriculture. The CGIAR Centers were never meant to replace national programs. The emergence of national programs with the capability of receiving, testing, adapting and distributing Center results to the growers in their respective countries is essential if Centers are to have the impact on agriculture which is expected and to play the role in research production for which they were designed.

Richard L. Sawyer
Director General
International Potato Center

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Director General Honored

Director General Richard L. Sawyer was honored by the Peruvian government and by his alma mater, the University of Maine, during 1979.

General Carlos Gamarra, Peruvian Minister of Agriculture and Food, "in view of the great services rendered to the agriculture of Peru and the world," conferred upon Dr. Sawyer in the name of the President of the Republic the Order of Agricultural Merit, in the Degree of Knight.

Referring to Dr. Sawyer, General Gamarra said upon conferring the award, that CIP's director general displays great dedication in favor of humanity to make the potato available to the whole world. "Who can fail to be grateful to CIP for what it is doing not only for us, but for the entire world?" the Minister added. He made the award in December as Peru's recognition, in the person of the director general, of the important role CIP is playing.

The University of Maine at Orono in May honored Dr. Sawyer, a 1949 graduate in agronomy, with a Doctor of Science degree. The citation stated in part: "Your alma mater honors you today not only for your notable scientific accomplishments, but more importantly, for your dedication to improving human conditions throughout the world."

The Peruvian Minister of Agriculture conferring the Order of Agricultural Merit upon Dr. Sawyer, director general of CIP. Mrs. Sawyer is at the director's right.

New Experimental Land Area

During 1979 the Ministry of Agriculture and Nutrition transferred certain field research activities of its Centro de Investigación Agraria del Centro (CIAG-C), La Molina, to a new site This transfer made land available immediately adjacent to the headquarters facilities of the International Potato Center. A formal request, Oficio N° L-637-CIP-79, August 17, 1979, by CIP for a parcel of this land for research use, was favorably considered and 15 hectares were granted by Ministerial Resolution N° 01497-79, November 19, 1979. On December 17, 1979, CIP formally acknowledged acceptance of the land graciously ceded by the Instituto Nacional de Investigación Agraria (INIA).

The land consists of four fields ranging in area from 2 1/2 to 5 1/2 hectares. The terrain is generally level with a well established surface irrigation and drainage system. The soil is a medium sandy loam, generally free of stones, average pH 7.4, and somewhat deficient in magnesium. The altitude of the area ranges from 241 meters above mean sea level adjacent to the headquarters buildings dropping to 231 meters in the vicinity of Las Hormigas.

CIP Donors 1979

In 1972 only three donors were listed as contributing to the financial support of the International Potato Center. The donor list for 1979 is as follows:

	Core	Special Project
Australian Development Assistance Bureau	X	
Danish International Development Agency (DANIDA)	X	
Swiss Development Cooperation and Humanitarian Aid	X	X
Netherlands Government	X	X
Belgium Government	X	
Swedish Agency for Research Cooperation with Developing Countries (SAREC)	X	
United Kingdom Overseas Development Administration	X	
Canadian International Development Agency (CIDA)	X	X
International Development Research Centre (IDRC)	X	X
Federal German Government	X	X
United States Agency for International Development (USAID)	X	
Inter-American Development Bank (IDB)	X	
Rockefeller Foundation	X	
Ford Foundation		X
W. K. Kellogg Foundation		X
European Economic Community	X	
French Government	X	

Thrusts ...

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

CIP Research Summary

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

With the exception of a few remote areas to be explored in Chile, Colombia and Mexico, the collection of primitive cultivated potatoes is essentially complete. Attention is now being focused on collecting wild tuber-bearing species of *Solanum*. Of the 54 wild species known to exist only as pressed specimens in world herbaria, 16 have now been collected in the living state. In addition to the new, recently discovered species *S. subpanduratum* Ochoa, another new species, *S. garcia-barrigae* Ochoa, has been identified in Colombian herbarium material. A still unnamed hexaploid wild species found in Ecuador is of importance from both a taxonomic and genetic viewpoint.

A Planning Conference on "Exploration, Taxonomy and Maintenance of Potato Germ Plasm" held in October, 1979, assigned high priority to exploring specific areas for species with a very restricted range or not known to exist in the living state.

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

During 1979 a total of 8,216 accessions of primitive cultivated potatoes were maintained for evaluation of various field attributes including disease and pest resistances and the identification of duplicates. Open-pollinated seed of 5,000 accessions, including duplicate accessions, were collected and placed in safe storage.

The world potato collection is the source of genes for resistance to physical environmental stress and diseases and pests. Through rigorous selection of assemblages of genes, genetic families are identified and by recurrent selection and screening for specific resistances desired genetic characters are concentrated and recombined. During the past year nearly 2,800 hybrid families, some with as many as four specific resistances were identified. Noteworthy advances continue to be made in the development of combined frost and late blight resistant clones for the Andean region, Pakistan, Nepal and Ethiopia. Other advances in disease resistance and tolerance to heat stress are cited.

Preliminary successes in the production of true seed indicate that a single hectare of potatoes can yield sufficient fruit to provide seed for up to 1,300 hectares.

Thrust III — Control of Important Fungal Diseases of Potatoes

Emphasis continued to be placed on screening for resistance to late blight and for the distribution of advanced blight-resistant clones for field trials in selected countries. Traditional late blight trials in Mexico were discontinued in favor of more convenient trials at Peruvian sites. Residual clones with R-genes resistance continued to be eliminated. A final report on contract research in Sweden on late blight is summarized. A set of three varieties to index field resistance is proposed.

Research on wart resistance indicates that there is sufficient resistance to any one race or race combinations of the organism causing wart to directly select in the field for resistance from otherwise adapted clones. The status of research of several other important fungal pathogens is outlined.

Thrust IV — Control of Important Bacterial Diseases of Potatoes

Wilting caused by *Pseudomonas solanacearum* is the most important bacterial field disease of potatoes in the tropics; Erwinias and clostridia rots are of secondary importance. Bacterial wilt-resistant clones developed through CIP-University of Wisconsin research: Molinera, Sirena, MS 35-22, and other selected MS and BR clones, are being grown where wilt is a problem in several developing countries. Screening trials for additional improved resistance under high temperatures are continuing. During 3 years study, cropping practices previous to planting potatoes had little influence on subsequent reduction of wilt. Resistance to *Erwinia chrysanthemi* is reported.

Host defense mechanisms against wilt, improved culture media to assay wilt bacteria in soil as well as an antisera for race 3, inoculation studies, and assays of the prevalance of Erwinias and clostridia in cold storage were among research activities under contract at the University of Wisconsin.

Thrust V — Control of Important Virus Diseases of Potatoes

During the year improved techniques were developed to screen seedlings for resistance to potato leaf roll virus (PLRV), X and Y viruses (PVX and PVY) and potato spindle tuber viroid (PSTV). Additional sources of resistance were identified and combined PVX and PVY clones were developed. Strains of PVY, the Andean potato latent virus, a calico type virus and P78 were further characterized. Nearly 6,000 tests were made to ensure freedom from PSTV in selected clones for breeding and distribution.

Studies to develop a serological type test for PSTV based on the presence of an aberrant protein in infected plants were initiated. Antibody sensitized latex (ASL) was distributed to national programs. The sensitivity of ASL in detection of a range of viruses was evaluated.

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

In the development of clones resistant to the various races of *Globodera* spp., the potato cyst nematodes, major emphasis is being placed on continuing to improve field screening. Results of some 1979 trials are presented in which encouraging sources of multi-race resistance are reported. Approximately 35 percent — a ten-fold increase in clones resistant or immune to *Meloidogyne* sp., the root-knot nematode — were identified at the end of the fourth cycle of recurrent selection commencing with an initial population of 11,000 genotypes. Yield trials were carried out with 76 clones having combined resistance to root-knot nematode and bacterial wilt.

A fungus has been found that parasitizes eggs of the root-knot nematode. Under field conditions up to 70 percent reduction in number of egg masses and root galls have been obtained when tubers were treated with fungus spores before planting.

A simple rapid screening technique has been developed to identify clones resistant to tuber moth, a serious field and storage insect in the tropics. Research is continuing on selecting and testing plants having high densities of sticky glandular hairs effective in trapping and suppressing populations of aphids, leafhoppers thrips, mites and flea beetles. Five of 72 wild species of potatoes were identified with high densities of lobed glandular hairs.

Thrust VII — Physiological and Agronomic Management of Potatoes Adapted to Environmental Stress

The development of techniques for field management of potatoes from true seed (in contrast to planting seed tubers) was emphasized during 1979. Weed competition, soil crusting and maintaining optimum moisture for field germination and growth are the principal constraints observed in direct field planting of true seed. A simple applicator for insertion into the soil of pre-germinated seed in a peat plug resulted in acceptable plant stands under high temperature conditions. To the present, transplanting from nursery to the field minimizes problems encountered in direct seeding.

A promising method for seedling screening based on early tuberization under high temperatures (38°C) as an index of heat tolerance is being evaluated in the field. In another procedure wherein seedlings are exposed to a dark-respiration interval resulted in the selection of more vigorous plants when grown under high jungle conditions. Research involving assay of endogenous gibberelic acid in heat adapted and non-adapted clones indicate lower GA activity in the roots of adapted clones possibly due to GA inactivation by the root system of these clones.

Certain species of potatoes such as *Solanum acaule* and *S. commersonii* can be gradually cold acclimated to withstand − 9°C while the common temperate zone potato, *S. tuberosum* cannot be cold acclimated to below -3°C.

Thrust VIII — Development of Storage and Processing Technology

Practical, small-scale, inexpensive, diffused light structures suitable for storing seed tubers for 4 to 5 months under hot conditions (25°C) have been developed and are under trial in nine developing countries. Seed tubers stored in diffuse light gave yields comparable to seed lots stored under refrigerated conditions at 4°C. In the Philippines at least 40 farmers have applied the technology. Research on diffused light and ventilated clamp storages is reported.

Simple, low cost equipment for peeling, cutting, cooking and drying have been developed over a period of several years to provide a straight-through flow of potatoes from storage to driers. The technology has been demonstrated at field days in the production of "papa seca" and potato starch

The Social Science Department has been involved in the research, development and transfer of the storage and processing technology.

Thrust IX — Seed Production Research for Developing Countries

Development of techniques for rapid propagation of pathogen-tested seed for distribution to national programs and research on the germination of true seed were the principal activities of the Thrust during the year. Eleven thousand plantlets were produced in culture for clean seed propagation from 63 disease-tested clones maintained in vitro. In addition, cultures of 90 PSTV-tested clones routinely used for breeding were placed in long-term in vitro storage. Cold therapy studies to eradicate PSTV continued in order to further verify the technique. Other tissue culture research included evaluating media for plant regeneration from callus and assessing the sensitivity of nodal segments to low pH and salt tolerance. Modifications in techniques used to propagate leaf-node cuttings were also evaluated during the year.

Temperatures above 25°C inhibited germination of true seed but the effect was reversible following transfer to 20°C. Dry seed did not lose germinability after 1 hour exposure at 70°C or 4 hours at 65°C when subsequently tested for germination at 20°C. Synchronization of germination and seedling vigor improved following soaking seed in a two-salt solution.

Thrust I

Collection and Classification of Tuber-Bearing *Solanums*

Gradual extinction of wild tuber-bearing *Solanum* species through encroachment into their habitat by man and domestic animals poses a serious threat to the future of this valuable genetic resource. Because of this genetic erosion, habitats to be explored for rare wild potatoes species are chosen in accordance with priorities assigned by experts at Planning Conferences sponsored by CIP. The third Planning Conference on "Exploration, Taxonomy and Maintenance of Potato Germ Plasm," in October 1979, designated six countries with areas in the "emergency" or "high priority" categories according to FAO classification of endangered species.

Encouraging is that 16 of 54 species, reported at the 1976 Planning Conference as existing only as pressed specimens in world herbaria, have now been rediscovered in the living state and added to CIP's germ plasm collection (Table I-1). A summary of the wild *Solanum* accessions collected to date is in Table I-2. According to a recent revision of the genus *Solanum*, Hawkes recognizes 154 wild species and 8 cultivated species grouped into 18 series.

Table I-1. Summary of wild *Solanum* species previously known only as herbaria specimens and now recovered in the living state. For some species the chromosome number has been determined.

Series	Species	2n	Country
Junglandifolia	*S. rickii*	–	Chile
Circaefolia	*S. circaefolium*	24	Bolivia
Conicibaccata	*S. albornozii*	–	Ecuador
Piurana	*S. paucissectum*	24	Peru
	S. solisii	48	Ecuador
Megistacrolobum	*S. dolichocremastrum*	–	Peru
	S. hastiforme	–	Peru
Tuberosa	*S. abancayense*	–	Peru
	S. alandiae	24	Bolivia
	S. humectophilum	24	Peru
	S. minutifoliolum	–	Peru
	S. neoweberbaueri	36	Peru
	S. orophilum	–	Peru
	S. paramoense	48	Venezuela
	S. rhomboideilanceolatum	24	Peru
	S. velardeii	24	Peru

Collecting expeditions into remote Andean areas require considerable advanced planning to ensure appropriate transportation by vehicle and pack animals and local assistance in carrying out the objectives of the expedition. CIP recognizes and sincerely appreciates the excellent cooperation by Ministry and Institutional personnel in countries where recent explorations have been made.

Some of the new or interesting wild species of potatoes recently discovered deserve specific mention. The tetraploid species, *S. paromoense* Bitt., has been rediscovered in its type locality of Tovar, Venezuela, where it was last reported 130 years ago. During the same expedition a new wild tetraploid species, *S. subpanduratum* Ochoa, was discovered for the first time. The CIP collection now contains three of the six wild *Solanum* species known to exist in Venezuela.

No collecting expeditions into Colombia were made during the year. However, a new species, *S. garcia-barrigae* Ochoa, was described from herbarium material in the Instituto de Ciencias Naturales de Colombia in Bogotá.

An expedition covering most of the important habitats of wild species in the Andean region of Ecuador resulted in collection of a new wild species with a 2n = 6x = 72 chromosome content. This species still to be named, is important from both a taxonomic and genetic viewpoint and for its implications for breeding programs. The species, *S. solisii* Hawkes, a very rare tetraploid, has been added to the CIP collection as well as *S. albornozii*, *S. suffrutescens*, *S. paucijugum*, *S. minutifolium* and *S. columbianum*.

The wild potatoes of Peru include more than 60 species grouped into nine series all in the Section Petota (= Tuberarium). A total of more than 400 samples of wild potatoes have been collected in Peru. In some fairly accessible areas in northern Peru it has not been possible to locate *S. olmosense*, *S. rachialatum*, *S. contumazaense*, *S. trinitense* and *S. scabrifolium* originally found some 15 years ago. Because some of these species have a very restricted range it will be necessary to make careful spot searches in an attempt to locate them. The recent finding of *S. humectophilum* required several trips and intensive search in virgin forest in the Amazon basin. Occasionally, as for the very rare species *S. ingaefolium*, the single clone collected has been in tuber form. As it is diploid and self-sterile

Table I-2. Summary of wild *Solanum* accessions, their country of origin and species classified.

Country	Total No. of accessions			No.
		Det.	Undet.	Species
Bolivia	130	80	50	16
Chile	49	15	34	4
Ecuador	45	28	17	7
Peru	401	200	201	34
Venezuela	11	6	5	3
	636	329	307	64

it has not been possible to obtain true seed.

Bolivia was assigned a high priority because of extensive erosion of its wild endemic species. An area between 15° to 20° South latitude was explored from the vicinity of Lake Titicaca to the area around Bermejo and Tarija near the province of Salta, Argentina. Among the 130 samples of wild potatoes collected, *S. circaefolium* Bitt. and *S. clandiae* Card., two rare diploid species, were recovered again in the living state. After a period of 70 years, *S. acaule* Bitt. and *S. megistacrolobum* Bitt. were collected in their type locality, Puna, Patanca. Although nearly 50 endemic species have been described for Bolivia, it is probable that a number of species are synonyms except for the following 10 species: *S. capsicibaccatum*, *S. circaefolium*, *S. yungasense*, *S. violaceimarmoratum*, *S. alandiae*, *S.* x *berthaultii*, *S. brevicaule*, *S. candolleanum*, *S. gandarillasii* and *S.* x *dodsii*.

An expedition to Chile during late 1978 and early 1979 collected specimens in the region of Valparaíso and Concón, the Island of Juan Fernández, Island La Mocha, the Archipiélago de Los Chonos and north of the Atacama desert. Noteworthy was the collecting of *S. maglia* between Valparaíso and Concón and *S. fernandezianum*, the only native species on the Island of Juan Fernández. The very rare species, *S. rickii* Correll, previously unknown in any living collection, was found in the highlands of Calama and Chuquicamata in the province of Antofagasta.

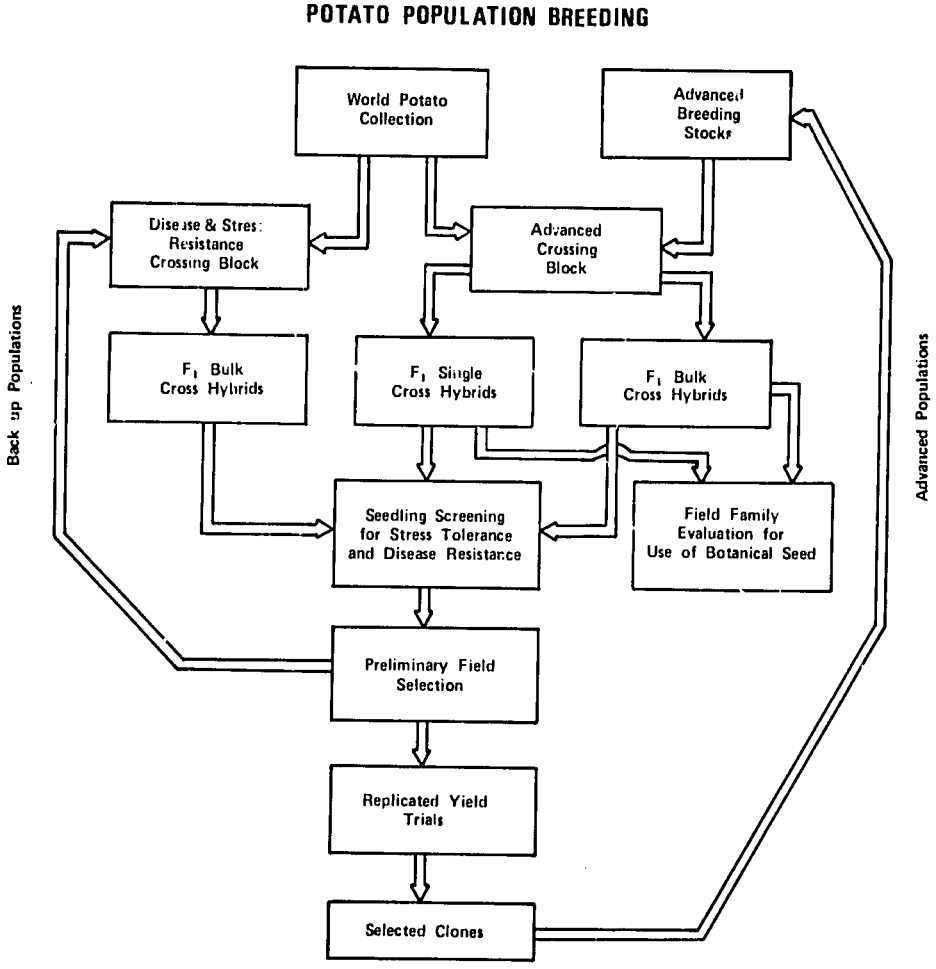


Figure II-1 — Potato population breeding flow chart (Thrust II).

Thrust II

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

Seven interacting projects of this Thrust are oriented to use the wide genetic variability of the genus *Solanum* and make it available to developing country programs as advanced clones and populations.

The population breeding approach at CIP contrasts fundamentally with traditional potato breeding that mainly exploits specificity of combination. CIP's cyclic breeding system is a broad germ plasm improvement program with these goals:

- Maintain a wide genetic diversity for yield and stability of performance,
- Increase frequency of genes controlling desirable traits, such as adaptation, yield, pest and disease resistances, and
- Stimulate recombination of desirable characters in the same genotypes and populations.

Basically, CIP maintains two types of populations, advanced populations and back-up populations (Figure II-1). Advanced populations constitute a pool of genes of advanced lines from several breeding programs and selected clones from CIP's world potato collection and some wild species. After assembling this genetic diversity with its desirable genes, the immediate goals were to decrease gene frequencies, and isolate genes in units of the total population. To improve the population, a rigorous recurrent selection system is combined with screening for resistance to stress factors, pests and diseases. After F_1 single and bulk cross hybrids are obtained, seedlings are screened and survivors evaluated in the field for specific resistances and are also selected for agronomic characteristics.

Selected clones are parental materials for a new cycle of recurrent selection. Within this system, selection for general combining ability uses bulk pollinations. Female clones producing good progenies with a pollen mixture from several clones are considered to have a good combining ability.

Back-up populations are developed from the world potato collection that includes both primitive cultivars and wild species. The objective is to concentrate and recombine genes controlling stress and pest and disease resistance which may be used in advanced populations.

Hybrid progenies were evaluated to assess their potential for the use of true potato seed for commercial potato production. Data from the 400-500 families evaluated yearly in replicated trials are used in the breeding program.

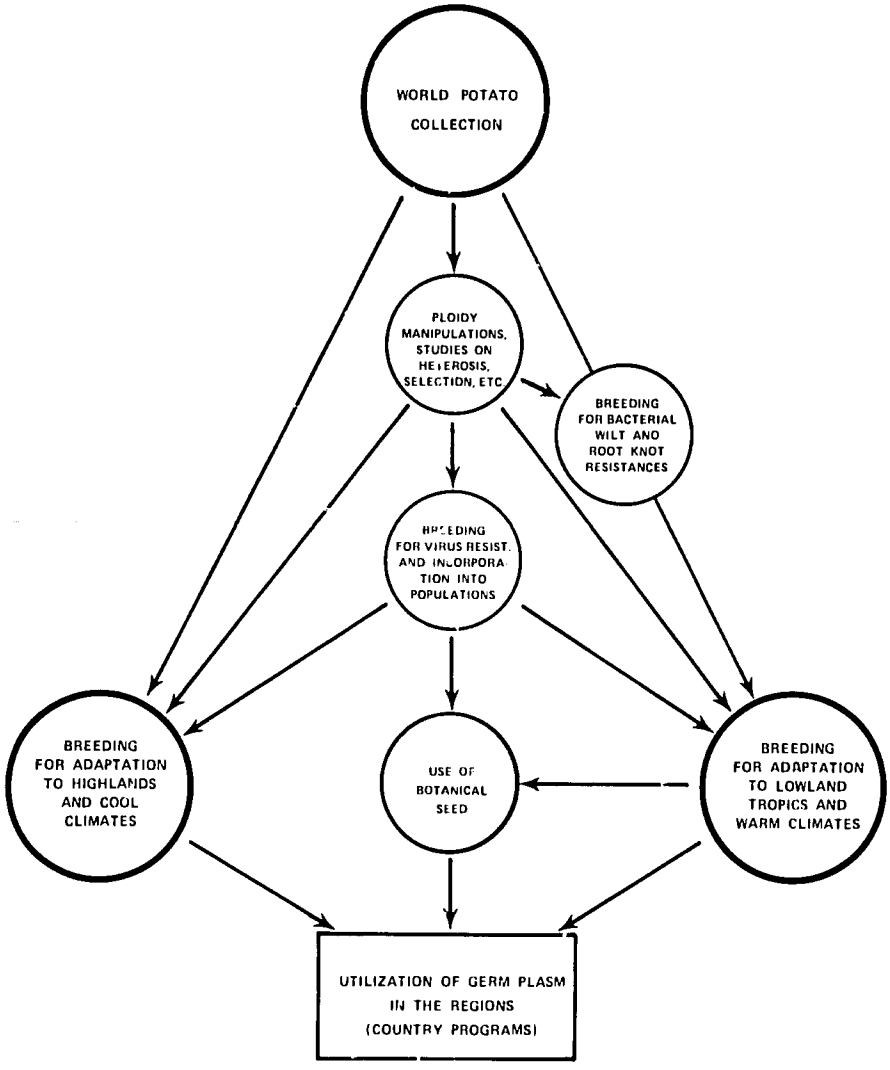


Figure II-2 — Interactions among Thrust II research projects.

Germ Plasm Maintenance, Distribution

CIP's germ plasm combines three main components: (1) wild species, (2) primitive cultivated clones, and (3) advanced clones and breeding populations.

The collection of primitive cultivated clones planted in the CIP world germ plasm collection site at Huancayo, Peru in the 1978-1979 growing season included 8,216 accessions. Although a hail storm caused considerable damage, sufficient tubers were obtained for both maintenance and evaluations. To prevent complete loss of materials that might result from un-

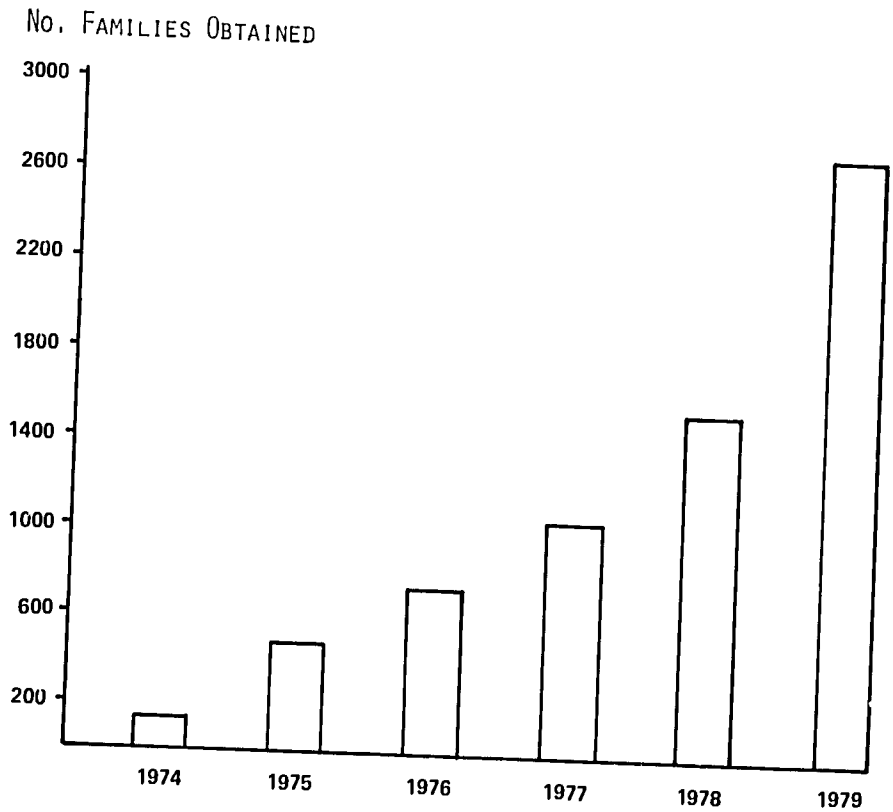
anticipated damage a cooperative agreement for clonal maintenance of the collection in Colombia was developed between the Instituto Colombiano Agropecuario and CIP.

In reducing size of the collection, 574 duplicate accessions were eliminated. Open-pollinated seed of 5,000 accessions were collected for storage in the National Seed Storage Laboratory at Fort Collins, Colorado, USA., as a safeguard against possible losses of germ plasm. Two thousand tuber samples were distributed for evaluation for resistance to two nematodes, three insect pests, two bacteria, four fungi, two viruses, and a viroid. Furthermore, 52 accessions were used as parental stocks in breeding programs to combine resistance to various pests and diseases.

Advanced Breeding Materials

Since 1974 a steady increase in the number of hybrid combinations has taken place. In 1979 nearly 2,800 hybrid families were obtained (Figure II-3). Many of these families combined as many as four resistances (late blight, bacterial wilt, PVY and PVX); or three resistances (bacterial wilt, root-knot nematode and late blight); or (late blight, frost and wart). The hybrid family increase led to increased distribution of materials as clones and populations to the regions (Figure II-4). A total of 427 tuber families representing 18,500 tubers were distributed to 12 tropical and subtropical countries for testing

Figure II-3 — Number of hybrid families obtained in various Thrust II breeding programs.



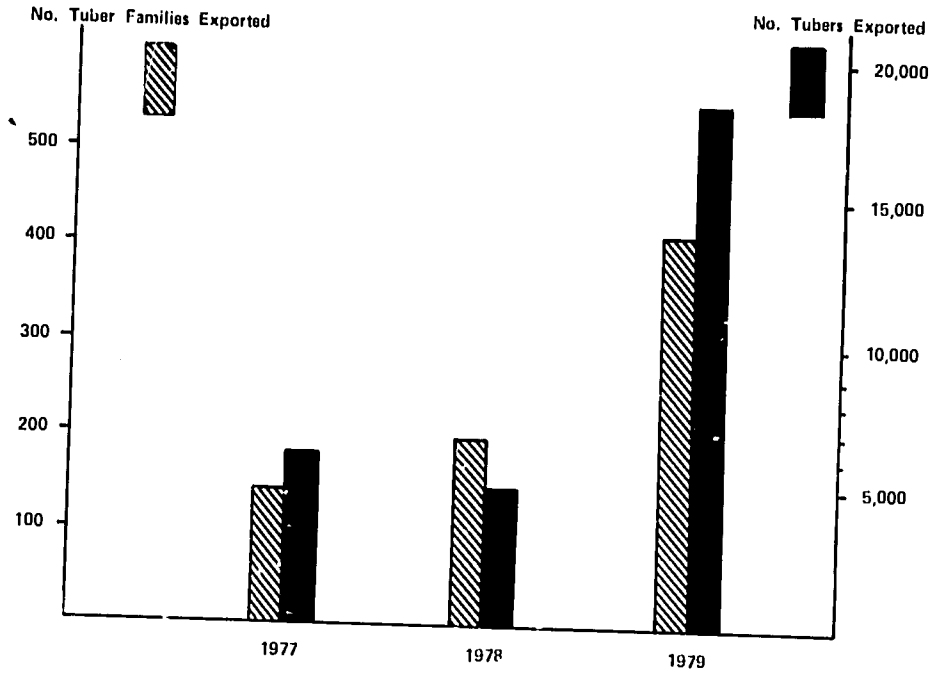


Figure II-4 – Distribution of advanced populations.

and selection of potential new varieties. Also, 5 to 50 tuber samples of five clones with adaptation to the lowland tropics were distributed to 16 countries.

Frost Resistance

In 1979 some 50,000 seeds were obtained from crosses between 2n, 3n, 4n and 5n resistant parental clones. A total of 165 families producing 27,000 seedlings were screened in a growth chamber at -4°C. Approximately 5,000 seedlings or 18.5% of the population was resistant.

Sixty selected clones with frost and/or late blight resistance were compared to six well adapted checks at Huancayo (3,200 m) in a replicated experiment. Results showed the high yielding potential of these improved materials (Figure II-5). From a population of selected clones trials were conducted at three locations in Peru and two in Bolivia where frosts of -3°C and -4°C were recorded during the growing season. Clones selected in all locations (Table II-1), had

Table II-1. Frost tolerant clones tested in various environments in Peru and Bolivia.

Clones No.	Huancayo 3200 m	Chocón 3300 m	Usibamba 3700 m	Toralapa 3700 m	Belén 3800m
Tested	690	166	510	97	400
Selected	216	26	80	30	130
Very promising	30	5	10	16	20

Table II-2. Population screening for adaptation to the lowland tropics and extreme resistance to PVY.

Steps in selection	Seedlings No.	Remaining %
Initial population	2,557	100.0
After screenhouse screening	688	27.9
After transplanting	384	15.0
After field roguing	362	14 2
Tuberizing	352	13.8
Selected in field	99	3.9
Graft-confirmed PVY immune	88	3.4

potential for countries of the Andean region, as well as for some subtropical countries. In countries such as Pakistan, Nepal or Ethiopia potatoes from these clones might be planted during fall or winter seasons when days are short with moderate frost hazards.

Progress was made in combining virus resistance with other resistances and tolerance to stress. Rigorous selection for specific disease resistance for PVY immunity and early maturity in the San Ramón site is detailed in Table II-2. Likewise, a small population of 14 families combining clones with PVY immunity, heat tolerance and late blight resistance was inoculated

Figure II-5 — Frequency distribution of yields of selected clones with frost and/or late blight resistances, Huancayo, Peru, 3,200m elevation.

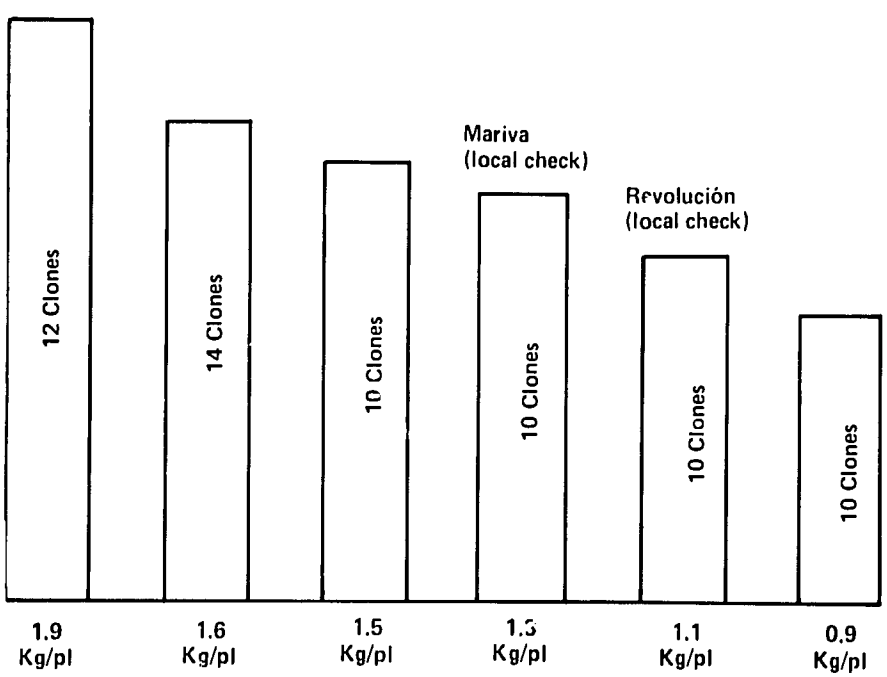


Table II - 3. Population screening for adaptation to the lowland tropics and combined resistance to late blight and immunity to PVY.

Steps in Selection	Population Size	
	Seedlings No.	Remaining %
Initial population	756	100.0
After 1st PVY inoculation	721	95.4
After LB inoculation	336	44.4
After PVY 2nd and 3rd inoculation	220	29.1

with PVY, then with a suspension of spores of *P. infestans* followed by two more PVY inoculations. This combined screening eliminated 70% of susceptible seedlings leaving for lowland field testing an adequate number of resistant clones to assess horticultural characteristics (Table II-3).

A 9x9 diallel of *andigena* cultivars from CIP's world potato collection was evaluated for resistance to infection by potato leafroll virus at the seedling stage. Seedlings were exposed to virus-carrying aphids for a week 3 weeks after sowing. Broad and narrow sense hereditability estimates of H = 0.58 and h^2 = 0.24, respectively, were obtained. Table II-4 presents estimates of general combining ability for each individual cultivar.

The sizeable and positive estimates of general combining ability for clones 700614, 701312 and 700024 indicate that when such parental material is used in a breeding program consistent progress can be made through selection. This is despite the narrow sense hereditability estimate h^2 = 0.24 obtained experimentally which may appear to be relatively low.

Wilt and Nematode Resistance

In this program, resistance from various cultivated and wild species was utilized. Diploid populations were created with the contribution of the species *S. phureja*, *S. stenotomum*, *S. sparsipilum*, *S. chacoense*, and *S. microdontum*. Evaluation of 196 hybrid families yielded 35% genotypes with resistance to root-knot nematode. This diploid germ plasm has been incorporated into the tetraploid level via 4x - 2x matings, using as females selected clones adapted to grow in the lowland tropics. The resulting F_1 population was intercrossed to produce an F_2 and also back-crossed to the tetraploid parents. Both populations were field evaluated and clones with good agronomic characteristics were selected, especially in the backcross population.

Table II - 4. Estimate of general combining ability.

Cultivars	$\hat{g}_i$
CIP 720026 cv. Renacimiento	-6.28
CIP 702514 cv. Chata Blanca	-6.03
CIP 700614 –	3.12
CIP 702066 cv. Yuracc Imilla	-2.95
CIP 700921 cv. Ccompis	0.63
CIP 701028 cv. Huagalina	-1.70
CIP 701312 cv. Hualash	4.43
CIP 700223 cv. Yana Imilla	0.13
CIP 700024 cv. Casa Blanca	8.61
S.E. $(\hat{g}_i)$ = 1.59	S.E. $(\hat{g}_i - \hat{g}_j)$ = 2.38

Use of True Potato Seed (TPS)

Representative populations from 60 hybrid tetraploid families and 20 diploid families were field evaluated at two locations in Peru: San Ramón (800 m) and La Molina (247 m). Results on average tuber yield as well as the number of true seed-containing berries produced per family are in Table II-5.

Data suggest strong family x environment interaction for tuber yield since only two families were within the top 10 tetraploid families at both locations. With diploids, this effect appears to be less pronounced. However, the reduction in yield under high jungle conditions at San Ramón was more drastic in the diploids.

With respect to the number of berries produced, both family and environmental effect were strong. An estimated 200 seeds are obtained per berry and an expected 80% of the seed will germinate. Thus, in two examples, seed production per hectare of tetraploid family No. 21 at Lima would be sufficient to plant 218 hectares and that of diploid family No. 19

Table II-5. Average tuber yield (kg/ha) and number of berries produced in tetraploid and diploid populations evaluated in two environments.

Tetraploids

Lima (250 m)			San Ramón (800 m)		
Family	Tuber y'd	Berries/ha x 1000	Family	Tuber y'd	Berries/ha x 1000
18	32.45	38.9	5	14.45	36.0
5	31.67	11.3	36	14.24	18.5
20	31.29	28.5	34	13.31	8.3
21	31.22	67.6	22	12.68	33.3
31	30.57	10.0	16	12.27	3.7
32	28.09	34.3	11	12.07	19.5
19	28.57	55.6	37	12.03	15.7
8	28.04	5.6	15	11.79	21.3
15	27.90	14.1	38	11.65	13.9
39	27.77	3.7	13	11.61	9.26
Berry yield $\bar{X}$ = 10.3			Berry yield $\bar{X}$ = 16.0		

Diploids

Family	Tuber y'd	Berries	Family	Tuber y'd	Berries
15	26.42	350.0	7	4.61	35.6
19	25.33	407.4	5	4.28	72.3
6	23.00	231.3	12	4.06	23.0
3	22.92	267.6	3	4.03	104.6
12	22.90	248.4	1	3.86	31.7
4	22.00	317.6	15	3.78	60.2
Berry yield $\bar{X}$ = 237			Berry yield $\bar{X}$ = 48		

would be enough for 1,300 hectares. Experimental results so far show no negative correlation between tuber yield and berry production as was anticipated.

To evaluate the most efficient type of population for adaptation to propagation by true potato seed, five different populations have been created: (1) selfed population, (2) open-pollinated population, (3) controlled cross population, (4) bulk cross population, and (5) composite population. These various populations are being evaluated under different environments.

Adaptation to Lowland Tropics

A total of 800 hybrid families were obtained by crossing heat tolerant clones with others which combine resistance to diseases. Resistances to late blight, bacterial wilt and immunity to PVY and PVX and tolerance to high temperature and excess humidity have been brought together. A sample of 1,500 selected clones were evaluated at San Ramón and Yurimaguas for adaptation to the lowland tropics. Two hundred selections were made with yields ranging between 0.5 to 2.5 kg/plant.

An 11 x 11 diallel rating scheme was used to study inheritance of earliness, using a sample of tropical clones. Fifty five hybrid families have been obtained and are being evaluated.

Thrust III

Control of Important Fungal Diseases of Potatoes

Under direction of a new Thrust coordinator who assumed duties during 1979, seedling screening for resistance to late blight was continued, studies began on the race distribution of wart fungus and methods for chemical and integrated control of pink rot and smut in the field continued to receive attention.

Emphasis in late blight breeding and screening was on testing of material with multiple resistances, using a wider variety of genetic sources of resistance, and elimination of R-genes. Identification of sources of early blight resistance and the role and control of soil-borne diseases especially with respect to adaptation of potato to the lowland tropics are of priority importance in the near future.

Late Blight
(Phytophthora infestans)

Seedlings screened for late blight resistance were derived from parental material free of PSTV. In addition to seedlings from the late blight breeding program (including frost resistant material), seedling families were also screened from parental lines adapted to the lowland tropics, or with resistance to cyst nematodes, PVX, PVY and PLRV (Table III-1).

During the year CIP late blight trials in Mexico were discontinued. However, field tests were conducted in San Ramón and Huánuco, Perú. Because blight appeared in San Ramón trials rather late, only one blight reading could be made. From 602 clones planted, 52 were selected with an average yield of 1 kg/plant. In Huánuco 980 clones were planted and four successive blight readings were taken. About 30% showed a high level of field resistance and the best 51 clones were selected.

Tuber families with late blight resistance were provided to various

Table III-1. Seedling screening for late blight resistance at La Molina, Peru, 1979.

Program source of families	Families No.	Seedlings tested No.	Seedlings selected %
Late blight breeding	209	52,215	37
Lowland tropics	64	7,796	11
Wild species	12	772	27
Nematode resistance	28	3,576	29
Virus resistance	14	712	47
	327	65,071	30 (Mean)

Table III-2. Tuber families sent to selected countries for late blight resistance trials in 1979.

Country	Families No.	Tubers No.
Brasil	23	1,165
Colombia	22	1,538
Ethiopia	25	858
Turkey	38	2,362
	108	5,923

countries in 1979 (Table III-2). In addition, approximately 32,000 true seed from 12 late blight resistant families were provided for agronomic trials at CIP.

Wart (*Synchytrium endobioticum*)

The seedling screening method for wart resistance reported last year has been further perfected. The Glynne-Lemmerzahl method for screening wart resistance in tubers was re-evaluated. Simpler methods than Glynne-Lemmerzahl and Spieckermann are required if wart screening has to be performed by scientists at experiment stations in developing countries. Studies were undertaken to define such methods and an example is illustrated (Figure III-1).

It was concluded that within most populations of potato clones enough resistant material to any one race or race combinations of the pathogen existed to allow for direct field selection of otherwise adapted materials (frost, late blight, virus.)

An apparent very complex race distribution in Peru continues to be studied and as well development began on simplified methods for open-air screening of wart resistant clones.

Smut (*Angiosorus solani*)

Repeated experiments on chemical control of smut under greenhouse conditions indicated that Benlate, Bayleton and Vitavax did not adequately control this disease. Preliminary results indicate that soil fumigants such as basamid and methyl bromide give good control. Yields in heavily infected soils at Cañete (coast) and Comas (mountains) increased up to 10-fold compared with untreated plots.

Pink rot (*Phytophtora erythroseptica*)

Pink rot, an important disease in the Peruvian highlands, is a continuing problem to potato production in CIP fields at Huancayo. Various methods for chemical and biological control are being tested. For experimental purposes, methods to artificially create a high disease incidence must be established.

Southern blight (*Sclerotium rolfsii*)

Potato seedlings from seed of nine open-pollinated clones adapted to tropical lowlands were tested for resistance to *Sclerotium rolfsii* at the National Agriculture University, La Molina, Peru (Figure III-2). No resistance to this pathogen was observed in any one seed lot, which constitutes a threat to tropical potato production. Preliminary studies on chemical and biological control of this disease show that inoculum potential of the soil can be raised by artificial inoculation of beans and potatoes and plowing plants under before maturation. A method that allows determination of inoculum potential of soil is being evaluated.

Verticillium wilt (*Verticillium* spp.)

All *Verticillium* isolates obtained in Peru at the coast and in

the Andes were of the species *V. dahliae*. Different methods used to infect plants artificially were assessed.

Rhizoctonia disease (*Rhizoctonia solani*)

A seedling assay for resistance appears feasible. All isolates obtained recently from the coast in Peru were pathogenic, but differed appreciably in pathogenicity. This disease has increased in importance in Peru in recent years, especially along the coast. The disease is also increasingly important in many countries where CIP is active and will receive more attention in the future.

Tropical Disease Problems

Porophyllum ellipticum (L) Cass is a common host of *Choanephora cucurbitacearum*, a serious cause of crop-loss in Yurimaguas (Figure III-3). At Yurimaguas *Rhizopus*, and *Pythium* spp. are also important pathogens.

Didymella bryoniae and *Alternaria solani* were observed as rather frequent pathogens in potatoes in warm environments. *Phoma cucurbitacearum* as well as its perfect form, *D. bryoniae*, were observed in Tingo María in potato, tomato and papaya.

True Seed Problems

A study began into the presence of fungal pathogens in true potato seed. So far only a limited number of saprophytic fungi have been isolated from true seed.

Contracts

Contract research in Sweden on the inheritance of components of general resistance to *Phytophthora infestans* has shown a significant correlation (r = 0.63) between resistance to entrance of the fungus

Figure III-1 — Tubers with symptoms of wart (*Synchytrium endobioticum*). In search for a simple screening method, scientists placed tubers in sand to which a small amount of wart inoculum was added. Warts developed within a short period around most developing stolons.

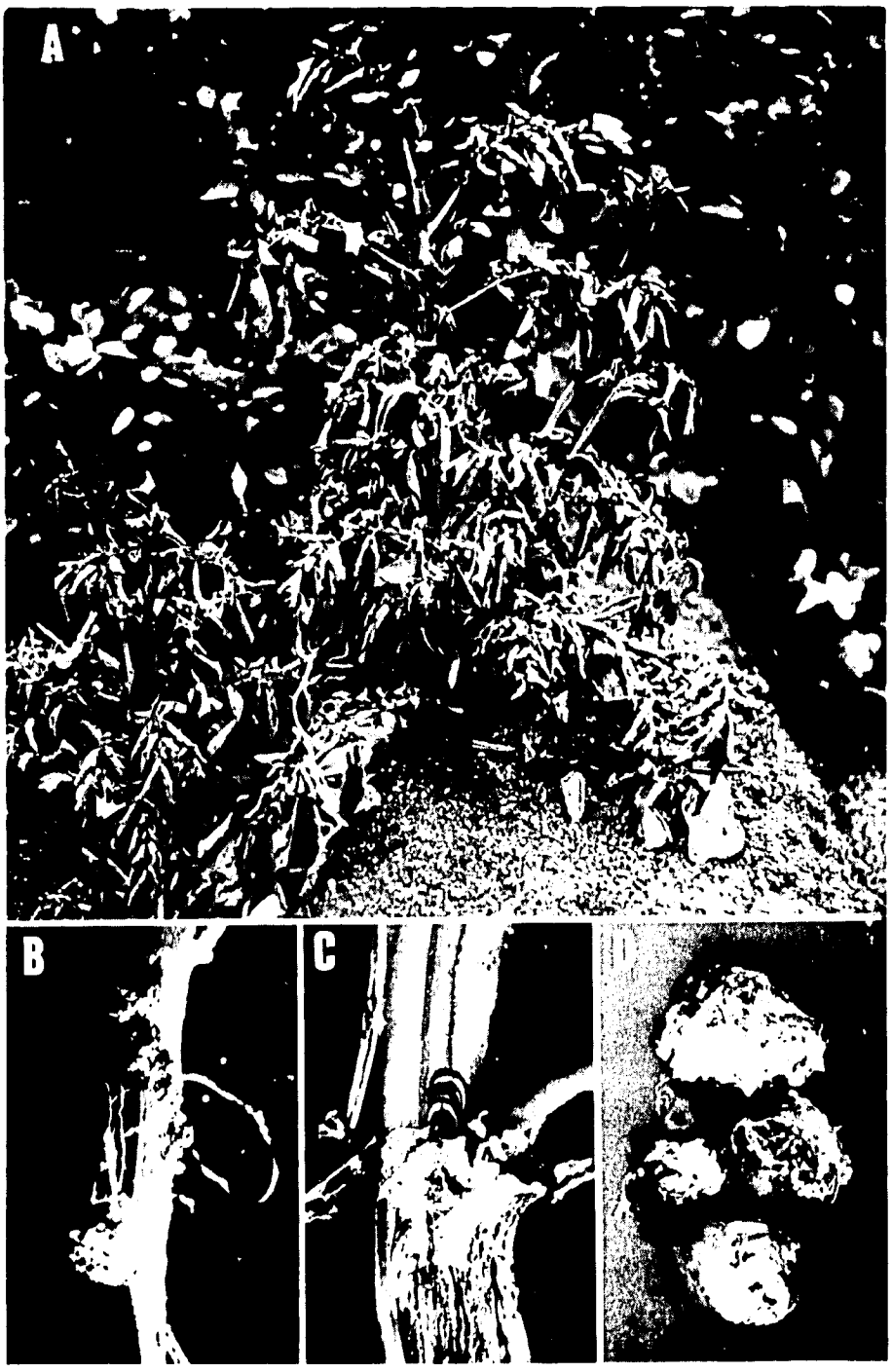


Figure III-2 — Southern blight (*Sclerotium rolfsii*) is a serious problem where potatoes are grown under warm conditions. (A) — Plant with a wilt caused by extensive damage of the root system and stem base by *S. rolfsii*. (B) — Stem base with sclerotia. (C) — Developing lesion on a stem base. (D) — Tubers affected by the pathogen.

Figure III-3 — Blight caused in hot tropical areas by *Choanephora cucurbitacearum* is characterized by a wilt preceding sporulation of the fungus. The plant remains green but seems to lose turgor systemically just prior to sporulation. (A) - Wilted plant with early sporulation. (B) - Spores of this fungus on same plant.

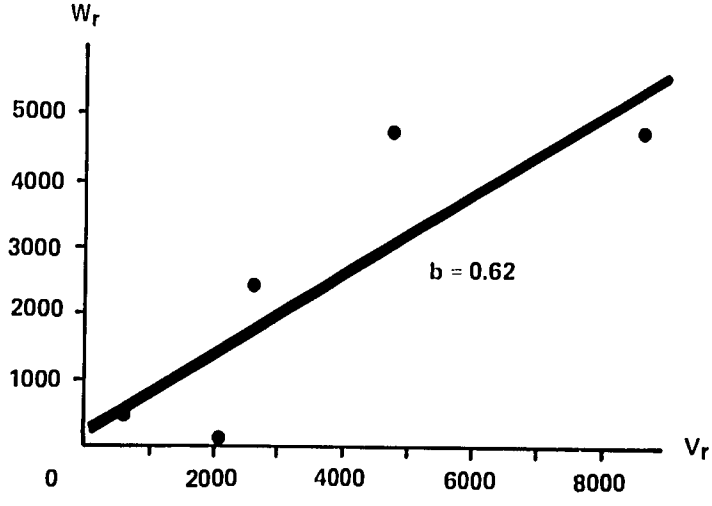
and resistance to invasion in self-pollinated populations from the Colombian potato collection. The best genotypes reached a medium level of resistance comparable to the cv. "Record." Although resistance to entrance was correlated with field observations during 3 years (1974: r = -0.91; 1977: r = -0.90; 1979: r = -0.92), no significant correlation was obtained concerning resistance to invasion and field observations. No significant differences in resistance were found between *S. tuberosum* ssp. *andigena* and *S. phureja* clones.

In another study, progeny derived mainly from *S. demissum* with different levels of late blight resistance were tested for foliage and tuber resistance. No significant correlation coefficient was found concerning mycelial growth on tuber slices and degree of attack or diameter of leaf lesions. Generally there was no significant relationship between foliage and tuber resistance. Tuber susceptibility was generally higher when tests were made 5 months after harvest than when tested 3 months earlier.

Diallel crosses were made between parents with varying levels of resistance to late blight: Eigenheimer (most susceptible), Sv 67117, Record, Sv U.L. 72156 and Sv 70103 (most resistant). About half of the resulting seedling populations examined were normally distributed indicative of a polygenic pattern of inheritance. The remaining populations deviated significantly from normal distribution suggestive of the influence of non-additive elements controling entrance of late blight fungus into the foliage. Similarly, a breeding scheme involving factors for resistance to invasion yielded equivocal results but suggestive that non-additive elements were also acting in some genotype combinations to inhibit fungal invasion of leaf tissue.

During 3 years an attempt has been made to identify a set of differentials for general or horizontal resistance to be used as a standard for field indexing. Of the

Figure III-4 — The relation between variance (V_r) and covariance (W_r) of the diallel scheme concerning resistance to entrance in foliage. The regression coefficient, *b*, deviated significantly from zero (t = 2.81).



seven varieties observed Bintje, Majestic and Eigenheimer were more susceptible than Record, which was more susceptible than Alpha, Libertas and Pimpernel. A set consisting of Bintje, Record and Pimpernel is worthy of further evaluation as an index of levels of field resistance under long-day conditions.

In a linkage project with the Research Institute for Plant Protection, Wageningen, the Netherlands, a start has been made to test Mexican and Peruvian germ plasm material for the presence of R-genes. It is of interest to note that the recently released Peruvian varieties Molinera and Caxamarca might be expected to have a genotype $R_1 R_3$ (or $R_1 R_3 R_7$) similar to their common Atzimba parent.

In experiments with *Solanum muricatum* it has been found that the differential reaction between isolates of *Phytophthora infestans* on common Peruvian field crops of *S. muricatum* is due to a monogenic, dominant gene. Six of 29 seedlings reacted as susceptibles while the remainder showed hypersensitive lesions.

Thrust IV

Control of Important Bacterial Diseases of Potatoes

Screening for resistance to bacterial wilt and late blight intensified in 1979 along with additional emphasis and work on field evaluations of clones developed over the past years, including a few screened during the present year. Field plots at Huánuco (Acomayo and Umari) were evaluated for resistance to late blight and bacterial wilt. Additional information on performance of clones was obtained by planting under irrigated desert conditions at CIP, Lima and also by establishing a trial at a moderately low (950 m) humid tropical field site (San Ramón) infested with *Pseudomonas solanacearum*. These field evaluations will permit selection of clones with a wider range of climatic adaptation as well as reducing the large number of clones developed during past years to only those with the best performance.

Studies on the ecology, distribution, pathogenicity and biochemical characterization of the *Erwinias* affecting potatoes continued during 1979. The importance and pathogenicity of *E. chrysanthemi* on potatoes has been clearly established.

Bacterial Wilt

Late in 1978, a total of 255 clones were planted in Acomayo (Huánuco, 2,400 m) for a late blight and yield trial. Included were 89 clones developed at CIP, Lima (MB clones), 112 from the Wisconsin Contract (PSY clones), and 54 selected clones from previous years (BR and MS clones). After harvest 63 clones were selected (Table IV-1 indicates the 10 best yielding). The 30 best plus 24 new MB were planted at Umari (Huánuco, 2,480 m) for a bacterial wilt resistance trial. Twelve out of the 54 clones planted did not show bacterial wilt infection, on either the foliage or in the tubers.

Data of the past few years and in 1979 from Peru and from collaborative country programs (Colombia, Costa Rica, Nepal and Sri Lanka) have resulted in selection of the best 35 clones developed over the past 10 years and the discarding of others, to establish a set of cultivars with which to continue more detailed observations and evaluations. The best eight of these 35 are in the seed program for further distribution (Table IV-2).

In another trial, the 35 selected clones plus 40 new MB clones and 65 retained in 1978 were planted at CIP, Lima during July to study adaptation to winter conditions of coastal Peru. Eighty-five clones yielded more than 1 kg/plant of which 21 yielded more than 1.5 kg/plant (Table IV-3). The same clones were also planted in a humid tropical site (San Ramón, 950 m) during July (dry season) in a bacterial wilt infested plot. Wilt

Table IV-1. Highest yielding bacterial wilt and late blight resistant clones among 240 tested at Huánuco (Acomayo, 2400 m) in 1979 during the rainy season under severe late blight stress. Average of 10 plants.

CLONE	Yield kg/plant	Skin color	Flesh color
MS 1C-6	1.000	Red	Cream
MS 42.3	1.030	Purple	Yellow
MS 91.18	1.010	Pink	Cream
PSY 100.15	1.200	White	White
MB 5.9	1.250	Purple	White
MB 5.23	1.040	Purple	White
MB 5.39	1.050	Pink	White
MB 6.13	1.000	Cream	White
MB 6.25	1.000	Pink	White
MB 6.42	1.000	Red	White
Ticahuasi (control)	0.540	White	White

Table IV-2. Most promising cultivars in the bacterial wilt and late blight resistance program and highest yield recorded to date (average of 5-15 plants, in grams).

CIP Nº & Code	Selected in	Yield Location	Color Skin	Color Flesh	Shape	Percent Protein	Percent Dry matter
800926 MS 35.22	Costa Rica Colombia Nepal Sri Lanka	875 g Turrialba Costa Rica	Cream	Cream	Round	*	–
800928 MS 42.3	Colombia Sri Lanka Nepal	1518 g Río Negro, Col.	Purple	Cream	Oval	10.9	19.8
800927 MS 91.18	Peru	1100 g Huánuco, Peru	Pink	Cream	Round	10.7	18.4
800929 MS 35.4	Peru Colombia Sri Lanka	1000 g Lima, Peru	Pink	Cream	Round	–	–
800936 PSP 30.10	Peru	1200 g Lima	Cream	White	Round	–	–
800935 MS 1C-2	Peru Colombia	1480 g Lima	Red	White	Round	8.8	20.7
– MS 1C-6	Peru Colombia	1260 g Lima	Red	Cream	R/Oval	13.2	18.6
800934 MS 35.9	Nepal	1600 g Lima	Red	Cream	R/Oval	10.6	20.6

* In process.

Table IV-3. Highest yielding bacterial wilt and late blight resistant clones under irrigated desert winter conditions at El Asesor, Lima, among 140 clones planted. Average of 3 replications of 5 plants each in kg/plant.

Clone	Yield kg/plant	Clone	Yield kg/plant
BR 63.65 (Molinera)	1.737	MB 6.11	1.693
MS 1C-2	1.618	MB 6.42	1.537
MS 27 B-7	1.566	MB 15.6	1.550
MS 82.60	1.503	MB 15.16	1.862
PSP 30.10	1.713	MB 34.9	1.816
PSY 101.29	1.725	MB 34.22	2.067
INDIA 1039	1.635	MB 34.47	1.510
MB 5.5	1.528	MB 34.55	1.970
MB 5.23	1.827	MB 34.115	1.763
MB 5.24	1.527	MARIVA (control)	1.194
MB 5.39	1.680		
MB 6.1	1.666		

symptoms developed in four of the 35 selected clones and in five of the additional clones because of *P. solanacearum*. However, tuber analysis after harvest indicated that the number of clones producing infected tubers is much higher than those showing foliar symptoms in the field. Despite relatively dry conditions at San Ramón, some clones yielded reasonably well: PSY 100.15 a total of 580 g/plant; MB 5.5 totaled 570 g; and MS 91.18 totaled 542 g. This indicates that among clones developed for upland conditions, some have a degree of adaptability to the lowlands.

Sixty-four clones from 16 tuber families were developed in 1978. They were derived from crosses of superior wilt resistant and late blight resistant clones (BR and MS) with clones adapted to warmer tropical conditions (e.g. DTO's and María Tropical). These materials were planted in July 1979 at CIP, Lima to evaluate yield and agronomic characters. Thirty-eight of the 64 clones yielded more than 1 kg/plant and 8 yielded more than 1.5 kg/plant (Table IV-4).

Screening *Solanum* wild species for resistance to bacterial wilt at high temperatures (26° to 32°C) continued during 1979. After screening 150 accessions from 65 species to isolate 013 (race 3, Peru), only five accessions had less than 20% wilted plants. The inoculation of the best nine accessions with five additional isolates has shown that three of the accessions have good levels of resistance (Table IV-5). The study has not found immunity to bacterial wilt.

During 1979, about 10,000 seedlings of 10 "MBN" families from crosses involving *S. sparsipilum* were screened first to isolate 013 (race 3), then the selected ones were multiplied and screened to both isolates 003 (race 1, Peru) and 048 (race 3, Costa Rica), the numbers being often reduced by each one. Further screening with isolate 052 (race 1, Taiwan) is underway.

First studies on perpetuation of races 1 and 3 of *P. solanacearum*

Table IV-4. Yield and agronomic characters of best eight of 64 clones from 16 tuber families developed in 1978-79. First field evaluation at CIP-Lima, winter season. Average of 3 to 5 plants in kg/plant.

CLONE	Yield kg/plant	Skin Color	Flesh Color
MB 37.3	1.600	Red	Cream
MB 40.8	1.583	White	White
MB 44.17	2.125	White	White
MB 44.42	1.650	White	White
MB 44.63	2.250	White	White
MB 47.4	1.950	White	Cream
MB 53.4	1.767	Pink	Cream
MB 56.10	1.612	White	White
MARIVA (control)	1.310	Purple	Cream

Table IV-5. Susceptibility of different tuberiferous *Solanum* spp. to six isolates of *Pseudomonas solanacearum*; percentage of plants developing wilt (minimum of 9 plants per test).

Solanum sp.	Isolates (race)					
Accession No.	013(3)	052(1)	092(1)	075(3)	048(3)	003(1)
S. bulbocastanum PI243504	25.0	9.5	9.1	0	19.0	21.4
S. chacoense CIP760917.1	18.7	40.0	*	64.7	58.3	57.1
S. jamesii CIP760476	16.8	11.9	3.8	10.0	22.2	22.7
S. jamesii PI275266	45.4	4.3	0	10.5	49.0	34.8
S. polytrichon PI275241	17.5	18.2	20.0	–	50.0	14.3
S. stenotomum OCH3571	32.0	18.2	0	–	40.0	66.7
S. stoloniferum PI161170	15.7	45.4	66.7	–	100.0	–
S. sogarandium PI230510	30.0	40.0	20.0	–	20.0	–
S. sparsipilum CIP760147.7	21.2	19.1	10.0	36.1	45.2	49.0
BR 63.76	65.3					
Ticahuasi	90.0					

* Data incomplete.

isolated from Yurimaguas have shown no difference in ability of isolates 077 and 141 (race 1), and 108 and 142 (race 3) to remain as latent infection in resistant cv. Molinera and susceptible cv. Mariva. Selecting diseased tubers by incubation at about 30° C for 6 weeks after harvest, and replanting healthy appearing tubers during two additional generations after they were inoculated by soil infestation, freed these clones of *P. solanacearum*. The hybrid 7/10, one of the first materials with resistance to bacterial wilt developed at the University of Wisconsin has been released as a variety by the Colombian National Potato Program with the name ICA-Sirena. Its earliness (80-100 days), bacterial wilt resistance, fair yield (15-20 tons/ha) and apparent tolerance to viruses are its principal characteristics. The clones BR 63.65 (Molinera), MS 42.3, BR 62.3, BR 63.76 and MS IC-2 continue to show good levels of resistance to bacterial wilt and late blight and good yields at Medellin, Colombia. Clean seed from CIP has been sent to the Colombian Program to be multiplied for regional trials.

Field studies during three consecutive years at Turrialba, Costa Rica, showed little influence of previous cropping patterns on the incidence of bacterial wilt. Rather, the relatively resistant clone MS 35-22 consistently had a lower percentage of wilt than the susceptible variety Atzimba (Figure IV-1). In other field trials the herbicide Paraquat significantly lowered the amount of wilt in the variety Atzimba except in plots where resistant tomatoes had been planted previously.

Erwinia Diseases

Erwinia carotovora var. *carotovora* (Ecc), *E. carotovora* var. *atro-*

Figure IV-1 — Average percentage increase of bacterial wilt in two potato genotypes after different crop rotations, 1976-1979, (Turrialba, Costa Rica).

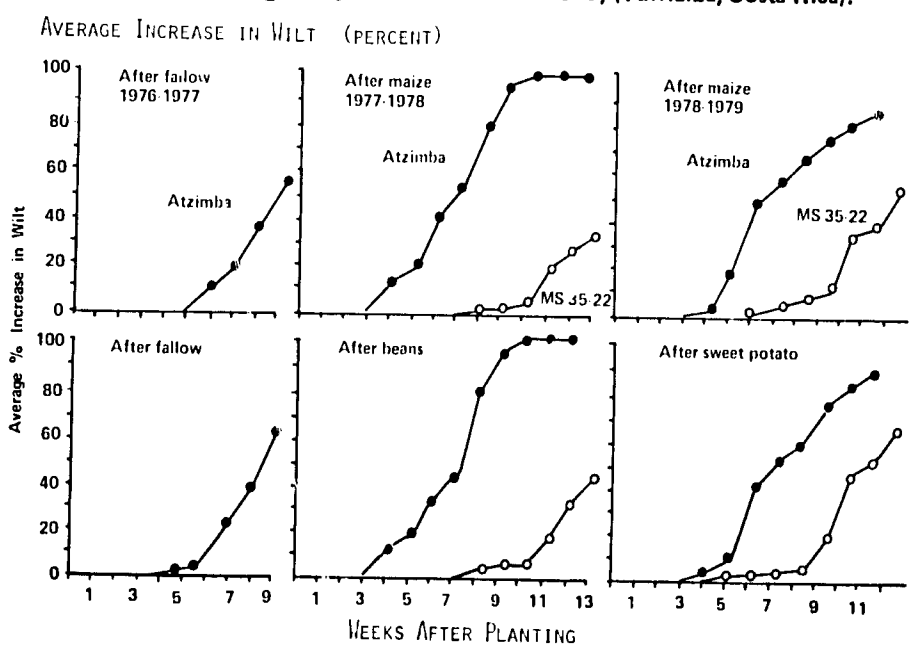


Table IV-6. Frequency of *Erwinias* on potato organs in the three regions of Peru.

	Region					
	Highland		Jungle		Coast	
Erwinia	Stem	Tuber	Stem	Tuber	Stem	Tuber
Carotovora	17	9	10	12	1	2
Atroseptica	7	1	0	0	0	0
Chrysanthemi	1	0	1	8	0	0

septica (Eca) and *E. chrysanthemi* (Ecy) were isolated from different plant organs (Table IV-6). Ecc has been found in the three zones: highland, jungle and coast. Eca seems restricted to the highlands, and Ecy has so far been found only in one field at San Ramón (850 m) and once at CIP's highland station at 3,300 m.

Cultivars selected last year were retested for resistance to Ecy by tuber inoculation using infectivity titration inoculations. Twenty-five Peruvian cultivars, advanced lines from CIP breeding programs, and some germ plasm clones were also tested, the total number being 395. Twelve were very resistant, 60 resistant, and the remainder rated as either moderately susceptible, susceptible, and very susceptible. Among cultivars from the breeding program, 16 frost resistant, 9 late blight resistant and 3 with both resistances were rated resistant to soft rot, but these must be tested further to confirm results.

Ecy from potato (isolate SR 298 from San Ramón, Peru) and SR 237 from dahlia in England were inoculated on potato plants at the University of Wisconsin. The dramatic difference in pathogenicity can be seen in Figure IV-2.

In the Wisconsin Contract research to develop control measures for bacterial pathogens the role of naturally occurring potato lectins as a defense against *Pseudomonas solanacearum* has been shown not to be specific, whereas lectin agglutination correlates with the amount of slime (extracellular physaccaride) produced by each strain (slime formers are pathogenic.)

The role of hosts that do not wilt but harbor the soil inoculum has been studied by developing a more effective selective medium (containing tetrazolium chloride, crystal violet and several antibi-

Figure IV-2 — Potato plants inoculated by stem puncture with *Erwinia chrysanthemi*. The potato isolate SR 298 (left) is from San Ramón, Peru, while SR 237 (right) from England was isolated from dahlia by Lelliot.

Figure IV-3 — Slimy rot characteristic of soft rot of potato tubers, caused by *Clostridium* spp.

otics) to assay soil and rhizosphere populations. The wilt bacterium was isolated from naturally infested soil from Florida and from the rhizosphere of resistant pepper inoculated by soil infestation, but only from pepper cultivars that developed root infection without symptoms of wilt.

Study of multiplication of *P. solanacearum* in stem inoculated potatoes, revealed that in susceptible plants the infection spreads rapidly and even initially the numbers of bacterial cells are two to three orders of magnitude larger than in the resistant plant.

Five highland potato isolates of race 3 and five of race 1 were inoculated to potato plants held at 16°, 20°, 26° and 28°(C). At the highest temperature all isolates were equally virulent, but at the lowest only two race 3 isolates caused wilt (however, in vitro their growth rate was not greater at 16°C).

Latent tuber infection occurred even in stem-inoculated resistant *Solanum phureja* 1386-15 which did not show wilt symptoms. Eleven hybrids of *S. phureja* x *S. tuberosum* inoculated at 28°C and then held at 20°C resulted in all but one yielding infected tubers. Soil infestations of eight resistant clones at 24° to 28°C resulted in 26.7% and 9.2% latently infected tubers with a race 1 and a race 3 strain, respectively. Some infected clones produced no infected tubers. Genetic factors therefore control tuber infection.

Among 146 clones developed for resistance to bacterial wilt and late blight resistance sent to Costa Rica for field screening, nine were selected.

An antiserum for race 3 has been developed using the cell wall lipopolysaccharide as the antigen. Cross adsorption with some isolates of race 1 and 2 was necessary to make this antiserum specific.

Determining the prevalence of pectolytic *Erwinia* spp. and Clostridia in cold storage it was found that 45% of the tubers had *E. carotovora* var. *atroseptica*, 13% var. *carotovora* and 13% *Clostridium* spp. The effect of incubation temperature determined to a great extent the predominance of a given bacterium. Although clostridia were often associated with Erwinias, clostridia alone can cause soft rot. A white colony *clostridium* was more frequently isolated than pink or yellow ones. A slimy gaseous rot characterizes *clostridium* rot (Figure IV-3). The taxonomic characterization of this pathogen is not complete; it belongs to the "butyric acid group" of clostridia.

Thrust V

Control of Important Virus Diseases of Potatoes

Emphasis continues on developing resistance to potato leafroll virus (PLRV) and potato virus Y (PVY). Resistance to these two viruses as well as potato virus X (PVX) would eliminate the principal degenerative diseases of potato and largely reduce risks for the small farmer in saving his own seed tubers for planting. Refinements in early and accurate detection of viruses which is essential to verification of rapid, large-scale seedling screening efficiency, are constantly under review. New approaches to spindle tuber viroid (PSTV) detection and the elimination of this infectious agency from breeding stocks continue.

Potato Leafroll Virus (PLRV)

Isolates of PLRV from several sources were collected to study strain differences by ELISA, immunosorbent electron microscopy, differential host range and reactions on selected potato cultivars.

Resistance to PLRV is tested by exposing seedlings 2 to 4 cm high to virus-infected aphids. Plants infested with the aphids are shaken over the seedlings twice during a 7-day interval and then the aphid population is killed. Seedling plants without symptoms are later selected for transplanting; those developing symptoms are discarded. During 1979 some 19,300 seedling plants from more than 200 crosses were exposed to infection. Approximately 25% of the seedlings were eliminated as susceptible before the first tuber generation. Crosses with low leafroll symptom percentage were selected for tuber families.

In cooperation with the Breeding and Genetics Thrust, more than 1,100 clones from various sources were observed in field trials near Lima to identify additional sources of resistance and to retest clones reputed to have some PLRV resistance.

Twenty-seven clones with apparent high resistance were selected for further evaluation and, where advisable, selections for combined PLRV, PVY, and PVX resistance were made.

In Pakistan, 721 tubers of 10 tuber families bred for PLRV resistance were planted in the spring season at Faisalabad in the Punjab. The average count of *Myzus persicae* reached a peak of 60 per week in water traps. At harvest 96 plants remained symptomless. Although 68 selections were replanted in the fall for checking symptoms, only 13 remained symptomless after 6 weeks.

The principal breeding effort in Turkey is to select clones with virus resistance. One clone, G4298 from Scotland, has been grown for three seasons under conditions of severe virus infection without showing either PLRV or PVY symptoms.

Potato Virus Y and Other Mosaic Diseases

Seedling inoculation with PVY or PVX, or in combination, used an air brush spraying an inoculum-carborundum mixture. A second inoculation was manual. Diploid intercrossed families from *S. phureja* and *S. stenotomum* contained approximately 0.4% highly resistant plants to PVY in a population of more than 1,700 seedlings. These plants could not be infected by mechanical means but were infected by grafting.

Tetraploid potato plants in a population of about 9,000 individuals contained approximately 30% highly resistant segregates to PVX, PVY or both. Good sources of resistance to PVY are in *Solanum tuberosum*, ssp. *andigena*. Seedling populations segregated into approximately equal numbers of resistant and susceptible plants. Antibody sensitized latex (ASL) is routinely used for PVX and PVY detection. A battery powered reciprocator for mixing preparations of ASL has been developed for field use (Figure V-1).

Of 94 potato fields examined in Ecuador, mosaic virus diseases were most frequent and severe with potato yellow vein virus next in importance (Table V-1). Symptoms of PLRV were absent. The fields were at 2,300 to 3,500 m altitude and ranged from 1 to 10 ha. in size.

Identity of the virus in mosaic diseased plants was determined by ASL. Approximately 100 samples were collected in several regions in Ecuador. PVY-containing samples were placed in desiccated storage and selected samples were tested on a range of indicator plants. PVY ranged from 25% of plants with symptoms in the north to 71% in the south (Table V-2). Prevalence of PVY in the south may be

Figure V-1 — Battery operated shaker for field tests with antibody sensitized latex for such viruses as PVY, PVX, PVS and others for which sensitized latex is available.

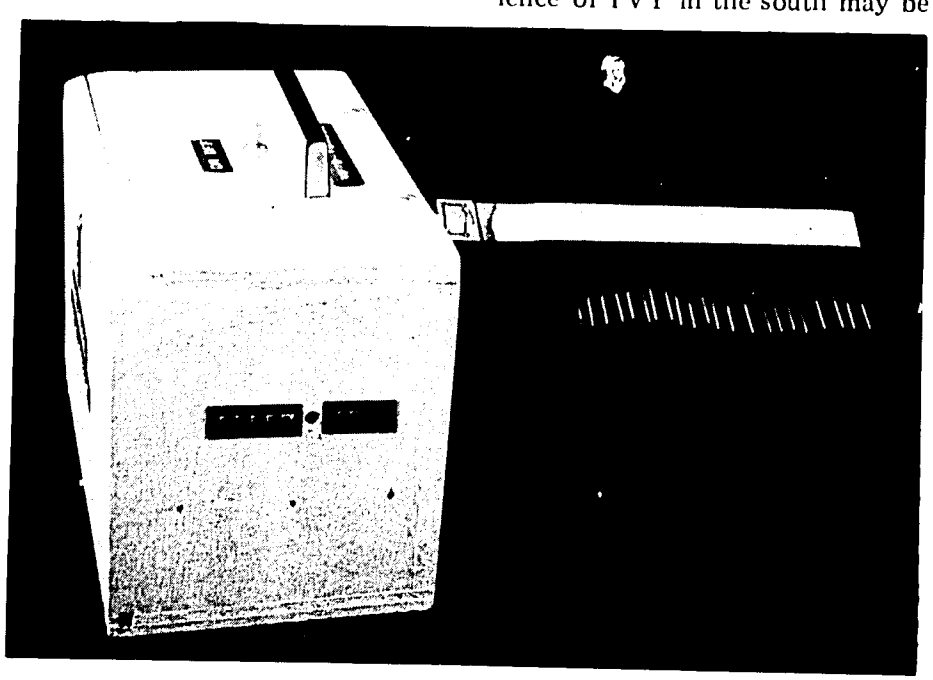


Table V-1. Fields in Ecuador with mosaic and yellow vein diseased plants.

Symptoms	Incidence	Fields (%)
Mosaic	0	12
	Some	9
	< 10%	12
	10-50%	29
	> 50%	38
Yellow vein	0	65
	Some	20
	< 10%	11
	10-50%	4
	> 50%	0

the result of cultivar (Bolona) susceptibility rather than geographical influences.

Potato Virus S

PVS was most prevalent in Ecuador followed by PVY and PVX. APLV (Andean Potato Latent Virus) and APMV (Andean Potato Mottle Virus), although consistently present, were considerably less frequent. Most severely affected plants were usually doubly infected with either PVS + PVY or PVS + PVX.

PVY has been collected from Perú (35 samples), and compared with two type strain isolates from the United States. All Peruvian isolates are both mechanically and aphid transmitted and all produce local lesions on the *S. demissum* x *S. tuberosum* hybrid A6. All 29 isolates from the Peruvian sierra were of the necrotic type (Y^N) except for one isolate, H13 from Cajamarca which was of the Y^O type. All six Peruvian isolates from the coastal area were of the Y^O type. When 14 of the Y^N and two of the Y^O isolates were tested on *Capsicum annuum*, cv. Avelar, they were avirulent. Pepper is used in the United States to differentiate PVY isolates into two groups, one virulent and the other avirulent. The two type strains from the United States were virulent to *C. annuum* cv. Ruby King whereas four Peruvian isolates, three of the Y^O and one of Y^N, were avirulent.

Table V-2. Relative prevalence of potato viruses in Ecuador detected in mosaic diseased plants as determined by antibody sensitized latex.

Viruses	Plants infected with the viruses (%)			
	North (Carchi, Imbabura)	Quito (Pichincha)	Center (Cotopari, Tungurahua, Chimborazo)	South (Cañar, Azuay)
PVY	25	26	50	71
PVX	13	24	24	79
PVS	90	80	80	43
APLV	8	4	8	7
APMV	8	4	8	7

Potato Spindle Tuber Viroid (PSTV)

Nearly 6,000 tests for PSTV were made using gel electrophoresis and tomato inoculation. These tests determine viroid freedom in nuclear stocks for maintenance of clones in seed for distribution. Because of pollen and seed transmission of PSTV, particular attention is given to selection of disease-free parents for seed production.

Studies on development of a serological type test for PSTV are underway. Purified PSTV-RNA as antigen has not been successful. Protein extracts from infected plants as antigens show some promise with an additional band in gel diffusion tests over the band obtained with healthy sap. This suggests that in PSTV infected plants a differential antigen exists. Of 63 accessions of *S. acaule* one is apparently resistant to PSTV.

Calcium hypochlorite (1%) was effective in destroying infectivity of PSTV inoculum and it is being used routinely for disinfection of hands and tools in greenhouse operations (Table V-3).

Novel Viruses

Andean Potato Latent Virus (APLV) isolates collected from Colombia, Ecuador, Peru, and Bolivia varied considerably in their serological electrophoretic properties. Of the 26 isolates tested, 14 were studied for symptom differences on indicator hosts. Three major serological strain groups were identified: Hu from only the southern Andes; CCC from only the northern Andes; and the Col-Caj group occurred throughout the Andean region. Enzyme-linked immunosorbent assay (ELISA) differentiated the major strain groups effectively. All isolates were detected by antibody sensitized latex (ASL) serology for routine identification tests.

Agar gel double diffusion tests were variable depending on the specific antiserum used. With this test, differences within the Col-Caj group were apparent.

The calico type virus, code named UC and mentioned in these reports previously, may be a sporadic nepo virus as it could not be recovered in the vicinity where first identified (Comas, Peru) in

Table V-3. Inactivation of PSTV with chemicals.

Treatment*	Infectivity**	
	Exp. 1	Exp. II
1% $Ca(OCl)_2$ (Calcium hypochlorite)	0/4	0/8
1% Extron (detergent)	1/4	–
pH 3.0 in phosphate buffer	1/4	–
pH 11.0 in phosphate buffer	0/4	3/8
1% $Ca(OCl)_2$ (Dyalized 4 hr in two changes phosphate buffer)	–	0/8
Phosphate buffer	3/4	7/8
Healthy tissue	0/4	0/8

* Solutions for all treatments were prepared in 0.06 M Phosphate buffer pH 7.2. PSTV-infected tomato (2g leaf tissue) was ground in the solution to test.

** Numerator indicates number of infected and denominator number of inoculated tomato plants.

Table V-4. Distribution of antibody sensitized latex (ASL) and antiserum (AS) to different countries *.

Countries No.	PVX		PVY		PVS		APLV		APMV	
	ASL	AS	ASL	AS	ASL	AS	ASL	AS	ASL	AS
South America										
5	19	30	19	17	18	20	14	10	14	10
Africa										
4	6	40	6	40	6	40	4	10	4	10
Asia										
6	38	30	43	30	31	20	12	–	12	–

* Figures indicate the number of plants x 100 which could be tested with the amount of antiserum sent to each location.

1979, nor could it be found in the CIP germ plasm collection obtained from many parts of the Andes. It could not be mechanically transmitted to several Peruvian cultivars, but was recovered after grafting to certain British cultivars. The virus is transmitted through true seed of *Chenopodium quinoa* and *C. amaranticolor* to at least 60% of the progeny. In preliminary trials it was transmitted by the nematode, *Longidorus* spp.

A pathogenic disease of possible virus origin, tentatively named P78, causes a wide array of symptoms in potato: tip burn of apical leaflets; necrotic spotting, often marginal, of leaflets; large necrotic ringspots in some clones, and under cool conditions a transient mottle. Mechanical transmission is with extreme difficulty.

Antiserum for Virus Detection

Distribution of ASL in 1979 to national programs (Table V-4) was considerably greater than in previous years. The antiserum is also used routinely in testing for the common viruses within the CIP virology program particularly for virus identification in seed stocks and also for research purposes.

Serological techniques were taught to trainees from Pakistan, Chile, Ecuador, Peru and Turkey during 1979.

The ASL test is considerably more sensitive than the simple microprecipitation test (Table V-5)

Table V-5. Sensitivity of three assay methods for detecting five potato viruses in leaf sap.

Virus	Assay Method				Factor of sensitivity	
	Micro-precipitation	ASL	Infectivity		ASL vs micro-precipitation	infectivity vs ASL
APLV	1/512*	1/512,000*	1/16,000,000*	(2/8)**	1000	32
APMV	1/16	1/8,000	1/256,000	(2/8)	500	32
PVS	1/2,000	1/32,000	1/64,000	(1/8)	16	2
PVX	1/8,000	1/1,000,000	1/2,000,000	(2/8)	125	2
PVY	1/128	1/2,000	1/32,000	(1/8)	15	16

* Highest dilutions of sap giving a positive reaction.
** Number of infected test plants/number inoculated plants.

with the isometric viruses APLV and APMV, but less so with the elongate flexuous viruses PVY, PVX and PVS. Infectivity is still the most sensitive test for virus detection although it was only twice as sensitive as ASL with PVX and PVS. Infectivity was, however, 16 times more sensitive than ASL with PVY and 32 times as sensitive with APLV, and APMV.

ASL tests were made on sprouts and later on leaves of plants grown from the same tubers to determine the most efficient assay method. Tests on sprouts were essentially similar to those on leaves with PVX, PVS, APLV, and to a slightly lesser extent with APMV. Testing sprouts for presence of PVY was ineffective. Samples should be taken from the leaves.

Thrust VI

Control of Important Nematode and Insect Pests of Potatoes

Research continued toward developing clones resistant and/or tolerant to potato cyst nematodes, *Globodera pallida* and *G. rostochiensis*; to root-knot nematodes *Meloidogyne* spp.; to potato tuber moths, *Phthorimaea operculella* and *Scrobipalpula absoluta*; to Andean potato weevil, *Premnotrypes suturicallus*; aphids and other foliar insect pests. Biological control of nematodes and insect pests was a major emphasis during 1979. Sources of resistance to these nematode and insect pests have been identified and are being used in breeding and in integrated control programs.

NEMATOLOGY

Potato Cyst Nematodes

In developing an efficient screening technique for resistance to *Globodera* spp., major emphasis was placed on seedling tests. In either direct seeding or in transplanted seedlings, use of cysts as inoculum at planting or transplanting time is not advisable due to poor plant growth. However, when cysts were inoculated at the hilling stage, seedling growth was not affected and nematodes developed properly.

A total of 2,042 clones from seven sources were tested against two potato cyst nematode races, P_4A from Huancayo, Peru (3,300 m) and P_5A from Otuzco, Peru (3,000 m), which are equivalent to the Dutch races D and E, respectively (Table VI-1). A total of 487 clones were resistant to P_4A and 345 were resistant to P_5A. Approximately 60% of the selected clones tested were susceptible. In screening 3,219 seedlings belonging to 144 entries from Germany (13), Wisconsin (80) and CIP (51), 233 had resistance to race P_5A.

In evaluation of potential *G. pallida* resistance in 24 tuber-bearing species of *Solanum*, a high percentage of resistance was reconfirmed in *S. sparsipilum*, *S. megistacrolobum*, *S. kurtzianum*, *S. spegazzini*, *S. sanctae rosae* and *S. vernei*.

Eight clones selected for resistance in 1975 had an average *Pf/pi* (*Pf* = final population, *pi* = initial population) ratio of 6. Progeny from intercrosses of these clones have been selected for resistance from 1976-1979. Table VI-2 shows the 10 best clones in terms of resistance as well as yields. The average *Pf/pi* ratio in cyst numbers of 1.08 is a marked improvement over parental material. These are good quality clones and represent new genetic material with resistance to P_5A of *G. pallida* for crosses as well as for field trials for agronomic characters.

Table VI-1. Reaction of selected clones to two races of *Globodera pallida.*

Source of Clones	Tested No.	Resistant to race: P_4A (Huancayo) %	P_5A (Otuzco) %
Cornell	1,195	35.4	24.4
CIP	519	7.7	3.9
Wisconsin	279	–	9.0
U.S.D.A.	18	33.3	22.2
Netherlands (SVP)	13	92.3	0.0
Germany	11	45.5	36.4
Mexico	7	14.3	0.0
Total	2,042		

In 1978 three sources of resistance (P_4A and P_5A from *S. andigena* and P_4A from *S. vernei* x *S. tuberosum*) were combined into four different groups and were tested for adaptation prior to screening for resistance to two races of *Globodera pallida* P_4A and P_5A. Adaptation trials were conducted under field conditions. Of the total of 7,400 seedlings, 680 or 9% were selected. The best group of families in terms of tuber shape and yield was of the type *andigena* x (wild spp. x *tuberosum*). The least desirable group of families were the intercrosses of P_5A resistant *andigena*. They clearly showed signs of inbreeding depression. It is evident that combinations of P_4A (*vernei* x *tuberosum*) of P_5A (*andigena*) are promising as a high percentage inherited resistance to P_4A and P_5A. Thus of the initial population of 120 clones 50% were resistant to either P_5A or P_4A and 30% were resistant to both. Furthermore, there was no evidence

Table VI-2. Clones selected for resistance to *Globodera pallida* race P_5A.

Clone	Cross	P_f/P_i* P_5A (Otuzco)	Yield/Plant** (kgs)
275.151.41	700031 x 700041	0.7	.940
275.152.15	700041 (self)	1.2	1.100
275.158.1	700166 x 700031	1.8	.850
275.166.11	701535 x 700031	0.6	.750
275.166.54	701535 x 700031	0.5	.700
275.168.8	700075 x 700031	0.5	.720
275.171.1	Merpata x 73B.23	1.5	.960
275.172.18	Varena x 73B.28	1.1	.812
275.172.20	Varena x 73B.28	1.5	.780
275.172.24	Varena x 73B.28	1.4	.830
		$\bar{X}$ 1.08	

* P_f/P_i = Final population ÷ initial population.
** Mean yield of 10 plants.

Table VI-3. Pathotype identification of potato cyst nematode populations (*Glodobera* spp.) in 1978-1979.

Populations	Number	Pathotypes							
		R_1A	R_1B	R_2A	R_3A	P_2B	P_3A	P_4A	P_5A
Peru	14 (11)*	–	2	–	–	–	–	5	7
Ecuador	3 (1)	–	–	–	–	–	1	2	–
Bolivia	10 (1)	–	1	1	4	2	1	1	–
Panama	2	–	–	–	–	1	–	1	–
Mexico	2	1	–	–	–	1	–	–	–
Total	31	1	3	1	4	4	2	9	7

* Tested also by J. Kort (Wageningen, the Netherlands).

of either maternal or paternal effect on the progeny.

Ten seedlots of crosses of clones resistant to *G. rostochiensis* R_1 A and *G. pallida* (P_4 A and P_5 A) were sent to Cornell for a test with race R_1 A. A total of 120 clones were rated resistant and sent to CIP for a further test to *G. pallida*.

The two clones reselected for resistance to race P_4 A from the germ plasm collection were tested against 33 different cyst nematode populations from Colombia, Ecuador, Peru and Bolivia. Clone 702535 reacted resistant to 30 of these while 702698 only to 16. The latter is thus considered a less desirable parent in the breeding program.

Potato cyst nematodes from India were identified by female color as *Globodera pallida* and *G. rostochiensis* species. This was confirmed when females' morphometrics were studied. Thirty-one populations have also been tested on differential plants to characterize the Andean distribution of pathotypes and their frequencies. Results show a new pathotype (P_2 B) and continuing predominance of P_5 A and P_4 A (Table VI-3). Some of these populations have also been tested on differential plants in Holland and results agree with CIP pathotype identification. For the first time, the presence of a new pathotype in a population from Bolivia has been detected.

Root-knot Nematode

A total of 213 families consisting of the fourth cycle of recurrent selections for resistance to root-knot nematodes were tested for resistance to *Meloidogyne incognita*. These families were represented by 11,085 genotypes which were grown in plastic cups and inoculated with 4,000 *M. incognita* eggs. Two months later the roots were removed from soil and evaluated for nematode infection (Table VI-4).

Segregating progenies immune to *M. incognita* consisted of 18.4% of the total population tested. In considering a galling index of 2 as resistance (based on 1 = no infection to 5 = very severe infection), total resistant and immune clones constituted 35.5% of the population. This is a substantial increase from the 3.5% resistance in initial screening of wild and cultivated *Solanum* species. Stem cuttings of most immune and some resistant plants were transplanted to the field. In addition, some tubers of

Table VI-4. Reaction of families consisting of the fourth cycle of recurrent selections for resistance to *Meloidogyne incognita*.

Families Tested	Total No. Seedlings	Root galling index *				
		1	2	3	4	5
213	11,085	2,040	1,890	3,707	3,306	142
		18.4%	17.1%	33.4%	29.8%	1.3%
		35.5%				

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

resistant clones of the first and second cycle of recurrent selections (from the previous years) were also planted. Of 184 families represented by 1,469 clones, a total of 63 clones consisting of 28 families were selected (Table VI-5). Similarly, 54 clones of the first and second cycle selections representing 11 families were selected. High yields of up to almost 3 kg/plant in the fourth cycle selections and up to 2.2 kg/plant in the first and second cycle selections were not uncommon. This material will be used for further testing for additional desired characters.

Some progenies of 4x - 2x intercrosses were developed from lowland tropic adapted clones used as females crossed with bulk pollen from intra- and interspecific hybrid clones selected for both *Meloidogyne* and *Pseudomonas* resistance. Contributing species in these crosses were *S. sparsipilum*, *S. chacoense*, *S. microdontun*, *S. phureja* and *S. stenotomum*. From 76 clones representing 32 families tested for their reaction to *M. incognita*, 10 clones were selected as immune or resistant (Table VI-6). All 76 clones are being tested for resistance to *Pseudomonas solanacearum* in addition to yield. Intercrosses of these clones should provide a higher number of resistant segregating progenies.

Biological Control

A fungus of the group hyphomycetes identified as *Paecilomyces*

Table VI-5. Field trials of the 4th and 1st + 2nd cycle recurrent selections of *Meloidogyne incognita* resistant material.

Source	Families Tested/Selected	Clones Tested/Selected	Range of Kg Yield/Plant
Stem cuttings			
4th cycle of recurrent selections	184/28	1,469/63	0.201-2.98
Tubers			
1st + 2nd cycle recurrent selections	60/11	678/54	0.39-2.214

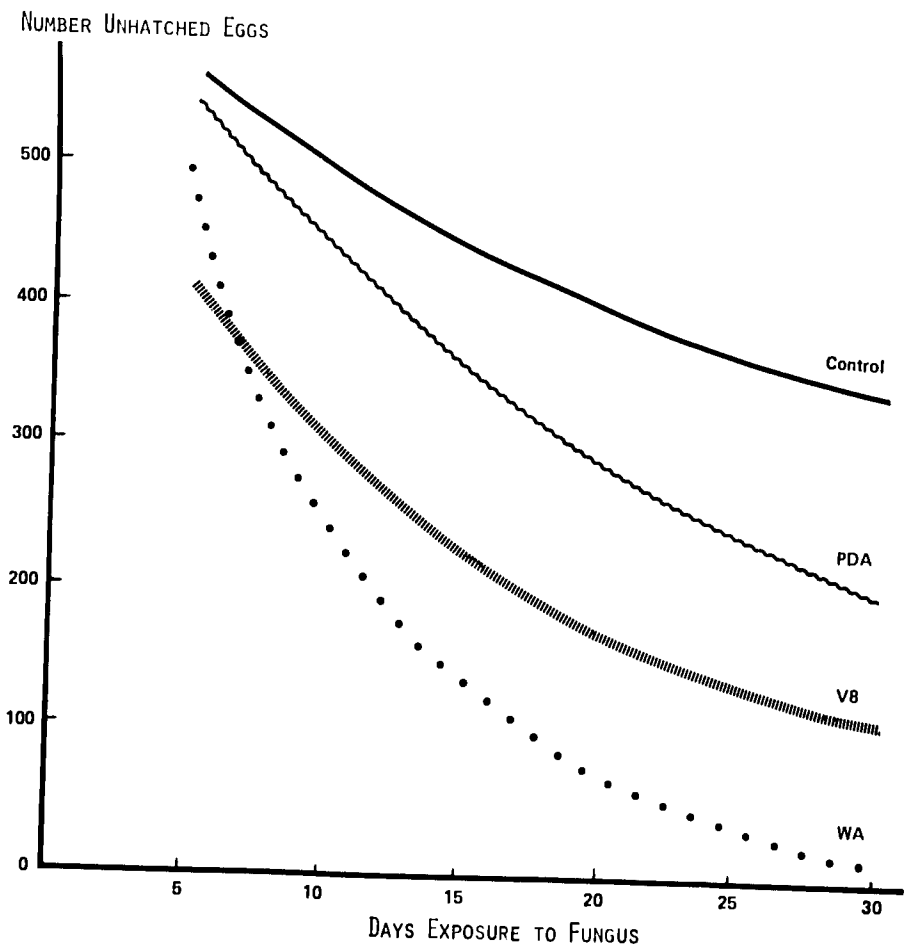
Table VI-6. Reaction of the progenies of 4X - 2X intercrosses to *Meloidogyne incognita.*

Families Tested	No. Clones	Root galling index *				
		1	2	3	4	5
32	76	3	7	29	33	4

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

lilacinus Thom. Samson was isolated from *Meloidogyne* egg masses found on an infected potato root from Huánuco. Preliminary greenhouse and laboratory experiments showed that this fungus was not plant pathogenic. To determine the efficiency of *P. lilacinus* as a biological control agent, egg masses of *M. incognita* were placed on

Figure VI-1 — Number of viable eggs of *Meloidogyne incognita* in different media inoculated with *Paecilomyces lilacinus.*



plates containing different media inoculated with the fungus. Results indicate that *P. lilacinus* infected eggs within 5 days and destroyed the embryo. Percent infection of the eggs was directly correlated with length of time they were exposed to the fungus (Figure VI-1). Egg masses placed on water agar inoculated with *P. lilacinus* were infected more readily and at a higher percent. This is attributed to lack of nutrient in water agar and the availability of the eggs as a food source. Data is presented as the function of the number of eggs hatched.

Tubers were treated in a greenhouse with spores of *P. lilacinus* prior to planting in a *M. incognita* infested soil. A reduction of up to 70% was observed in the number of egg masses and root galls caused by *M. incognita* in the fungus-treated tubers. In addition, up to 60% of the eggs within egg masses were infected with the fungus, reducing the number of subsequent nematode generations (Table VI-7). Similar results of a randomized block field experiment indicate that plants grown in plots inoculated with the fungus had a significantly lower root galling index than those grown in nematicide treated plots (Table VI-8).

Eighty-six percent of egg masses collected from plants grown in fungus treated plots were infected and 54.7% of the eggs within were destroyed. This is the first report of a successful application of a fungus for biological control of nematodes under field conditions.

Effects of this fungus on *Globodera pallida* were not as conclusive or as outstanding as those on *Meloidogyne*. Data indicate the fungus grows well on both potato dextrose agar and a medium of V8 juice and $CaCo_3$. It sporulates within 24 hours and has a high reproductive capability.

Table VI-7. Effect of two types of tuber applications of *Paecilomyces lilacinus* on the infection by *Meloidogyne incognita*.

Treatment	Average No. of galls & egg masses/plant
Dry spores	114.5
Spores in tween 80	182.5
Non-treated	377.0

Table VI-8. Effect of different treatments on the reaction of potato cv. "Cuzco" to *Meloidogyne incognita*.

Treatment	Average root galling index *	% egg mass infection	% eggs destroyed
Paecilomyces lilacinus	2.93	86.0	54.7
Temik 10% G (25 kg/ha)	3.36	0	0
Nemacur 5% G (50 kg/ha)	3.44	0	0
Furadan 5% G (50 kg/ha)	3.57	0	0
Organic matter (10 ton/ha)	3.62	0	0
Control	3.60	0	0
L.S.D. 0.01	0.19		
0.05	0.14		

* Based on 120 observations.
1 = no root galling to 5 = very severe root galling.

Table VI-9. Survival of *Nacobbus aberrans* in air dried soil.

Source of Inoculum	Root galling index *					
	1 mo.	5 mo.	8 mo.	12 mo.	16 mo.	24 mo.
Moist infested soil	3.5	3.8	3.4	3.0	3.0	3.0
Dried infested soil	3.2	3.3	3.0	3.1	3.0	1.2
Uninfested soil	1.0	1.0	1.0	1.0	1.0	1.0

* 1 = no root galling to 5 = very severe root galling.

Optimum temperature for growth of this fungus on PDA was 25°C and 30°C on V8 juice media. This is desirable because *Meloidogyne* species attacking potatoes require relatively high temperatures for development.

False Root-Knot Nematode

Survival of *Nacobbus aberrans* under dessicated condition for up to 8 months was reported last year. However, because limits of survival under this condition were not known, further studies were made of its survival in air dried soil (relative soil humidity of 7% - 9%). Data indicate that *N. aberrans* can survive and withstand dessication for at least 24 months as immature adult females and eggs (Table VI-9).

Because soil temperatures in the highland plateaus of Peru and Bolivia drop below 0°C, an additional study was made to determine if *N. aberrans* can survive such temperatures. *Nacobbus*-infested soil and infected tomato roots packed in sterilized soil were placed in small plastic bags and stored in a freezer with a temperature of -13°C. Monthly samples were taken to determine survivors. It was determined that *Nacobbus aberrans* can survive a temperature of -13°C for at least a year as immature adult females and will infect plants readily after thawing of soil (Table VI-10). Preliminary observations indicate that chilling the infested soil for a month prior to its use as inoculum would enhance nematode infection. Data support the potential viability of *N. aberrans* under adverse conditions in the Andes.

Table VI-10. Survival of *Nacobbus aberrans* under adverse temperature conditions.

Treatment	Root galling index at different exposure periods *				
	1 mo.	3 mo.	6 mo.	9 mo.	12 mo.
Stored at -13°					
Infected roots	2.0	2.0	1.3	1.3	1.7
Infested soil	3.0	3.0	1.0	1.3	1.7
Control					
Infected roots	4				
Infested soil	4				

* 1 = no root galling to 5 = very severe root galling.

Potato Tuber Moth

The major species of tuber moth, *Phthorimaea operculella*, received major emphasis. This species, which attacks both tubers and foliage, is found in combination with *Scrobipalpula absoluta* which primarily infests the foliage. These two species are difficult to distinguish in the adult stages. However, larvae of *P. operculella* have a distinct distinguishing sclerotized triangular brown patch in the first segment behind the head region. Studies related to storage damage potential indicate that even a low population of 60 larvae per 20 kg potatoes damaged 100% of the tubers within 110 days after infestation (Table VI-11).

A simple, quick laboratory screening method has been developed for the first time to identify resistance (CIP Circular 1979, Vol. VII, No. 5). The visual scale used for screening is shown in Figure VI-2. In the field, selective insecticides such as Pirimor and Dipterex have been used for screening to identify resistance to this insect. Under laboratory conditions 1,066 clones were tested for resistance of which 770 were from the inventory of accessions maintained at CIP for resistances to certain pests and diseases. Twenty-four accessions, significantly less damaged due to infestation by first instar larvae, have been selected for further resistance trials. Of 30 root-knot nematode resistant accessions screened, three clones were resistant with high levels of antibiosis (Table VI-12). (Genetic background of these clones consist of combined genes of *Solanum sparsipilum*, *S. chacoense* and *S. phureja*.) Field studies of the relationship between mean tuber depth and percent of tubers damaged by potato tuber moth were conducted in Huancayo, at 3,300 m, and at El Asesor on the coast. Results of the Huancayo studies are in Figure VI-3. Tuber depth was significantly correlated with tuber damage (r = -0.5197). Oviposition tests with 1- to 2-day-old adult moths indicated significant egg laying differences in certain potato clones selected for resistance (Table VI-13). However, both rugose and smooth skined tubers of "Renacimiento" variety were equally preferred for oviposition. Skin type does not appear to influence egg laying by this insect.

The role of "Muña" an Andean weed *Mintostachys* sp. (Fam: Labiatae), in reducing oviposition

Table VI-11. Damage by potato tuber moth larvae to potato tubers of variety "Mariva" under storage conditions.

No. of larvae infested per 20 kgs.	% Tubers Damaged (Days after infestation) 21	110
30	6.00	39.00
60	8.00	100.00
90	13.00	100.00
120	17.00	100.00
Check	0	0

Table VI-12. The reaction of selected root knot resistant clones to potato tuber moth larvae.

Clone	Resistance Rating*	Type of Resistance	No. of holes/tuber	Pupation	Adult Development
116-36	R	Antibiosis	–	Absent	Absent
108-27	R	Antibiosis	0.50	Absent	Absent
120-13	R	Antibiosis	0.83	Absent	Absent
96-23	S	–	2.70	Normal	Normal
88-19	S	–	3.50	Normal	Normal
79-60	S	–	3.60	Normal	Normal

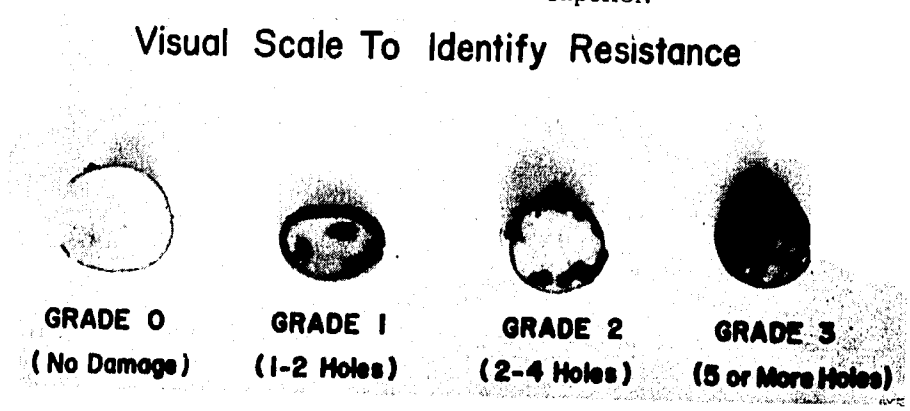
* R = Resistant S = Susceptible

and damage by potato tuber moth in storage was investigated under laboratory conditions. Egg laying was significantly reduced when this weed was present (Figure VI-4). Further studies in storage indicated that covering potato tubers with this weed gave significant protection against egg laying and damage by the tuber moth.

Seasonal patterns of potato tuber moth abundance were determined for Huancayo and El Asesor regions by pheromone trapping. Populations were high in both areas with slightly lower populations in Huancayo than in El Asesor. The incidence of tuber moth (*Phthorimaea operculella*) during the spring crop was measured at Menemen, Turkey, using pheromone traps. Up to 34 males per day were monitored between 9 and 14 weeks after plant emergence. Such data could aid in more effective timing of insecticide application for control. More detailed investigations will begin in 1980 with posting of an entomologist in Turkey.

A polyembryonic parasite, *Litomastix* sp. (Hymenoptera: Encyritidae), has been found attacking the tuber moth larvae. Studies of using this insect as a potential biological control are underway. In chemical control studies with carbamate, organophosphate and pyrethroid insecticides the pyrethroid insecticides were superior.

Figure VI-2 – Visual scale to identify resistance to potato tuber moth, *Phthorimaea operculella*.



Aphids

Emphasis has been on stabilizing genes for high densities of glandular trichomes, known to suppress populations of aphids, leafhoppers, thrips, mites and flea beetles. Interspecific crosses between *S. berthaultii*, selected for high densities of glandular trichomes, and "Pentland Crown" (*S. tuberosum*), with field resistance to potato leafroll virus (PLRV), were evaluated and selected for glandular trichomes. Certain F_2 progeny of *S. berthaultii* and *S. phureja* crosses were also selected and are being used in breeding. Aphid suppression studies in F_2 clonal selections of *S. berthaultii* x *S. phureja* with varying densities of glandular trichomes are summarized in Table VI-14. Cultivar "Renacimiento" which has very few glandular trichomes supported higher populations of *Myzus persicae* Sulzer.

In an attempt to identify new wild species with glandular trichomes, 138 *Solanum* accessions from 72 wild species obtained from Sturgeon Bay, Wisconsin, were tested. Of species tested *S. ambosinum*, *S. polytrichon*, *S. pampasense*, *S. raphonifolium* and *S. multidissectum* had high densities of 4-lobed trichomes (2.7-6.1/mm^2).

The effect of glandular hairs on PVY transmission by *M. persicae* on *S. berthaultii* was studied at Rothamsted. Preliminary results indicate that this species was more difficult to infect with PVY.

Figure VI-3 — Relationship between tuber depth and tuber damage by potato tuber moth larvae for 31 accessions in Huancayo.

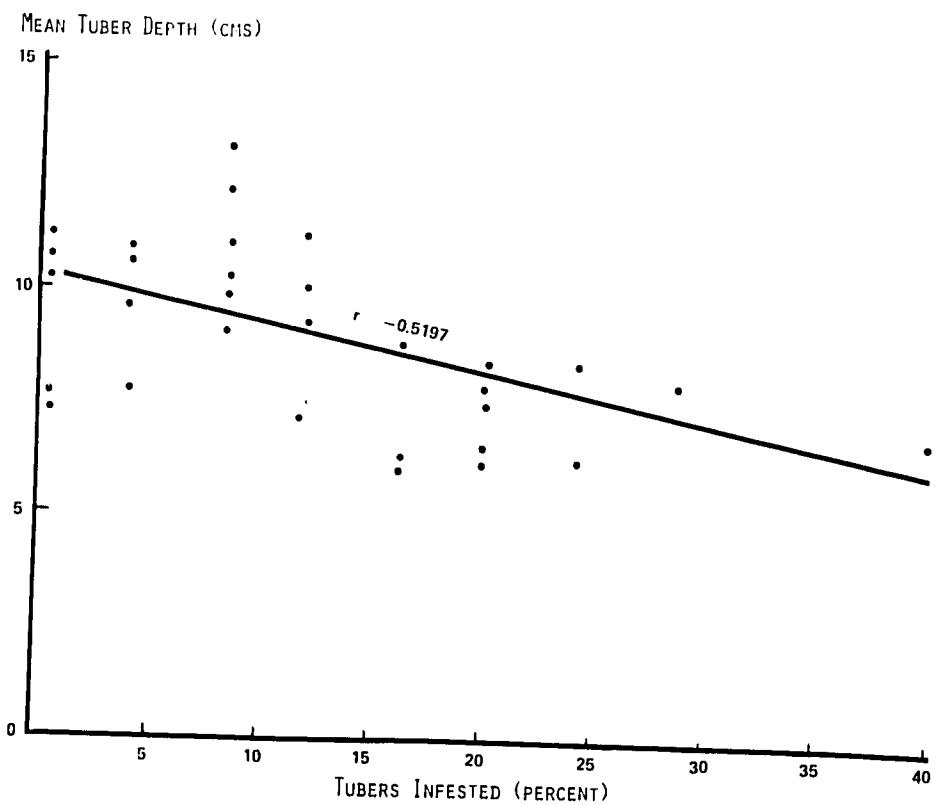


Table VI-13. Differences in egg laying by potato tuber moth in certain potato clones.

Clone	No. of Eggs Tuber (Days after infestation) 2	4	12
CIP 700502	43a 1/	72a	85a
CIP 702205	15b	18b	20b

1/ Means within the column followed by different letters are significantly different at the 0.1 level by the paired T test.

Acquisition of PVY by aphids was signigicantly lower on plants possessing glandular trichomes. Studies have begun to determine if glandular trichomes restrict PLRV transmission by aphids under field conditions.

Studies on effects of Type A (4-lobed) and B (simple) trichomes on resistance at Cornell University indicated accessions with both types were far more resistant than those with Type A alone. Tarsal and labial gumming tended to increase with pooled density of Type A and B trichomes for *E. fabae* and *M. persicae*. Frequency

Figure VI-4 – Effect of *Mintostachys* sp. (muña) on oviposition by potato tuber moth.

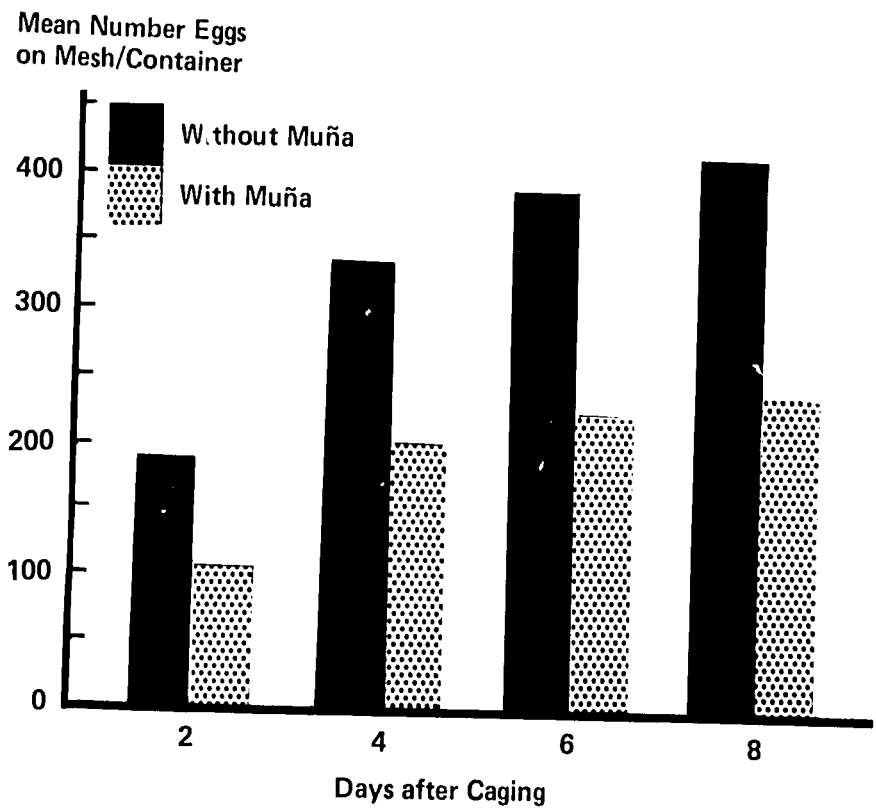


Table VI-14. Effect of varying densities of glandular trichomes on green peach aphid infestation.

Cross	Cycle	Plant No.	Abaxial trichome density/mm² Simple	4-lobed	x̄ Aphids/Plant 12 DAI
S. berthaultii x *S. phureja*	F_2	1	6.0	4.0	6.6
		2	5.0	3.5	5.0
		3	3.0	3.0	3.0
		4	3.0	4.0	2.5
		5	4.0	2.0	5.0
		6	5.0	2.0	3.3
		7	3.0	4.0	2.5
		8	3.0	4.0	2.3
		9	4.0	3.0	1.3
	Renacimiento		–	0.4	32.00

of gummed tarsi for the former species was highly correlated with trichome density (r = 0.72), while that for gummed labia of green peach aphid followed a similar trend (r = 0.80). Resistance and yielding ability of 11 seedling clones of *S. tuberosum* x *S. berthaultii* selected for high glandular trichome densities showed that infestations of *E. fabae* nymphs and adults were reduced 90% and 97% on the most resistant clones PCB 4-103-2, compared to the *tuberosum* cultivar. The highest yielding clone, B227-128, produced an average of 736 g/plant.

Preliminary studies on the chemical defense mechanism of glandular trichome indicate that the browning reaction associated with glandular trichomes of *S. berthaultii* was due to the action of polyphenol oxidase (PPO). However, it is unlikely that PPO is the only phenolic oxidase system in trichomes. The involvement of a peroxidase-dependent phenolic oxidase system is being investigated. In addition to these enzymes the possible presence of phenolic compounds are being studied. The major phenolic component identified was protocatechuic acid. A rapid screening test for glandular trichome effectiveness has been developed by measuring the PPO activity of glandular trichomes.

Andean weevil

Reaction of tuber-bearing *Solanum* species (*S. stenotomum*, *S. juzepczukii*, *S. tuberosum* ssp. *andigena*, *S. curtilobum*, *S. acaule* and *S. ajanhuiri*) to the Andean weevil *Premnotrypes suturicallus* Kuschel indicate that clone OCH 12059 (*S. acaule*) was the most resistant to adult feeding and clone CIP 702558 (*S. ajanhuiri*) was highly susceptible. Longevity of this insect was highest on clone CIP 10112 *S. acaule* (127 days) and lowest on *S. stenotomum* clone OCH 3486 (56 days). Number of eggs laid was highest on clone CIP 701022 *S. juzepczukii* (19 eggs/female) and lowest on clone HUA 876 *S. ajanhuiri* (3 eggs/female).

There was no correlation between foliar and tuber damage.

Infestation and penetration of tubers by the larvae was least on *S. tuberosum* subsp. *andigena* clones. Percent tuber damage was significantly correlated with the depth of tubers (r = -0.49).

Leafminer Fly

Only open-pollinated progeny 575031 was rated moderately resistant in an experiment in which true seed from 36 open-pollinated families planted in the field for agronomic trials were evaluated for leaf mining damage by *Liriomyza huidobrensis* Blanch. All others were susceptible.

Among cultivated clones, cultivar "Tomasa Condemayta" was previously identified as resistant. Microscopic examination of this cultivar revealed high densities of simple non-glandular hairs on the lower leaf surface.

Thrust VII

Physiological and Agronomic Management of Potatoes Adapted to Environmental Stress

Agronomic research is organized to develop appropriate cultural practices to grow potatoes under tropical conditions characterized by high temperature and in new areas where the crop is not presently commercially cultivated. Good yields have been obtained in farmers' fields in the high Peruvian jungle of San Ramón with commercial varieties normally grown in the Andean mountain regions. Similarly, these varieties have produced well when evaluated with different production input packages under coconut palms without supplementary irrigation and only 300 mm rainfall. This indicates the potential in large tropical areas of the world for potato production by benefiting from the shading effect of coconut palms and possibly other trees.

Information is being obtained on the effect of aluminum toxicity on potato yield, a limiting factor in some tropical soils of the world. Rock phosphate seems to reduce aluminum toxicity and differences in tolerance have been found in some potato clones.

Promising results in development of a screening method for heat tolerance. This allows the selection of heat tolerant clones at the seedling stage. Thus, large numbers of seedlings can be evaluated in a short time with minimum space.

The use of "plug-mix" has been helpful in growing potatoes from true seed under tropical environments by accelerating seed germination and controlling the effect of soil crusting. Research emphasis is on transplanting seedlings from nurseries to field, Because of advantages this technology has for small farmers, relative to the period the crop stays in the field and similarity in agronomic management practices of transplanting other vegetables.

Agronomic Management

Climatic conditions of the high tropical jungle of San Ramón, Peru (850 m altitude) characterized by high temperatures and seasons of high and low rainfall are major agronomic constraints for growing potatoes. No commercial potato production is known in this area or at lower altitudes.

A set of agronomic and phytosanitary control practices have emerged from several years of CIP research at the experiment station El Milagro in San Ramón. These practices were based on high technology inputs. From this knowledge, three technological packages that included high, medium and low production inputs were evaluated. Research was on use of fertilizer and use of soil pesticides and herbicides were evaluated in farmers' fields as well as at the CIP

station during high and low rainfall season. Commercial potato varieties grown in the mountain region of Peru and one from Mexico were used in these experiments.

During the high rainfall season (1,000 mm from December 1978 to March 1979) yield trials in two farmers' fields (SC and CH) and the CIP station gave these results:

- Significant differences in yield between varieties with Mariva the highest (21.3 ton/ha) followed by Revolucion (17.4 ton/ha) and Antarqui (12.9 ton/ha). No significant yield differences were found among agronomic packages in farmers' fields either within varieties or with combined varieties. At the CIP station, within pooled varieties, the high input package significantly outyielded the low input.

  The overall mean yield at CIP station was significantly higher (21.5 ton/ha) over the farmers' field trials (18.5 ton/ha and 11.7 ton/ha). These results reflect the different management and environmental conditions between locations. They also suggest the potential to increase yield through improved management practices.

During the low rainfall season (300 mm from June to September, 1979) two other farmer field trials were added (RC and EC). EC was planted under coconut palms to evaluate effect on potato yield of lowered light intensity, air and soil temperatures, and maintaining higher soil moisture during the dry periods.

Yield results during the low rainfall season trials showed no significant differences between the varieties Cuzco, Revolucion, Rosita and Antarqui (Table VII-1). The high input treatments outyielded significantly the other two treatments when yields were pooled over sites. Within locations, high input treatments always outyielded low input treatments. Significant differences in yield were produced over locations, with the yield at the CIP station being highest. Potato yields under coconut palms and the RC farmer's field were not different, although significantly superior to SC and CH. The major reason for these differences was attributed to supplementary irrigation at the CIP station and the RC field, but not to the trials under coconut trees. This suggests the positive effect of shading on temperature and soil moisture.

Fertilizer trials under field conditions of San Ramón with commercial varieties grown in mountain regions provided these results:

- Highly significant yield increases from 14.3 ton/ha to 18.2 ton/ha by doubling the formulation of 80-80-80 kg of N-P-K.
- Treatments with 2 ton/ha of rock phosphate produced the highest yields (20.6 ton/ha).

Plant emergence studies were under high temperature-humid conditions of Yurimaguas at 180 m in the Amazon jungle. Significant differences were noted in number of days required for plants to emerge when tubers were planted at different depths, with and without grass-mulch. Although plants emerged sooner under mulch (16.4 days) when compared with no mulch (22.9 days), no differences were found between depths of planting. Plants under mulch conditions, 68 days after emergence were 14-18 cm taller than plants without mulch.

Table VII-1. Yields in ton/ha of three agronomic packages evaluated in the open and under coconut trees in farmer fields and at the CIP station in San Ramón during the low rainfall season.

Packages	Mean yield of 3 varieties in ton/ha					
	Farmers' fields				CIP Station	Mean all locations
	SC	CH	RC	EC under coconuts		
Low Inputs	4.9 b*	8.2 b	13.7 b	13.0 b	22.5 a	12.5 c
Medium Inputs	7.1 a	10.8 a	14.6 b	14.8 ab	23.6 a	14.1 b
High Inputs	7.8 a	12.0 a	16.3 a	16.7 a	23.2 a	15.3 a

* Mean yields in vertical rows followed by the same letter are not significantly different at P = 0.05 by Tuckey Test.

Preliminary results from agronomic trials in hot humid coastal areas of the Philippines with commercial varieties indicate that mulching and shading are appropriate practices to improve tuber production under these adverse conditions. Deep planting and supplementary irrigation produced higher yield and better quality potatoes than shallow planting with or without irrigation.

Potatoes from True Seed

Research at CIP for development of agronomic technology to produce potatoes from true seed has been at several locations representing a range of environments from temperate to tropical climate. Two methods for growing potatoes from true seed are being investigated: (1) direct seeding, and (2) transplanting seedlings from nursery to field.

Yields of true potato seed progenies at El Asesor, Lima.

Under tropical conditions at San Ramón and during summer in Lima, the major agronomic problems in direct seeding are: (1) soil crusting, (2) keeping soil moisture constant for adequate germination and growth, and (3) weed competition and control.

In testing several combinations of soil media on germination, a local Peruvian organic soil called "Pomacocha" was best when compared with sand or peat moss. The major effect was to prevent soil crusting. Germination was lower when seed was sown directly in a shallow furrow and covered with soil.

Initial germination of several controlled cross-pollinated and open-pollinated progenies treated and non-treated with gibberellic acid occurred within 3 to 5 days while complete germination was after 12 to 14 days. The germination period varied in different progenies. No difference was noted in germination between gibberellic acid-treated and non-treated true seed when seeds were approximately 6 months old.

To control soil crusting and hasten seed germination, a "plug-mix" seeding technique was evaluated. Local peat moss was mixed thoroughly with true potato seed and water added slowly during mixing until the peat moss was saturated. The mix was next placed in a plastic bag and left for 2 days to pre-germinate the seed before sowing. Under high temperature conditions a more uniform and rapid seed germination was obtained within 6-8 days versus 12-14 days without the "plug-mix." More than 0.7 gr of true seed per 10 liters of peat moss did not increase yield significantly although the rate of 0.9 gr of seed produced the highest hill density and yield (Table VII-2).

Table VII-2. Yield of several true potato seed rates in "plug-mix" under summer conditions in Lima, Peru.

Grams of True Seed per 10 liters peat moss	Hills established %	ton/ha
0.4	48	12.0 c*
0.5	53	12.0 c
0.6	65	13.0 bc
0.7	65	14.8 ab
0.8	73	15.9 ab
0.9	80	16.4 a

* Mean yields followed by the same letter are not significantly different at P = 0.05 by Tuckey Test.

In comparing different formulations of "plug-mix", highest yields were obtained with a commercial growing medium "Jiffy-mix," which contains several plant nutrients. However, because of its expense, trials are underway to determine effects of adding fertilizer to the local growing medium.

A major emphasis in agronomic research for producing potatoes from true seed is on transplanting seedlings from nurseries to the field. In nursery bed soil mixes, highest seed germination and most vigorous seedlings were from 2 parts peat moss, 2 parts organic soil ("Pomacocha") and 1 part sand.

Under high temperatures seedlings between 6-12 cm height produced the highest plant density and significantly superior yields when transplanted with all leaves above ground and with a soil plug around the roots. No differences were noted in survival when transplanting seedlings with bare roots or soil plug around the roots under cool and adequate soil moisture conditions.

Preliminary results indicate, for both direct seeding and transplant-

Table VII-3. Yield of transplanted seedlings with different rates of nitrogen in Waynesville, N.C. (USA).

Nitrogen rate, kg/ha*			
At transplanting	At hilling	Hills established %	ton/ha
130		85	20.4a**
130	60	81	19.5ab
190		79	17.1abc
190	60	82	17.1abc
130	120	83	17.3abc
250		85	13.1c

* P and K were constant at a rate of 200 kg/ha each.

** Mean yields followed by the same letter are not significantly different at P = 0.05 by Tuckey Test.

ing, that a fertilizer formulation of 160-160-160 kg of N-P-K per hectare is adequate for high yields under Lima and San Ramón conditions. In Waynesville, North Carolina, USA, highest yield was from 130 kg of N per hectare incorporated at transplanting time with 200 kg/ha each P and K (Table VII-3).

Three seedlings per hill produced optimum yield; however, this density per hill may change depending upon new information from evaluations of true seed progenies and their interaction with fertilizer levels and plant density within the row. The practical minimum number of seedlings transplanted per hill should not be less than two. This is specially important under tropical conditions to assure adequate plant density under conditions of high temperature, moisture stress and attack by insect such as cutworms, leafminer fly and tuber moth.

In the past 2 years several open-pollinated and controlled cross-pollinated progenies have been evaluated under both moderate climates and tropical high temperate environments. As shown in Table VII-4, the yielding ability of several progenies from current breeding programs is good in both environments and the foliage and tuber skin color and shape in some are as uniform as standard commercial varieties.

Physiological Studies

Preliminary data suggest that under high temperature conditions

Table VII-4. Mean yield in ton/ha of progeny groups and best progeny of transplanted true seed seedlings.

Progeny group*	Foliage, tuber uniformity	Mean yield in ton/ha of progeny groups and best progeny							
		Lima (Winter)		Lima (Summer)		San Ramón		Waynesville NC	
		Mean	Best	Mean	Best	Mean	Best	Mean	Best
Wisconsin cp W	Acceptable	15.9	16.9	28.2	31.5	6.0	7.7	12.9	21.4
Cornell cp A	Acceptable	12.0	15.1	25.9	35.8	9.8	18.0	11.0	22.0
Cornell cp U	Good	9.0	11.5	24.7	25.6	4.6	6.8	11.3	11.7
Cornell op U	Fair	24.7	25.7					4.9	7.8
CIP cp HT	Acceptable	32.9	42.3	17.2	19.6	9.3	10.9		
CIP op HT	Acceptable	22.4	27.5	16.9	18.1				
CIP cp LT	Good	37.3	45.6			11.0	17.2		

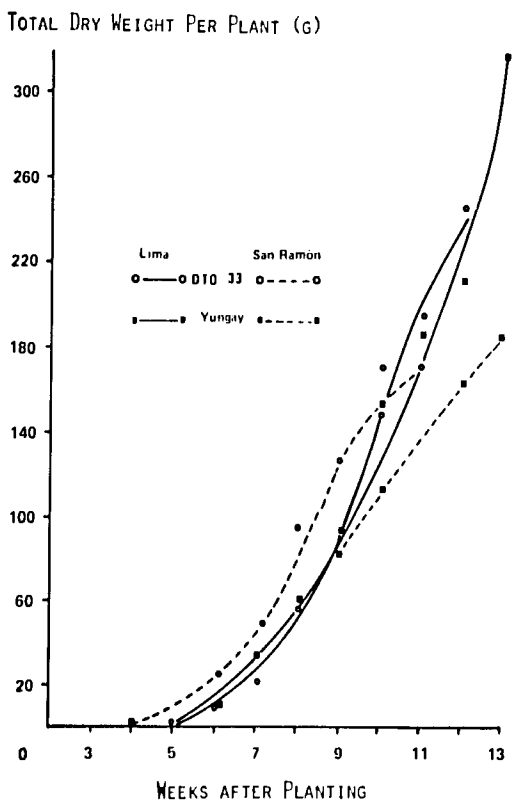
* cp: controlled cross-pollinated progenies.
op: open-pollinated progenies.

W: Wisconsin progenies.
A: Cornell progenies (tub x adg) x tub.
CPU: Cornell progenies tub x bulk adg.
OPU: Cornell andigena progenies.
HT: Highland tropic adapted progenies.
LT: Lowland tropic adapted progenies.

adapted clones may have a lower endogenous Gibberellic acid (GA) activity than non-adapted clones. This may be one mechanism enabling adapted clones to tuberize under sub-optimal conditions. This was tested with three varieties of different adaptation grown in growth chambers under two day/night temperature regimes: 20° C/15° C and 30° C/20° C.

Extracting GA's from the shoot and roots biweekly showed that high temperature increased GA activity in both shoots and roots of all three varieties. In heat tolerant clone DTO-28, the GA activity was lower in the roots and higher in the shoot than in non-adapted varieties. To further examine this, feeding experiments with $^{14}CGA_3$ were carried out. After feeding plants grown under high temperature conditions via the shoot with $^{14}CGA_3$, in DTO-28 only 20% of the total ^{14}C activity of the roots was still associated with GA activity. In contrast, more than 57% total ^{14}C activity in the roots was still associated with GA in the non-adapted variety Mariva if exposed to the same temperature. This could indicate ability of adapted clones such as DTO-28 to tuberize under high temperatures in spite of rather high GA activities in the shoot. This may be due to the ability of its root system to inactivate GA.

Figure VII-1 — Total dry weight of heat tolerant clone (DTO-33) and a non-heat adapted clone grown under coastal desert conditions (Lima) and high jungle (San Ramón).



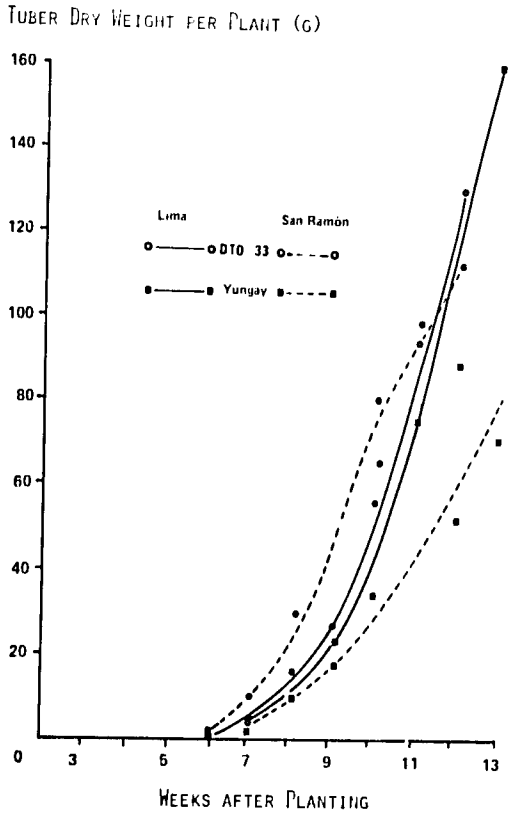
When individual growing tubers were subjected to high temperatures (35° C) tuber growth stopped. Simultaneously, growth rate of the remaining untreated tubers of the same plant increased. Resumption of tuber growth after the period of high tuber temperature (7 days) was mainly restricted to areas near the eyes, leading to malformation of the tuber. These effects were irrespective of the variety tested (Ostara, DTO-28, Mariva).

Comparison of growth and development of the non-heat adapted variety Yungay under high jungle conditions (San Ramón) with those in coastal desert (Lima) showed a reduction in dry matter and in tuber yield (Figure VII-1 and 2). Not only the total dry matter production but also the partitioning of the carbohydrate was affected. About 50% of total dry matter remained in the tubers while in Lima 97 days after planting in contrast only 35% remained in the tubers under higher temperature conditions at San Ramón. The adapted clone DTO-33 reacted

quite differently. Total dry matter production and tuber yield were almost unchanged at the final harvest. Because DTO-33 reached its maximum leaf area at San Ramón about 2 weeks earlier and also senesced earlier than in Lima, the bulking period was longer in Lima than in San Ramón.

To identify the major physiological constraints on tuber yield the influence of environment in the hot tropics on source-sink balance was studied. Three varieties with different adaptation, DTO-33, Mariva and Yungay were shaded (actual shade 51%) 3 weeks after the first tubers were detected (Figure VII-3).

Figure VII-2 — Tuber dry weight of heat tolerant clone (DTO-33) and a non-heat adapted clone grown under coastal desert conditions (Lima) and high jungle (San Ramón).



Data suggest that source activity limited tuber growth in the adapted clone DTO-33 under San Ramón conditions. DTO-33 was sink limited in Lima as were Mariva and Yungay in both Lima and San Ramón. These results suggest that if DTO-33 is typical for adapted material, breeding for higher photosynthetic efficiency (lower light respiration) may be beneficial. Also, because leaf longevity was reduced under San Ramón conditions by about 10 days, this restricted length of the bulking period. Lengthen leaf longevity either by breeding for this characteristic or by management practices (such as fertilization or shading) would probably be beneficial.

Adaptation to High Temperature

From the physiological viewpoint, a plant adapted to high temperature conditions should have vigorous shoot and root systems, early tuberization and rapid tuber growth.

Heat tolerance screening used 4-week-old seedlings exposed for 28 hours to 40°C in darkness. Then, surviving seedlings were selected and tubers planted in San Ramón and in Yurimaguas. No significant yield differences were noted from the material planted. However, plants selected for heat tolerance were visibly more vigorous, particularly in Yurimaguas under Amazon jungle conditions.

To screen for early tuberization under high temperature conditions, a new method is being developed. Four-week-old seedlings planted in small plastic cups were grown in a glasshouse with maximum day temperature of 38°C and minimum night temperature of 21°C. Three weeks later they were examined for tuberization simply by pulling out the entire root system. Plants that

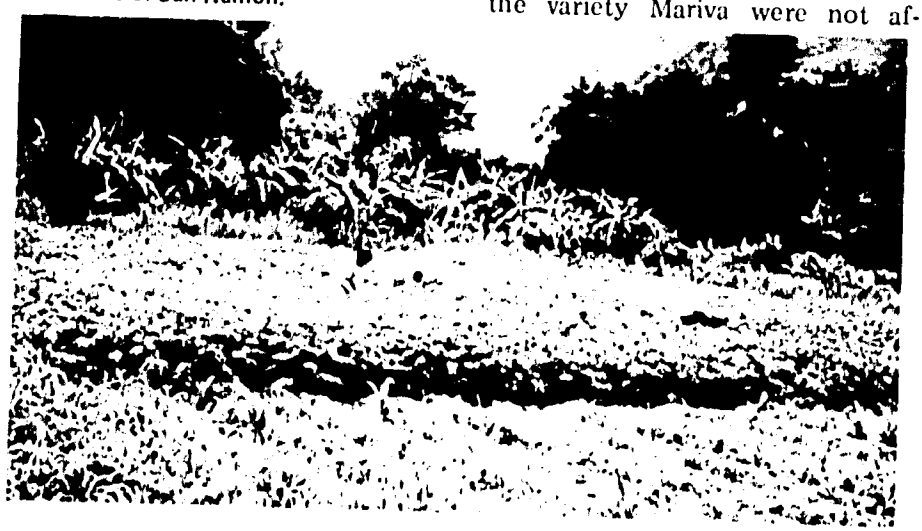
Figure VII-3 — Shading experiment for potatoes in Lima. Covers gave an actual shade of 51 percent.

tuberized early were transferred to a screenhouse for multiplication in pots. The remaining non-tuberized plants were maintained in the glasshouse for 4 more weeks and then evaluated again. At this time both tuberized and non-tuberized plants were transferred to a screenhouse for further growth and tuber formation. Thus, three groups of seedlings were obtained: (1) early tuberization under glasshouse treatment, (2) late tuberization under glasshouse treatment, and (3) those that did not tuberize under glasshouse treatment, but tuberized when transferred to screenhouse conditions. Tubers from these three groups are being screened under high temperature field conditions to determine if the screening procedure correlates with field performance.

Aluminum Toxicity

In pot experiments with soils of the low jungle near Pucallpa in Peru, when the concentration of exchangeable aluminum was less than 60% of the cation exchange capacity, production of tubers of the variety Mariva were not af-

Developing agronomic technology to produce potatoes under hot humid tropical conditions of San Ramón.



Potato plants growing beneath coconut trees under the tropical research conditions of San Ramón.

fected. When exchageable aluminum was neutralized to 34% with rock phosphate, $Ca_2(PO_4)$, yield increased. In soil with 50% exchangeable aluminum, potato yield was severely affected because of phospate deficiency. Addition of rock phosphate and simple superphosphate to the soil increased yields markedly.

Potato clones exposed to different levels (from 89% to 3%) of exchangeable aluminum showed different degrees of susceptibility to aluminum toxicity. The clone DTO-2 was the most affected and the variety Mariva was the most tolerant.

Harvesting potatoes grown beneath coconut trees under the tropical research conditions of San Ramón.

Cold Tolerance

The critical temperature for cold acclimation of tuber-bearing *Solanum* species has been determined as about 12°C. Below this temperature, cold acclimation was induced by directly exposing plants to low temperatures. Increased hardiness depended on the acclimating temperature: the lower the acclimating temperature, the more hardiness achieved. A day/night temperature of 2°C, regardless of photoperiod, appeared to be the optimum acclimating temperature, while a subfreezing temperature hardened plants less effectively. The maximum level of hardiness was reached after 15 days of cold acclimation. However, it took only one day to deacclimate the hardened plants to the pre-acclimation level when plants were subjected to a warm regime after cold. The degree of deacclimation was dependent on the temperature of the warm regime. Characteristic frost resistance does not appear to be an absolute requirement for cold acclimation. The mechanisms of frost resistance and cold acclimation seemed to be independent of each other. The potato is usually considered to be resistant to chilling, yet chilling injury was observed in *S. trifidum* plants grown at 2°C.

Solanum acaule, a frost tolerant potato, and *S. tuberosum*, frost susceptible, were used to study biochemical changes in response to cold hardening. During 3 weeks of cold hardening, *S. acaule* increased frost hardiness from

-6.0°C (killing temperature) to -9.0°C while frost hardiness of *S. tuberosum* remained unchanged at -3.0°C. Under cold hardening conditions, both species showed the same trend for increased total sugar and starch with an insignificant decrease in leaf water content. High levels of total RNA, rRNA and total and soluble protein were observed in treated *S. acaule* plants as compared with controls, but not in *S. tuberosum*. Levels of total lipid and phospholipid also were high in treated *S. acaule* plants as compared with controls, but decreased in *S. tuberosum* during hardening.

Plants from *Solanum tuberosum*, *S. acaule* and *S. commersonii* were hardened at different temperatures to varying hardiness levels. They were cold treated at constant day/night (D/N) temperatures of 10°, 5° and 2°(C) with 14-hour daylength. Each species responded differently in terms of increased frost hardiness upon subjecting plants to a low temperatue. For instance, after 20 days at 2°C, a net frost hardiness increase of 3°C to 7°C was observed in *S. acaule* and *S. commersonii*, while the frost hardiness in *S. tuberosum* remained unchanged. Also, various levels of frost hardiness can be achieved in a species by subjecting plants to different degrees of low temperature. Under a warm regime of 20/15 D/N (14-hour light), both *S. acaule* and *S. commersonii* survived -4.5°C or colder, while *S. tuberosum* survived only to -2.5°C.

Biochemical changes in the leaf tissue of these species were examined at 5-day intervals during low temperature treatments. Increases in total sugar and starch were found in all three species during hardening, although *S. tuberosum* failed to harden. Soluble protein was increased in both *S. acaule* and *S. commersonii* but decreased in *S. tuberosum*. RNA levels changed in a pattern similar to the soluble protein. Net increases in soluble protein were positively and significantly correlated with net increases in frost hardiness in *S. acaule* and *S. commersonii*.

Thrust VIII

Development of Post-Harvest Technology

Storage

Research continued on use of natural diffused light for storage of seed tubers in simple low cost structures at ambient temperatures. Under average experimental storage temperatures of 11°C to 14°C at Huancayo, Peru, the beneficial effects of diffused light storage have been repeatedly demonstrated with a wide range of potato varieties (Tables VIII-1 and VIII-2). Major advantages over conventional bulk storage in darkness are: less sprout growth leading to reduced weight loss during storage, elimination of the need to desprout tubers prior to planting, and earlier and more uniform field emergence which commonly results in earlier and higher yields.

These experiment station results have been confirmed at farmers' level in a series of six on-farm trials with seed producers in the Mantaro valley of Peru. Additionally, similar results at both experiment station and farm levels have been obtained using similar diffused light stores in a collaborative project with CIP regional and national scientists and farmers in the Philippines (Figure VIII-1). After introducing this type of seed storage to potato producers in the Philippines in late 1978 with six small demonstration stores, at least 40 farmers have applied the technology to modify their existing storage buildings or to construct new ones.

Similar storage research and transfer of technology projects are underway in Peru, Colombia, Bolivia, Guatemala, Honduras, Costa Rica, India, Kenya, Ethiopia, and Nepal (Figure VIII-2). Differences in farmer acceptability of the seed storage technology in different countries is currently being studied on a multidisciplinary basis involving both CIP and national technical/biological and social scientists. Throughout the research, development, and transfer of storage technology a close working relationship has been maintained between CIP technical/biological and social scientists.

As a result of this research three natural diffused light stores (Figure VIII-3) with a capacity of 7 to 12 tons each have been built to store CIP seed tubers in seed trays (Figure VIII-4) at the Huancayo station. Preliminary research began with this storage technique under hot conditions (25°C) at La Molina and San Ramón, Peru (Figure VIII-5). Results indicate that if potato tuber moth is controlled, seed tubers can be successfully stored under such conditions in low cost stores for 4 to 5 months. In the field, seed tubers perform comparably to similar seed lots stored under refrigerated conditions at 4°C.

Table VIII-1. Effect of natural diffuse light during storage* on storage behavior of seed potato tubers.

Variety	Antarqui	Cuzco	Mi Peru	Mariva	Renaci-miento	Revolu-cion	Rosita	N-578-4	Average
Mean length of sprouts (cm)									
Dark stored	22.5	20.6	12.1	33.7	10.3	19.8	19.3	11.8	18.8
Light stored	2.1	1.5	1.1	1.2	1.2	1.6	1.8	1.1	1.4
Mean number of sprouts/tuber									
Dark stored	1.2	1.7	2.0	1.2	2.1	1.1	1.1	2.6	1.6
Light stored	2.5	3.5	5.0	5.1	3.0	2.8	3.8	6.1	4.0
Mean storage loss (% initial weight)**									
Dark stored	16.3	23.3	12.2	22.8	8.7	11.8	15.3	12.3	15.3
Light stored	8.8	10.7	6.3	11.2	5.5	7.8	9.7	6.7	8.3

* 180 days storage with average monthly storage maximum temperature of 17.9°C and average monthly storage minimum temperature of 5.7°C.

** Includes tuber weight loss and weight of sprouts removed prior to planting.

Table VIII-2. Effect of natural diffuse light during storage* on field performance of seed potato tubers.

Variety		Antarqui	Cuzco	Mi Peru	Mariva	Renaci-miento	Revolu-cion	Rosita	N-578-4	Average
% field emergence after:										
20 days:	Dark stored**	1.5	0.0	3.1	0.0	0.0	0.0	0.0	4.7	1.2
	Light stored	71.8	64.8	54.7	67.2	37.5	46.9	5.0	78.1	58.8
30 days:	Dark stored	90.6	68.7	100.0	76.6	89.0	96.8	87.5	95.3	88.0
	Light stored	100.0	100.0	100.0	100.0	95.3	100.0	96.8	98.4	98.0
40 days:	Dark stored	100.0	92.2	100.0	100.0	100.0	100.0	100.0	100.0	99.0
	Light stored	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Yield (t/ha)* **										
Dark stored		23.7	25.8	25.8	26.6	18.1	28.6	18.9	25.7	24.6
Light stored		26.4	30.2	35.1	29.4	19.6	34.8	24.1	31.1	28.8

* 180 days storage with average monthly storage temperature of 17.9°C and average monthly storage minimum temperature of 5.7°C.

** Desprouted prior to planting.

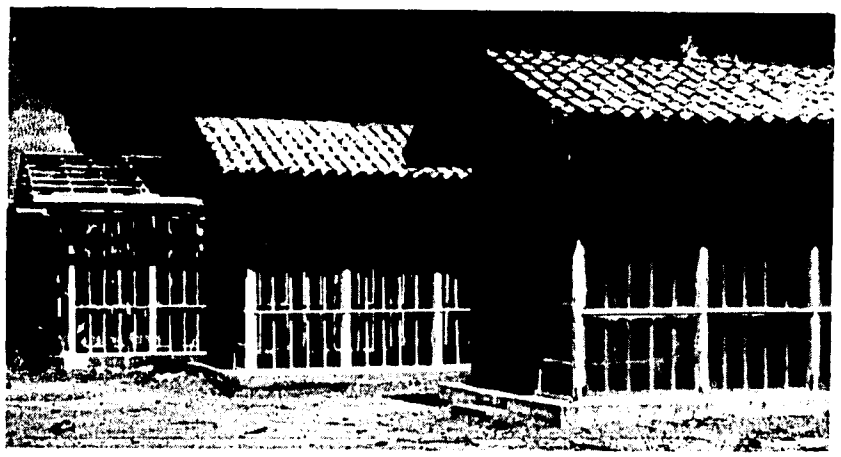
*** Average of 4 replicates each with 66 plants.

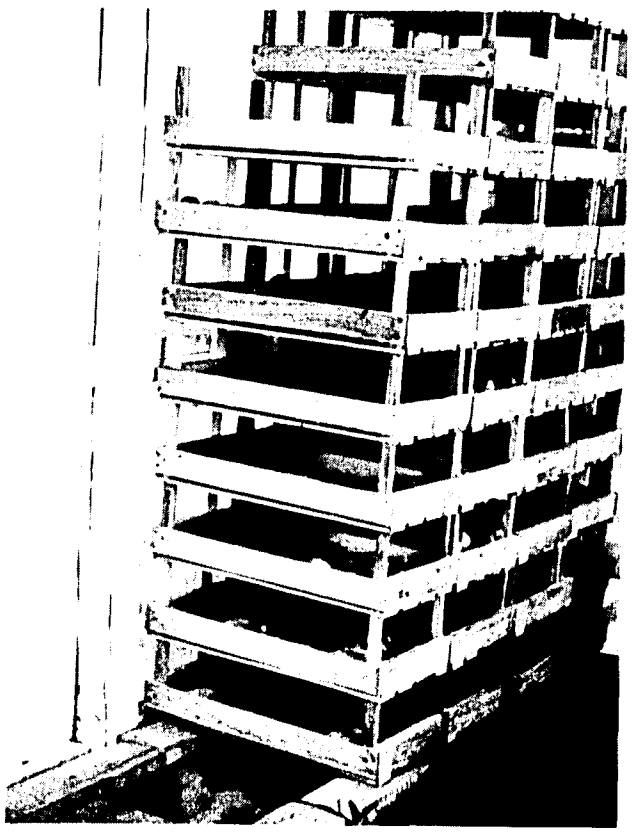
Philippines

San Ramón, Peru

Nepal

Figure VIII-1, 2 and 5 — Same idea for on-farm potato storages in three different parts of the world.





Figures VIII-3 and 4 - Three natural diffused light stores (top) are used for CIP seed tubers at Huancayo. Their capacities range from 7 to 12 tons each. Tubers are stored in seed trays (left) inside the storage facilities at Huancayo.

Continued development of low cost naturally-ventilated structures for storage of consumer potatoes has confirmed the usefulness of white paint in reducing heat absorption by buildings, thus reducing insulating needs (Table VIII-3 and Figure VIII-6). Thus, in practice, white paint acts as an insulator and enables acceptable temperatures to

Figure VIII-6 - White paint on low-cost, naturally ventilated storage structures aids in reducing heat absorption.

be maintained in simple stores.

Work with different clamp types (CIP Annual Report, 1978) in different storage seasons has resulted in improved storage by increasing ventilation through placement of ducts below the clamps. This is particularly true when soil covered clamps are used in warm wet seasons. In Huancayo, Peru, best results were from ventilated clamps first covered with straw and then with inverted corn stalks to keep out rain as well as increase insulation without impeding ventilation. The most appropriate clamp design and length of time clamps can be used successfully to store potatoes will need to be determined

Table VIII-3. Effect of white paint on temperature* of simple wooden stores (Huancayo-Peru).

Time (hrs)	External surface		Internal surface	
	Natural	White	Natural	White
0800	2	2	2	2
0900	23	15	8	4
1000	32	22	15	8
1100	37	24	17	10
1200	42	25	22	14
1300	44	28	24	15
1400	46	32	25	15
1500	20	17	19	15
1600	20	17	19	14
Ave.	29.6	20.2	16.8	10.8

* Average over 5 days (°C).

by local experimentation with local materials and varieties.

Two international regional CIP Storage Courses were held. The Second International Regional CIP Storage Course was in April/May 1979 in Spanish, in Peru. Scientists from Peru, Bolivia, Colombia, Chile, Brazil, Guatemala and Honduras attended. The first Philippine/CIP Regional Potato Post-harvest and Storage Course was given in English in November 1979 for participants from the Philippines, Thailand, Burma, Korea, Bangladesh, Sri Lanka, Afghanistan and Nepal. In May 1979 a position for an advanced storage trainee was established. This position, to be held for periods of approximately 8 months, was filled by a Bolivian scientist who had been conducting storage research alongside the CIP team at its Huancayo facilities.

Processing

Work in 1979 included:

- Emphasis on refinement of equipment.
- Field day involving farmers and cooperative members to get their reactions to applicability/acceptability of new technology.
- Planning and obtaining equipment for the 1980 program (May-September).
- Planning Conference to set a course of action for 1980 and beyond.

Experience in 1978 indicated some processing equipment did not function efficiently or was of inadequate size. Storage capacity was enlarged to 5 metric tons. The peeler was enlarged and modified for easier filling and emptying. The cutter was changed from hand operation to belt driven operation by machine. The cooker was redesigned to make more efficient use of fuel. Observation indicated that a simple modification of the solar drier could increase capacity by 25%. The equipment was rearranged to give a straight-through flow of potatoes from storage to driers.

Two field days helped evaluate the applicability/acceptability of the proposed technology. With cooperation of the Ministry of Agriculture office in Huancayo, 47 farmers representing about 30 farms and cooperatives attended the 2 meetings. Expressed enthusiasm was high and several cooperatives had additional demonstrations for their entire boards of directors. At season end (September) cooperatives with a total of 50 tons of potatoes requested permission to use the facilities. It was necessary to decline the request because of lateness of the season. Cooperatives with more than 150 tons (representing 5 months processing) requested assistance for 1980.

Other field days were held for the press, radio, and television. A camera crew of FAO made a film of CIP's potato processing activities. Soup packagers from Lima also attended field days.

Plans were made to establish a second processing unit for papa seca and starch. The CIP Social Science Unit identified the location as Otuzco, La Libertad, where papa seca is now produced as a cottage industry. This location supplies more than half of the 4,000 tons consumed in Lima each year.

The second processing unit will have a capacity of a half ton of potatoes daily for papa seca and a similar amount for starch. Some equipment too small for the Huancayo facility was transferred to

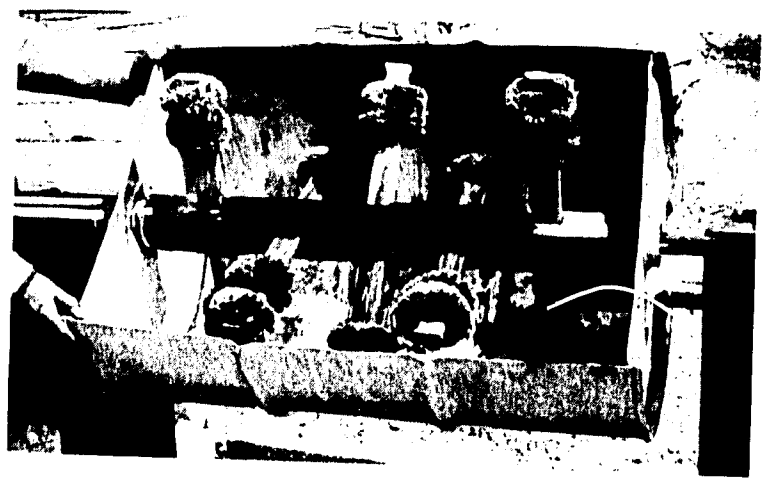
Otuzco. Scheduled completion date for this new unit is May, 15, 1980.

Social Science Unit personnel aided in identifying the size and shape of the Lima market for papa seca. They also identified Otuzco as the logical location for a second processing unit.

Illustrations on this and the following pages of this section show equipment being developed by CIP for use in processing potatoes.

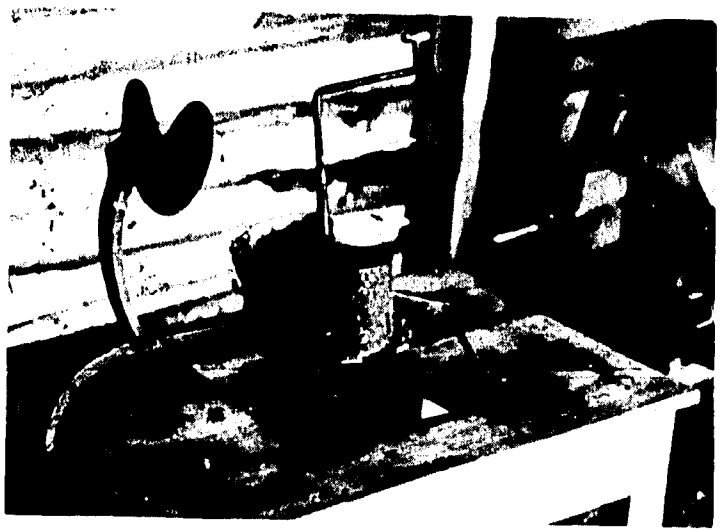
General view of the potato processing pilot plant at Huancayo, Peru. Solar dehydrators are at right.

Potato washer.



Potato peeler. The first model is at center with a simplified low-cost model at right.

Oven and steam cooker.

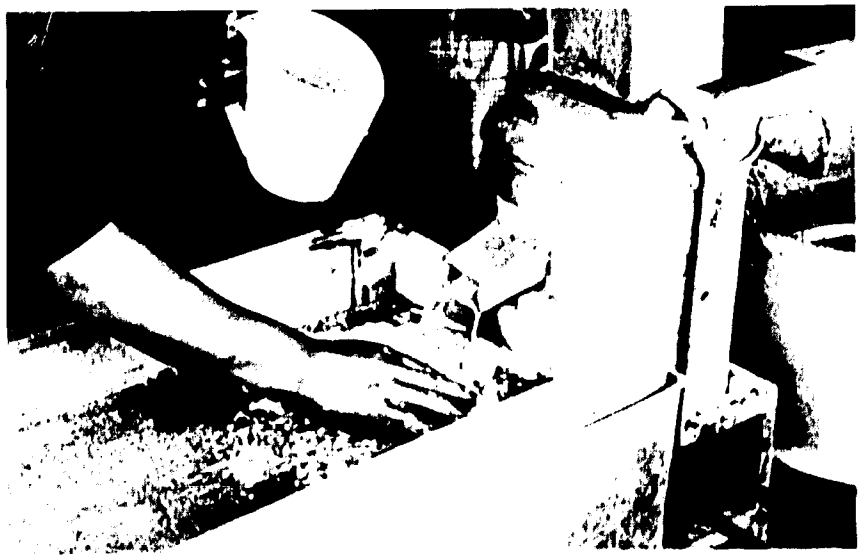


Hand operated cutter.

Solar dehydrator with drying trays.

Mill for grinding papa seca
and potato flour.

Pulper and tanks for starch.



Thrust IX

Seed Production Research for Developing Countries

CIP distributed a large amount of germ plasm to various research projects around the world in accordance with each country's phytosanitary regulations. All materials passed two rigorous tests for potato spindle tuber viroid (PSTV).

These materials represent a diverse genetic base which included adaptation to lowland tropics, tolerance to frost and resistance to *Phytophthora infestans*, potato leafroll virus, *Pseudomonas* and combination resistances to *Phytophthora infestans*, *Pseudomonas* and adaptation to lowland tropics.

Tissue Culture Research

Eight more clones and cultivars were added to the collection of disease-tested plants freed by tissue culture techniques. The collection now contains 63 disease-tested clones and cultivars which also passed two testing methods for PSTV.

Of disease-tested clones and cultivars, 11,000 plantlets were produced in vitro for seed tuber production and breeding purposes. These plants were grown in quarantine screenhouses and some of their tubers were either exported or used locally. During the year, 45 disease-tested clones were propagated and sent in vitro to collaborators in 12 countries.

In addition, 90 PSTV-tested clones routinely used by CIP breeders, were propagated in vitro by the shoot-tip culture method and transferred subsequently to in vitro long-term storage as a security measure in case of PSTV outbreak.

Long-term Storage

The addition of 4% manitol to Murashige and Skoog medium containing 0.5% sucrose was useful for long-term in vitro storage at 25°C of plants of different genetic background. With this medium, plantlets required a transfer to new medium only about every 6 months. Previously plantlets were transferred to a new medium every 2 months of storage at 25°C when the medium contained higher sugar concentration and no manitol.

PSTV Eradication

Attempts were made to eradicate PSTV from plantlets regenerated from callus cultures obtained from infected tubers and leaves. These regenerated plants contained PSTV even after five to eight callus subcultures.

Another method to eradicate PSTV from infected plants used plants produced from nodal segments and tubers and grown at 6°C and 8°C for 4 or 6 months, respectively. Meristems were then excised and incubated to regenerate plantlets at 22°C and 25°C for two generations to maximize the multiplication of PSTV. The plantlets were then tested for PSTV by

Table IX-1. Effect of incubation temperature on PSTV.

Origin of meristem	Temperature °C	Number of plants treated	Number of PSTV-free plants
Nodal	6	20	7
Nodal	25	16	0
Tuber	8	22	5
Tuber	22	16	0

electrophoresis and tomato bioassay. Results of this method are in Table IX-1.

Because of the time-consuming process of excising true meristems for PSTV eradication in the method explained above, studies were made to determine if shoot-tips can be substituted for true meristems. Shoot-tips were excised from PSTV-infected plants grown at 6°C for 4 months. Plantlets were regenerated from the shoot-tips at 25°C and then tested for PSTV. Only 6 out of 56 cold treated plants of two clones were PSTV negative. This low frequency of PSTV-negative plants could have resulted from the large size of the explanted shoot-tip.

Table IX-2. Suitable nutrient media for organogenesis from leaf callus.

Clone or cultivar	
LT-1	LAM3, MS13
Rosita	LAM3, MS13
N561-1	MS13
Revolucion	LAM3, LAM15, MS13, LAM-A
BR 63-5	MS13
Mariva	MS13
DTO-2	LAM3, MS13
ASN 69-1	MS13

* LAM A, 3 and 15: S.L. Lam, 1977. Am. Potato J. 54: 575-580. J.A. Shepard and R.E. Totten, 1977. Plant Phys. 60: 313-316.

MS 13: M. Behnke, 1975. Z. Pflanzenzuecht. 75: 262-265.

Spontaneous and Induced Mutations

Several nutrient media were evaluated for callus induction and growth, and regeneration of plantlets from callus. The Linsmair and Skoog (1965) medium was most suitable for callus induction from leaf explants and further growth in suspension. For plant regeneration from callus LAM3 and MS13 can be used successfully as shown in Table IX-2.

The sensitivity of growth of nodal cuttings in vitro of 4 clones at low pH was tested. The growth of axillary buds on agar media adjusted to pH 4 was not different from that at pH 5.6.

The effect of major salts in sea water on in vitro growth of shoots from nodal segments indicated that one clone (DTO-2) had slightly higher tolerance than the others (Table IX-3). The salts were added to the Murashige and Skoog agar medium at 3 concentrations: Full concentration — 19.00gm/1 NaCl, 0.53gm/1 KCl, and 5.10gm/1 $MgCl_2.6H_2O$; Half concentration — half of the full, and Quarter concentration — half of the half.

Studies on True Seed

Meager information is available in the literature on the physiology of potato tree seed, its germination, and the factors affecting it. Experiments sought optimal conditions

for seed germination and seedling emergence.

Temperature and Germination

Seed germination was studied during incubation at 10° C to 45° C. Maximum germination of a large number of seed families occurred in the shortest time around 20° C. Germination at temperatures above 25° C was inhibited. Seed incubated between 25° C and 40° C did not lose viability and germinated following transfer to 20° C, thus suggesting the presence of a seed thermo-dormancy.

Temperature and Seed Moisture Effect on Germination

Superficially wet and dry seed were exposed for one hour to six different temperatures, 22°, 30°, 40°, 50°, 60° and 70° (all C) and then tested for germination at 20° C. Results showed that true potato seed can tolerate exposures to elevated temperatures as long as the seed is dry. No significant difference was noted between final germination of dry seed exposed to 22° C and 60° C. Germination of superficially wet seed was always less than that of dry seed at temperatures above 22° C especially at 60° C.

Temperature and Duration Effect on Germination

Germination of seed exposed to 65° C for 1, 2 and 4 hours was not significantly different from that of untreated seed. Following 8 hours of exposure to 65° C, germination was reduced by 25%. A 2-hour exposure to 70° C reduced germination also by 25%.

Synchrony of Seedling Emergence

The onset and uniformity of germination as well as seedling emergence in soil were significantly improved by soaking seed for 10 days at 20° C in a mixture of 10.6 g KN03 and 11.5 g $K_3PO_4H_2O$ per liter of water. The treated seeds were sown wet or after air drying at room temperature. Seedlings obtained from salt treated seed were larger and reached a transplantable size earlier than those obtained from non-treated seed.

Propagation by Leaf-Node Cuttings

Plants of the Mariva cultivar grown under long photoperiods (16-hour days) were taller and had more internodes but tuberized poorly (1.3%). In contrast, plants of Red Pontiac increased in height only with long photoperiods but most of the propagated leaf-node cuttings tuberized. Short photoperiods (12-hour days) resulted in the production of sessile tubers, while long photoperiods resulted

Table IX-3. Growth (cm) of shoots from nodal segments at three salt concentrations.

Clones	Salt Concentration					
	Control	Full	Half	% of Control	Quarter	% of Control
LT-1	17.7	0	2.7	15.2	5.6	31.6
LT-2	33.6	0	1.8	5.3	9.5	28.3
DTO-2	32.8	0	4.9	14.9	19.9	60.7
DTO-33	25.7	0	1.9	7.4	4.9	19.1

in the production of stoloniferous tubers which contained shoots in some cases.

The position of the leaf-node cutting on the "mother" plant had no effect on tuberization. However, the position of the bud on the cutting affected tuberization. Best tuberization was obtained from cuttings where the bud was in the middle of the cutting.

Regional Research & Training

As in previous years this section gives a general survey of program activities in the seven Regions, with details of specific research and training activities reported under the Thrusts and the Training program.

Region I

A major change in 1979 was transfer of regional headquarters from Lima, Peru to Tibaitata, Colombia. The objective is to collaborate with a potentially strong national program with which CIP has previously cooperated and also to make a physical separation between this regional program and CIP headquarters in Lima. Another objective is to establish a second base for the maintenance of the international collection of germ plasm and avoid possible consequences should a natural disaster occur at Huancayo, Peru.

Two scholarships for a Ph.D. in breeding were awarded to scientists in Colombia and Argentina to strengthen the existing emphasis on utilization of the new germ plasm derived from the international collection and breeding program.

More emphasis has been placed on using national scientists to conduct production and seed production training courses at national and regional level. Thus a sub-regional seed course at Balcarce, Argentina included professionals from Chile and Brazil. A second sub-regional seed course at Santa Catalina in Brazil in conjunction with the Brazilian Agricultural Research Agency (EMBRAPA), included participation of professionals from Argentina, Uruguay and Chile.

In the Andean zone a joint seed technology course with Colombian Agricultural Research Institute (ICA) in Colombia included participation by professionals from Peru, Ecuador and Venezuela. In Peru, four national courses on potato production were sponsored by CIP using professors from the National Agricultural University.

CIP scientists participated in the biennial meeting of ALAP (Potato Association of Latin America) in Brazil. CIP also financed the participation of national scientists from several countries in Central and South America.

CIP scientists were invited to review annual potato research program evaluations in Brazil, Colombia, Chile and Ecuador. CIP is also part of the technical committee in charge of policies for a large multilateral project to assist the Ministry of Agriculture, Peru.

In conjunction with the Social Science Department in Lima, the regional scientist is supervising a project financed by the Ford Foundation to evaluate a pilot scheme for the production of high

quality seed for Colombia and Ecuador. A total of about 50 tons of good quality seed was produced for distribution to growers. This project is basically an agro-economic study and CIP input will terminate in 1980. Thereafter the program will continue with supervision by the national potato program.

In the coastal valley of Cañete in Peru, the regional associate scientist worked in collaboration with local professionals on a series of experiments related to the optimizing productivity project. There was a total of 40 experiments covering various agronomic and cultural techniques. In 1980 CIP input will decrease now that local professionals have been trained in an agro-economic course conducted by Social Science Department. Large amounts of germ plasm have been distributed to many countries in the region and at least one selection was named as a variety, ICA-Sirena by Colombia.

Region II

The first phase of the 5-year program of Regional Cooperative Program for Potato (PRECODEPA), the organization of six Centro American potato research programs began in May. The concept of PRECODEPA was given in the 1978 Annual Report. Various research projects have started according to the original program and a training course on rustic storage was conducted by Guatemala, the leader for that particular project while Mexico gave regional training in seed production.

To further strengthen the experience of the professionals involved in the different projects of PRECODEPA, specialized training in nematology, storage, tuber moth methodology and bacterial wilt research has been given to individuals at CIP, Lima.

During 1980 as PRECODEPA grows in efficiency and strength, CIP's input will diminish with the principal role being research on bacterial wilt selection.

In August, a workshop on agro-economic methodology to optimize potato productivity was held in Costa Rica. There were participants from most countries of the region, but the participation of Costa Rican seed farmers was extremely fruitful. The scientists' ideas and technology were critically evaluated by growers for their suitability.

Region III

There were several staff changes in the region during the year. The regional scientist changed as did the Dutch associate scientist. The seed specialist left at the end of the year to take up duties in Bangladesh.

A new country project was due to start in Rwanda/Burundi and first to arrive was the plant pathologist followed by the production specialist who will lead the team.

Many political difficulties occurred in the region during 1979, which reduced the number of country programs visited. The situation in Uganda affected the start of the Rwanda/Burundi project as all materials and supplies travel by road and these could not get through until July. Initially, a seed specialist worked until April to get the program started and then he returned to post in Izmir, Turkey. In August, the production specialist transferred to Ruhengeri, Rwanda and after an initially difficult period started construction of housing and laboratories. This program is now well advanced and the first full growing season is underway with 5 hectares of seed multiplication. The next stage is to coordinate these activities with the ongoing potato research program in Burundi.

Lima scientists and the regional representative visited Ethiopia to investigate the current situation and the work plan of the local scientist, who has been collaborating with CIP for several years. The timing of this visit was very opportune as six clones had been proposed for varietal status, three of which came from the CIP/Wisconsin contract. As a result of the contracts made with the University of Addis Ababa, two new collaborative projects have been proposed: one, for evaluation of improved genetic material, and the other on low cost storage. The proposal for bilateral funding of the Ethiopian potato program has been revised and will shortly be presented.

In Kenya, there were four principal research activities:

1. Increase capacity and efficiency of regional germ plasm multiplication project at the Kenyan Agricultural Research Station, Muguga.
2. Evaluation of clones suitable for Kenya and subsequent multiplication by ADC farms, Molo.
3. Continuation of studies of low cost storage technology together with Ministry of Agriculture.
4. Testing of clones and agronomy suitable for lowland tropical conditions of the Kenya coast.

A regional Seed Production Course for 10 countries was conducted in Nairobi with the assistance of the University and the Potato Research Station, Tigoni. French-speaking professionals from Malagasy, Burundi and Rwanda attended the francophone course in Tunisia.

Two in-country short courses were organized in Kenya and Malawi and practical training in handling of germ plasm, virus diagnosis and rapid multiplication techniques was given at Muguga, Kenya.

One professional at the Plant Quarantine Station, Muguga, was trained in meristem techniques at CIP, Lima. For various reasons there have been changes of trained personnel at the Quarantine Station, but because of its importance to CIP it has been necessary to train more professionals at Lima.

Region IV

Personnel changes included: The seed specialist was in Rwanda from January to March initiating the country program; he returned to Izmir in April. The scientist in Tunisia was transferred from the country program to CIP-Lima in July and his place was taken by a member of the regional team in Izmir. This team was strengthened by the arrival of another Dutch associate scientist.

The basic seed production scheme in Turkey now needs further fortification after initial development work of the last few years. A proposal for a basic seed production station in eastern Turkey has been prepared and submitted to Turkish authorities for evaluations and for financing by a bilateral donor.

Two other bilateral projects which the regional scientists have been promoting, Potato Seed Multiplication Project for Morocco and a similar project in Syria, are still being considered by the donors. The project in Morocco will begin with appointment of a seed expert by a German technical assistance agency to assist the existing vegetable project. A feasibility study for the Syrian project will be carried out in 1980. A small seed production scheme to be bilaterally

financed in Jordan appears to have run into funding difficulties.

In May the Regional Production Training Course was held at Izmir and two short country courses in Jordan and Morocco. CIP assisted in a national potato seminar in Algeria.

In October, the Regional Workshop on the potential of potato genetic resources was held in Izmir. This meeting was essential at a time when more and better materials are being introduced and selected in Turkey. Much greater utilization of these materials will occur within the Region as a result of the Workshop.

Tunisia. The country program has continued to concentrate on production of good quality seed for the autumn crop. A total of 350 tons of seed were produced and distributed to farmers. The target for 1980 is 700 tons of seed.

The francophone production course was again conducted in April and has now become a much appreciated permanent feature of the program. Professionals have been sent on short visits to Lima and France to study the latest techniques with regard to seed production and rapid multiplication.

Region V

The political problems of the area make it impossible to develop a viable regional program. The only possible country where CIP scientists can operate is Pakistan and a major effort has been made during the year to get the Pakistan Agricultural Research Council to develop a program covering research, transfer and marketing. A working paper has been produced which may be the basis for a bilateral project to coordinate research in all the provinces and integrate three existing projects. It has been accepted in principle by the provincial directors of research.

Trials at the Research Station in Islamabad confirmed that low yields were mainly a result of low stem densities and low fertilizer application. Further trials on physiologically aging tubers to increase stem density confirm this view. As this is an example of low cost inputs, a package has been designed to test physiological age, fertilizer and water regimes to increase yield with the existing potato stocks in the country.

A training course on field plot techniques and seed tuber physiology was conducted at Faisalabad, Punjab. A 2-day course on virus disease and aphid recognition took place in Peshawar. On the job training was given when CIP staff took part in seed potato roguing in Kaghan Valley. Two senior Pakistani scientists took part in a basic seed course in Lima, Peru.

Region VI

Favorable weather in India and Bangladesh resulted in a greatly increased potato crop. In India, production was estimated at 9.3 million tons, the actual target set for 1983. In Bangladesh, production was 2.3 million tons, the target for 1982. These large increases posed many administrative problems and particularly in India, transport and marketing were inadequate. As a result much of the crop was never harvested after prices plunged.

In view of these experiences, a symposium on post-harvest technology and utilization organized jointly by CIP and Indian Council for Agricultural Research (ICAR) generated considerable interest. This theme has been examined at government level in order to adopt policies to resolve similar problems if they occur again.

An initial CIP socio-economic bibliographic survey revealed a wealth of information in various libraries related to the development and production of potatoes as a major food in India. This is being examined in more detail and the final document will serve as a case study, and is also required by governmental authorities when developing long-term policy for potato production and consumption.

Collaboration in India has principally been with the Central Potato Research Institute (CPRI), and with the Indian Agricultural Research Institute (IARI), in New Delhi. CPRI has received large quantities of advanced germ plasm but due to lack of greenhouse facilities at Simla, only part of this has been utilized. Quarantine regulations are very strict in India but it was hoped to alleviate this problem by constructing a CIP greenhouse at IARI. For various administrative reasons this has not happened, thus the problem remains and multiplication of imported material is slow.

In collaboration with IARI a series of simple investigations at farmers level has been started with the object of familiarizing small farmers with the role that the potato can play in their overall cropping program. Initial results indicate that inadequate management practices are the principal causes of yield variations between the selected farmers.

Other areas of work in India in which CIP has an interest are the production of potatoes from true seed being investigated by CPRI, and post-harvest preservation and utilization of potatoes by IARI. The National Physical Laboratory is examining aspects of solar dehydration and it is hoped to incorporate some ideas developed by CIP in Peru.

In Bangladesh, assistance was given to develop an agronomic program to define optimum fertilizer rates and planting and harvesting dates. More diverse germ plasm has been supplied to the selection program, but an important area of concentration has been seed multiplication of imported varieties. A consultant was brought from India to investigate aphid epidemiology and its relation to seed multiplication. It was concluded that by early January aphids were increasing rapidly and the latest date for harvesting seed tubers is mid-January. As the crop has approximate 90-day maturity this indicates mid-October as the optimum planting date for the seed crops. To follow up and fortify this and other areas of work the Bangladesh potato team has been joined by a CIP specialist on special project funds for an initial period of 8 months.

In conjuction with the Agricultural Department of Bhutan and the United Nations Development Agency (UNDP) technical assistance team, CIP has developed an overall work program. This includes identification of a suitable seed farm, introduction of a wider range of germ plasm and agronomic trials at farmer level. A most important aspect of this collaboration has been to implement measures to restrict the spread of wart disease which has been identified in isolated pockets. As rapidly as possible wart resistant varieties are being introduced.

In-country short courses on seed production have been organized in Bhutan and Bangladesh and opportunity has been taken to sponsor selected trainees to the principal seed production course organized by CPRI Simla in July each year.

CIP has one production specialist based in Nepal, who is funded by a special project. This project completed its third year in 1979. During the year the full complement of a four-man Swiss bilateral team arrived and a new Nepalese Potato Coordinator was appointed.

The germ plasm clones imported into Nepal over the last 5 years now total 200. During the year a rigorous selection took place and these were reduced by half. The process will continue and it is hoped that the numbers of clones can be brought to a manageable proportion to allow varietal naming.

Training materials and the training program had a high priority this year. A training manual in Nepali and English was made in time for the training courses for extension workers in the latter part of the year. CIP, Lima, produced training lessons served as basic material but needed further simplification for the local circumstances. There is now a core of appropriate technology accumulated in Nepal and the intention of the training is to transfer existing knowledge to local farmers as rapidly as possible.

One Nepalese scientist with considerable field experience departed for post-graduate studies in USA on a CIP scholarship. He will return at the end of 1980 with an MS.

Other scientists went to the CPRI course in Simla, India, and in 1980 it is planned to send a candidate to the International Potato Course in Wageningen, the Netherlands.

As a result of the joint activities of Nepal, the Swiss team and the CIP scientist, it appears that the Government will soon be faced with the problem of marketing and distributing several hundred tons of high quality seed potatoes. In a country with the topography of Nepal this will be a task as no relevant organization or cold storage facilities exist.

Region VII

The main regional objective is to help develop at least one strong national potato program from which horizontal transfer of technology to other countries can take place. CIP has continued to support the development of the Philippine Potato Program as explained below.

The integrated plan of research includes the main institutions with an interest in potato research. The first national review of this program took place during the year.

A special project was prepared to strengthen the existing national agencies with bilateral funding. This has been reviewed and modified and two international donors have expressed an interest in funding the program. Five principal research areas have been defined:

(1) agronomic research for utilization of true seed,
(2) rapid multiplication research for seed production,
(3) evaluation of optimum agro-economic technology,
(4) integrated storage studies,
(5) development of technology appropriate for medium and low elevations.

Interest in collaborating with CIP regional program has renewed by Sri Lanka, South Korea and Indonesia. In 1980 this interest may provide a national commitment particularly in Sri Lanka where a CIP scientist will spend a one-year sabbatical.

It has been a regional priority to develop a germ plasm distribu-

tion center. A newly-built screenhouse at Baguio, Philippines is now producing clean material. During 1980 regional distribution of these materials will begin. The field multiplication phase will also start in 1980.

Initial trials on growing potatoes in the hot lowland areas were started north of Manila. Shading, deep planting and frequent watering tended to increase yields. Heat tolerant varieties not previously available have since been introduced into these studies.

Simple seed stores utilizing natural illumination to restrict sprouting have been accepted by farmers who have quickly modified the first models to suit local materials and conditions. At least 40 stores have been built by the farmers themselves.

A number of national training courses have been organized by the Philippine program in addition CIP organized regional courses in potato virus identification, rapid multiplication by vegetative means and the first post-harvest technology and storage course.

A number of senior scientists from the region were sent on study visits to Australia; CIP, Lima; and other countries.

C I P T R A I N I N G S C H O L A R S H I P S I N 1 9 8 0

CODES	NAME	COUNTRY	DEGREE	UNIVERSITY	DATE START/END	SUPERVISING SCIENTIST	NOTES
	Breeding & Genetics						
A (a)	Calua, Luis A.	Peru	M.S.	U N A	10-78/07-81	Mendoza	Inheritance of Earliness in Tetrapoloid Potato
A (a)	Galvez, Rosario	Peru	M.S.	U N A	02-79/01-81	Brown	Plant Breeding
S (a)	Huarte, Marcelo	Argentina	Ph.D.	Cornell	08-79/08-82	Plaisted	Plant Breeding
S (a)	Landeo, Juan	Peru	Ph.D.	Wisconsin	07-76/07-79	Hanemann	Potential of *Andigena* in Breeding
S (a)	Lazin, Michael	U S A	M.S/Ph.D.	Cornell	04-76/05-79	Ewing	Head & Photoperiod Interaction
A (a)	Lecaros, Jose M.	Peru	M.S.	U N A	08-77/10-79	Mendoza	Combining Ability of *Andigena*
S (a)	Leon Gomez, Pedro	Colombia	Ph.D.	Cornell	06-79/06-82	Plaisted	Plant Breeding
S (a)	Muñoz, Francisco	Ecuador	Ph.D.	Cornell	01-77/08-79	Plaisted	*Andigena* Populations
S (a)	Vasquez, Victor	Peru	M.S.	U N A	10-78/09-80	Estrada	Late Blight Resistance
	Nematology/Entomology						
A (a)	Alcazar, Jesus	Peru	M.S.	U N A	06-78/06-80	Jatala	Andean Potato Weevil Biology
A (a)	Astocaza, Evelio	Peru	M.S.	U N A	11-78/11-80	Franco	New Globodera Spp
S (a)	Canto, Manuel	Peru	Ph.D.	Cornell	05-78/07-81	Brodie	Meloidogyne Resistance
A (a)	Gonzales, Alberto	Peru	M.S.	U N A	03-79/03-81	Scurrah	Inheritance of resistance to *Globodera pallida*
S (a)	Gunenc, Yildiz	Turkey	M.S.	Rothamsted	08-78/08-80	Gibson	Glandular Hair, Effect on Aphids
A (a)	Lazaro, Monica	Peru	M.S.	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
S (e)	Shah, B.B.	Nepal	M.S.	Colorado	01-79/01-82	Workman	Seed Certification
	Pathology						
A (a)	Abad, Jorge	Peru	M.S.	U N A	04-76/06-79	Fribourg	Virus Studies
A (a)	Abad, Gloria	Peru	M.S.	U N A	10-79/12-80	Henfling	Phitopathology
S (a)	Ciampi, Luigi	Chile	Ph.D.	Wisconsin	10-78/07-79	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. Carolina	01-78/07-81	Echandi	Pathology
A (a)	Lopez, Glicerio	Peru	M.S.	U N A	01-79/12-80	Henfling	*Synchytrium endobioticum* biotypes in the Andean Region of Peru
S (d)	Santillan, Franklin	Ecuador	M.S.	U N A	06-77/02-79	Fribourg	Ecuadorian Viruses
S (a)	Torres, Edgardo	Peru	M.S.	U N A	01-79/07-80	Martin	Plant Pathology
S (a)	Velupillai, Malarmagal	Sri Lanka	M.S.	Florida	04-78/08-80	Cook	Bacterial Wilt

	Physiology						
A (a)	Bedoya, Ana María	Peru	M.S.	U N A	10-78/06-79	Booth	Storage
A (b)	Bernal, Miguel	Peru	Ing.Agr.	U N C P	07-78/10-79	Shaw	Processing
A (a)	Campos, Ruben	Peru	Ing.Agr.	U N C P	10-79/09-80	Shaw	Quimical Sprout Inhibitors
A (a)	Egoavil, Carlos	Peru	M.S.	U N A	01-76/07-80	Accatino	Drought Resistance
A (a)	Egoavil, Rey A.	Peru	Ing.Agr.	U N C P	01-79/12-79	Shaw	Storage
A (b)	Guerra, Cayo	Peru	Ing.Agr.	U N C P	09-78/01-79	Shaw	Processing
P (a)	Glas, Tjaart	Holland	Post-Doc	C I P	09-77/02-79	Accatino	Physiology of Drought Resistance
A (a)	Inga, Marcelino	Peru	Ing.Agr.	U N C P	10-79/03-81	Shaw/Booth /Yupanqui	Storage of Potato
A (a)	La Torre, Braulio	Peru	M.S.	U N A	01-78/02-80		Erosion
A (a)	Maguiña, Ana María	Peru	M.S.	U N A	01-78/06-79	Shaw	Nutrition
S (a)	Manrique, Luis	Peru	Ph.D.	Hawaii	09-77/09-80	Meyer	Tropical Soils
A (a)	Quevedo, Juan M.	Peru	M.S.	U N A	09-78/07-80	Bryan/Nganga	Seed Production
P (a)	Sattelmacher, Burkhard	Germany	Post-Doc	C I P	01-77/06-81	Accatino	Hormone Control of Tuberization
A (a)	Vasquez, Juan J.	Peru	Ing.Agr.	U N C P	05-79/10-80	Shaw	Potato Flakes
S (d)	Werner, Linde	Germany	Ph.D.	Justus Liebig	01-79/01-81	Sadik	Potato Adaptation to Humid Tropics conditions
	Social Science Unit						
A (a)	Achata, Adolfo	Peru	M.S.	U N A	08-78/09-80	Monares	Agro-Economic Studies on Seed Production
A (b)	Cordova, Jorge	Peru	M.S.	U N A	04-79/12-79	Scott	Production and Marketing of Potato
S (b)	Recharte, Jorge	Peru	Linc.	Catolica	07-79/07-80	Horton	Agricultural Systems in Tropical farm enterprise
S (a)	Tardieu, Francois	France	Ph.D.	INAF	01-78/12-80	Horton	Optimizing Potato Production
A (b)	Uribe, Fulgencio	Peru	Ing.Agr.	U N C P	01-79/03-79	Werge	Agro-Economic
S (b)	Vargas, David	Peru	M.S.	U N A	01-78/03-80	Monares	Agro-Economic
A (b)	Villena, Joseph	Peru	Econ.	S. Agustín	01-79/04-79	Scott	Stadistics
S (a)	Scott, Gregory	U S A	Ph.D.	Wisconsin	08-79/03-80	Horton	
	Taxonomy						
S (a)	Cheng Song Tay	China	Ph.D.	Birmingham	04-77/09-79	Ochoa/Hawkes	Taxonomy of Cultivated Diploid Species

SCHOLARSHIP TYPE: A-Student Assistantship; S-Full Scholarship; P-Post-Doc

FUNDING: (a)CORE; (b)IDRC; (c)GERMAN; (d)Swiss Special Project; (e)Nepal Special Project

Training Department

CIP's overall training effort is planned and programmed by the Training Department. The program includes activities in Regions as well as those conducted and directly administered in Lima.

In the Regions the focus continues to be production-oriented short courses, symposia, seminars and workshops. There is a trend toward specialized topics, such as latest research technologies of a single or several Thrusts. These activities are listed in detail by Region. Primary emphasis is given to this training because more national program scientists and extensionists are directly touched through these efforts.

The training program at headquarters has concentrated on scientifically specialized areas of work. Specialized training for individuals is primarily on-the-job experience working with scientists. The experience is tailored to meet the specific needs of the trainee. In 1979, a total of 22 scientists from 10 different national programs received 66 weeks of training. Often demand is sufficient to organize specialized short courses for small groups. In 1979, four such courses were held: Storage Course, Agroeconomic Research Methodologies, Agroeconomic Procedures, and Production of Basic Seed. A total of 28 national program researchers and extensionists from 13 different national programs participated. This represented a total of 105 weeks of training.

While CIP has always recognized the need to increase the overall skills of national programs, it has also recognized the need for developing advanced research competencies in certain areas of specialization. For this reason, CIP continues to provide degree scholarships. These scholarships are a significant investment, not only financially but also of human resources. Research during the scholarship is of priority to the scholar's country, yet it is monitored or supervised directly by a CIP scientist. In 1979, CIP supported 46 scholars from 11 different countries for 31.6 man-years of instruction. Thirty of these were in Peruvian institutions. The remainder in North America or Europe.

Post-doctoral positions within the various research departments are in another area of training. These are positions for recent doctoral recipients who are contracted for a determined period of time to conduct specific research projects — usually of 2 to 3 years. The intent is to conduct priority research and to allow the individual an opportunity to experience research in an international setting; thus, perhaps, entering international work as a career.

Undergirding all research efforts is the realization of the need for

training materials. CIP has an advantage in synthesizing this kind of information and also has the responsibility of providing it in appropriate forms to national programs for subsequent adaptation for their particular clientele. In this respect, in 1979, a program was initiated to develop and disseminate these types of materials. Lesson plans, slide sets, and a disease booklet in French were distributed to the Regions and to several individuals and trainees from national programs.

Social Science Department

The Social Science Department conducts research on three major topics: (1) constraints to potato production in developing countries, (2) the potential role of the potato as a foodcrop in the tropics, and (3) processes and consequences of technological change.

Major 1979 emphasis was on constraints, with the other two areas gaining importance over time. Social science research was with CIP Thrusts IV, VII, VIII and IX and with regional and national scientists. Fieldwork was in two highland valleys of Peru (Mantaro Valley and Huánuco), in the jungle (San Ramón and Iquitos), and on the coast (Lima and Cañete). Fieldwork was also done in Ecuador, Colombia, Kenya, India, Rwanda and the Philippines. In 1979 a Working Paper Series was begun to disseminate research findings and to encourage debate, exchange of ideas and advancement of social science knowledge about production and use of the potato.

Production Constraints

The main objective is to develop and field test procedures for identifying farm-level constraints to potato production and for evaluating possible technical solutions to these constraints. These procedures are meant to be used by Regional and National Programs in carrying out CIP's strategy for optimizing potato productivity in developing countries. In late 1979 a production specialist joined the department, with responsibility for coordinating the implementation of this strategy. In addition to the methodological goal, this research generates useful information on potato production systems and their constraints in diverse environments.

Four types of technical constraints have been examined: the general area of agronomic management and the three specific areas of tuber seed, pest control and post-harvest technology.

On-Farm Research in Mantaro Valley

Research on agronomic production constraints in the Mantaro Valley of highland Peru included surveys in 1977 and 1978 that identified three yield constraints for on-farm evaluation: tuber seed, fertilization and insect control. Four types of trial designed for small and medium-sized farms included a technological package trial, fertilizer trial, improved seed trial and an insect control trial. A fifth trial aimed at increasing the proportion of seed-size tubers in the yield was designed for large seed farms.

The technological package trial included fertilizer, improved seed and insect control applied at four different input levels: (a) farmer,

Inspection of tuber quality at harvest of a farm-level trial.

A farm-level trial is marked off on a mountain-side in Peru. Note incline of field as shown by nearly-level tape held by person at the left.

Taking agronomic data of a farm-level package trial. The area of the trial (in center of photo) shows more vigorous foliage growth than for the surrounding area in which normal inputs were used.

Survey information is gathered by CIP representatives both before and after the farm trials.

(b) "low," (c) "medium" and (d) "high-cost" input levels. This trial employed relatively large land parcels (150 m^2) with no replications. The other trials evaluated a single input at different levels. They employed smaller parcels (75 m^2) with two replications. In all trials the farmer's own technology was used as the control treatment and all non-experimental factors were kept at the farmer level (Table SSD-1).

Of 45 trials installed, 42 were harvested and 39 were analyzed. In 27 trials, one or more of the proposed technologies outyielded the farmer's technology by more than 20%, while in 25 trials one or more of the proposed technologies was more profitable than the farmer's. The agronomic and economic performance of technologies varied between agro-ecological zones (Table SSD-2).

Package Trial. On the Valley Floor (3,000 - 3,450 m), where small farmers' yields were lowest (average 4.0 t/ha), the high-cost package maximized yields (8.9 t/ha), but the low-cost package was more profitable. In the Intermediate (3,450 - 3,950 m) and High Zones (over 3,950 m), where farmers' yields were higher, the high-cost package maximized both yields and profits.

Fertilizer Trial. On the Valley Floor the high-cost fertilizer treatment maximized yields and profits. In the Intermediate Zone the medium and high-cost fertilizer levels yielded approximately the same, and the medium-cost level was most profitable. In the High Zone none of the proposed fertilizer levels increased yields significantly, and no treatment was as profitable as farmer technology.

Improved Seed Trial. On the Valley Floor, where high temperatures contribute to seed storage problems and spread of virus diseases, seed selection, greening and use of "guaranteed" seed increased yields and profits substantially. But these management practices were not profitable in the Intermediate Zone where seed problems are less important.

Insect Control Trial. Improved methods for controlling insects were profitable in both the Low and Intermediate Zones. Better control of Andean tuber weevil through changes in timing and placement of insecticide increased both yield and quality of harvested tubers.

Seed Production Trial. Experiments with seed producers had mixed results. While the proposed technology (increased planting density and seed greening) increased the proportion of seed-size tubers in the yield, these technologies were less profitable than seed growers' own practices because they cost more and higher prices were not received for this seed size.

Of the various technologies evaluated in the 1978/79 Mantaro Valley trials, improved insect control produced the most consistent increases in yield and net income.

Seed Production and Use

Tuber seed in the single most costly potato production input, and the shortage of good quality seed is a major production constraint in developing countries. Research in the Cañete Valley of Peru's central coast, in the Machachi region of highland Ecuador, and near Bogotá in highland Colombia evaluates the production potential and economic viability of alternative seed sources and planting methods.

Survey and Trial in Cañete. A 1979 farmer survey indicated that while most potato farms are small,

Table SSD-1. Specification of Treatments in On-Farm Trials in Mantaro Valley, Peru, 1978/79.

Type of Trial	Variable Inputs	Input Level by Treatment					
		A	B	C	D	E	F
Nº 1 Package (4 treatments)	Seed	The farmer's own input level	Same as Treatment B of Trial Nº 3	Same as Treatment D of Trial Nº 3	Same as Treatment F of Trial Nº 3		
	Fertilizer		Same as Treatment B of Trial Nº 2	Same as Treatment C of Trial Nº 2	Same as Treatment D of Trial Nº 2		
	Insect Control		25 kg Aldrin*	50 kg Aldrin*	25 kg Furadan		
			Modified timing and placement of soil and foliar insecticide.				
Nº 2 Fertilizer (4 treatments)	Kg N-P_2O_5-K_2O Valley Floor		120-180-60	150-180-100	200-250-150		
	Intermed. Zone		120-180-50	150-180-100	200-250-150		
	High Zone		60-100-100	80-150-150	120-200-200		
Nº 3 Improved Seed (6 treatments)	Seed Source		Farmer	Farmer	Farmer	Guaranteed	Guaranteed
	Seed Weight ($\bar{x}$g)		50	64	69	66	69
	Seed Greening		Yes	No	Yes	No	Yes
	Plants/ha		25,000	25,000	25,000	25,000	25,000
Nº 4 Insect Control (2 treatments)	Soil application		25 kg Aldrin*				
	Foliar application		Phosphoric and systemic insecticides				
Nº 5 Seed Production	Seed Greening		Yes	No	Yes		
	Plants/ha		Farmer	30,000	30,000		

* Aldrin is the insecticide most commonly used by farmers in the area.

Table SSD-2. Agro-Economic Results of On-Farm Trials in Mantaro Valley, Peru 1978/79

Type of Trial and Agro-Ecological Zone	No. of Locations	Total No. of Tests[1]	No. of Tests Where Alternative Technol. Yielded More[2]	No. of Tests Where Alternative Technol. Was More Profitable[3]	Highest Yielding Treatment[4]	Most Profitable Treatment[4]	Change in Net Income[5] (US$/ha)
1. Package Trial (3)[6]							
Valley Floor	2	6	4	3	D	B	148
Intermediate Zone	11	33	18	17	D	D	534
High Zone	1	3	2	3	D	D	464
2. Fertilizer Trial (3)[6]							
Valley Floor	2	6	5	4	D	D	229
Intermediate Zone	4	12	9	9	C	C	320
High Zone	2	6	1	1	D	A	—
3. Improved Seed Trial (5)[6]							
Valley Floor	3	15	9	10	E	E	632
Intermediate Zone	5	25	10	7	D	A	—
4. Insect Control Trial (1)[6]							
Valley Floor	2	2	2	2	B	B	97
Intermediate Zone	5	5	2	3	B	B	249
5. Seed Production Trial (3)[6]							
Valley Floor	2	6	3	2	D	D	171

1. Total number of tests = (number of technological alternatives tested) x (number of locations).
2. Criterion: yield of alternative technology > 20% above farmer's yield.
3. Criterion: net benefit/cost ratio > 1.5.
4. Treatments are specified in Table 1.
5. Average for all trials in the agro-ecological zone.
6. Figures in ( ) show the number of alternatives to the farmer's technology tested in the agro-ecological zone.

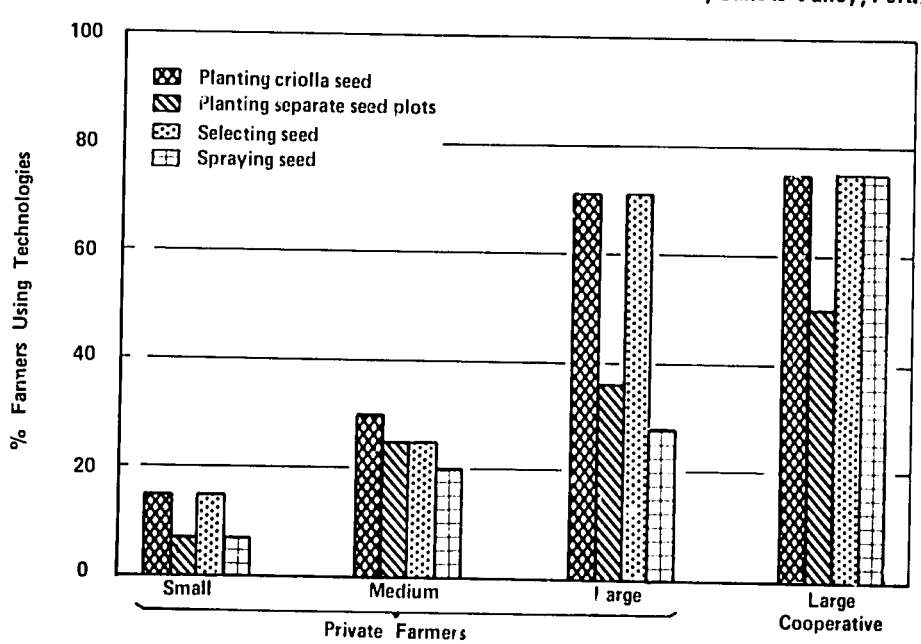
most potatoes are produced by large farms with more than 40 hectares of farm land. The similar average yield (about 20 t/ha) among small, medium and large producers reflects a degree of uniformity in their potato production technologies.

Only improved varieties are cultivated, and there is a strong preference for those maturing early. The seed rate is about 2.5 t/ha, there is a preference for large seed (60 g) and the planting distances are around 90 cm between rows and 30 cm between plants. In the production of *criolla* seed (the first coastal multiplication of material from the highlands) large farmers apply better technology than smaller farmers: a higher percentage cultivate seed in separate plots and select, disinfect and desprout their seed (Figure SSD-1). Concerning the management of highland seed, cooperatives apply the best technology, followed by large, medium and small farmers (Figure SSD-2).

During the early 1979 season an agro-economic experiment evaluated alternative tuber seed sources and two planting distances. The control treatment was the farmer's own seed source and planting distance, and in all treatments non-experimental factors were kept at the farmer level.

Six of the seven alternative seed sources yielded significantly more than the farmer's own seed, and all highland seed sources yielded equal to or more than coastal seed (Table SSD-3). The average yield of highland seed was significantly above that of coastal seed. However, the average yield resulting from planting at 20 cm between plants was not significantly different from the yield from planting at 30 cm (Table SSD-4). Significant differences were not found among highland seed sources or among coastal sources.

Figure SSD-1 — Production technology used for criolla seed, Cañete Valley, Peru.



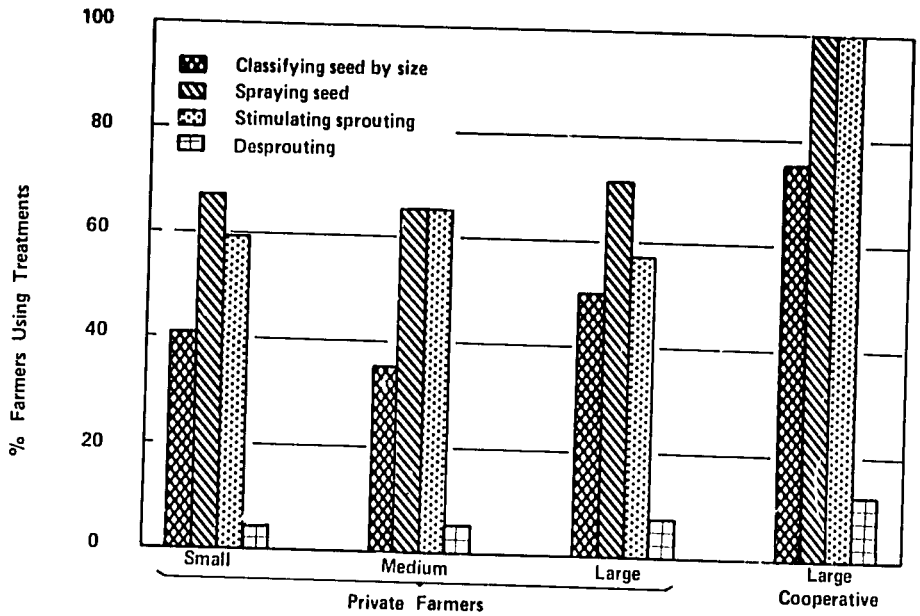


Figure SSD-2 — Pre-planting treatment of highland seed, Cañete Valley, Peru.

CIP trainees learn of results of an experiment in which potatoes are grown in the shade of coconut palms. Explaining the research is a cooperative manager (left).

Table SSD-3. Agro-Economic Results of a Farm-Level Experiment in Cañete Valley, Peru 1979.

Seed Source	Seed Spacing (cm)	Marketable Yield (t/ha)	Change in Total Income (US$/ha)	Change in Cost (US$/ha)	Change in Net Income (US$/ha)
Coastal Seed					
Farmer Seed 1/	30 1/	15.3	–	–	–
	20	20.2 n.s.	501	112	389
Alternative (a) Seed Sources	30	14.5 n.s.	82	354	- 272
	20	14.5 n.s.	112	616	- 504
(b)	30	20.2 n.s.	501	- 8	509
	20	26.2*	1,114	191	923
(c)	30	25.1*	1,001	102	899
	20	24.6*	950	252	698
Highland Seed					
Alternative (a) Seed Sources	30	31.7**	1,676	598	1,078
	20	31.7**	1,676	974	702
(b)	30	27.7**	1,267	547	720
	20	33.3**	1,839	877	962
(c)	30	30.6**	1,563	375	1,180 2/
	20	25.7*	1,063	708	355
(d)	30	25.6*	1,052	364	688
	20	29.8**	971	641	330

1/ Farmer's own technology.
2/ Most profitable treatment.
Yield difference from farmer's own technology: n.s. = not significant
* = significant at 5% level
** = significant at 1% level

Highland seed yielded more than coastal seed and was more profitable at the farm level. But since highland seed cost more than twice as much as coastal seed, Cañete producers may use coastal seed to minimize their costs. Increasing plant density may be profitable when using coastal seed but not when using more costly highland seed (Table SSD-5).

Trials in Machachi, Ecuador. During the 1978-79 crop year five on-farm trials and one experiment on "Santa Catalina" Experimental Station evaluated the use of farmer's own seed and registered seed at two planting distances (20 and 30 cm between plants). In the six experiments the control treatment was farmer seed and planting distance, and in all treatments non-experimental factors were kept at the farmer level. The control treatment of the experiment station trial used seed of one randomly selected producer.

In most experiments no statistically significant difference was found between the yield of farmer seed and registered seed, or between the 20 and 30 cm planting

Table SSD-4. Marketable Yield and Profitability of Two Seed Sources and Two Planting Distances, Cañete Valley, Peru 1979.

	Marketable Yield (t/ha)	Change in Total Income (US$/ha)	Change in Cost (US$/ha)	Change in Net Income (US$/ha)
Seed Sources				
Coastal Seed 1/	21.9	–	–	–
Highland Seed	29.5*	774	527	247 2/
Plant Density				
30 cm 1/	25.2	–	–	– 2/
20 cm	27.4 n.s.	223	254	-31

1/ Farmer's own technology.
2/ Most profitable treatment.
Yield difference from farmer's own technology: n.s. = not significant
* = significant at 5% level

distances. Due to small price difference (17%) between farmer seed and registered seed, the latter source was more profitable. However, since the registered seed price is subsidized, a commercially viable certified seed program would have to charge more for its seed. The experiments indicate that, with current seed and ware prices, increasing plant density would also be profitable (Table SSD-6).

Blight, Wilt-Resistant Variety

Inadequate pest control is a major potato production constraint in developing countries, where many small farmers cannot afford

Table SSD-5. Marketable Yield and Profitability of Different Seed Sources and Planting Distances, Cañete Valley, Peru 1979.

	Marketable Yield (t/ha)	Change in Total Income (US$/ha)	Change in Cost (US$/ha)	Change in Net Income (US$/ha)
Coastal Seed				
at 30 cm 1/	20.2	–	–	–
at 20 cm	23.6 n.s.	354	154	200
Highland Seed				
at 30 cm	28.9*	889	440	449 2/
at 20 cm	30.1*	1,014	769	245

1/ Farmer's own technology.
2/ Most profitable treatment.
Yield difference from farmer's own technology: n.s. = not significant
* = significant at 5% level

Table SSD-6. Average Marketable Yield and Profitability of Two Seed Sources and Two Planting Distances, in Six Farm-Level Experiment in Machachi Region, Ecuador.

	Marketable Yield (t/ha)	Change in Total Income (US$/ha)	Change in Cost (US$/ha)	Change in Net Income (US$/ha)
Seed Sources				
Farmer Seed	20.4	–	–	--
Registered Seed	22.6 n.s.	457	168	289 1/
Plant Spacing				
30 cm	20.2	–	–	–
20 cm	22.9 n.s.	572	200	372 1/

1/ Most profitable treatment.
Yield difference from farmer's own technology: n.s. = not significant.

chemical pesticides or manage them poorly. Hence, the importance of pest resistant varieties. Experiments in three farmers' fields in Huánuco, Peru, tested a new variety, "Molinera," that is resistant to bacterial wilt and late blight, against farmers' current variety, "Renacimiento." These trials were seeded during the rainy period, when farmers do not usually grow potatoes because of late blight. Included were two management levels: farmer and "improved," with the latter including higher fertilization and better pest control.

Molinera matured 5 weeks before Renacimiento and yielded more in every case (average 38% more with farmer technology and 74% more with improved technology). Due to low yields and the unusually low market price for potatoes at harvest, neither variety was profitable with current farmer technology. With improved technology the variety Renacimiento still registered an average loss of around US$ 400/ha but Molinera broke even.

Post-Harvest Technology Marketing

Recognizing that post-harvest problems of storage, processing and marketing are important barriers to potato production and utilization in developing countries, the Department conducted a series of studies in this area.

On-Farm Storage Trials. Four trials on the Floor of the Mantaro Valley evaluated seed storage in indirect sunlight against traditional farmer storage in darkness. In each case the proposed technique reduced storage losses and average length of sprouts and increased the number of sprouts. Differences were greatest for early varieties. The stored seeds were planted and data were recorded on emergence, number of stems per plant and yield. Storage in indirect light tended to reduce time to emergence and increase number of stems per plant and yield. Partial budget analysis indicated that storage in indirect light was more profitable than storage in darkness.

Peruvian Study of Papa Seca. A market potential study for *papa seca* (sun dried potatoes) indicated that annual Lima consumption is less than 1 kg per capita, and is linked to a traditional, festive dish, *carapulcra*. Most papa seca comes to Lima from the northern and central highlands, where discard potatoes are dried with simple methods on a small scale (average 40 kg per producer in Mantaro Valley). Unless final uses for this product are diversified, it seems unlikely that price reductions or quality improvements would stimulate significantly greater consumption.

Potential of the Potato

Research is appraising the potential role of the potato as a foodcrop in the developing world. In 1979 a survey of National Potato Program Leaders was analyzed and comparative studies of potato production and consumption were initiated. These studies complement on-going research based on published statistics and country studies.

National Program Leader Survey. In 1978 and 1979, 34 "Country Questionnaires" were filled by potato program leaders from developing countries and 4 by representatives from Europe and North America.

According to national program leaders in developing countries, the potato yield gap between experimental stations and the best farms is smaller than the yield gap between the best and poorest farms. Even in countries with high experimental yields, the national average yield tends to remain near to that of the poorest farms. According to national program leaders, the main factors limiting potato yields are use of poor quality seed, inadequate pest control and generally poor management.

Consumption levels for fresh and processed potatoes are much lower in most developing countries than in the developed countries. Program leaders identified the major factor limiting demand for fresh potatoes as high prices and the major factor limiting demand for processed potatoes as consumer preferences for fresh potatoes.

The survey indicates that average potato prices are higher in developing than in developed countries. Marketing costs were reported to be lower in the developing countries, but production costs per kilogram were higher. A major reason for the high cost of producing potatoes is the high price and poor quality of seed tubers. Building viable seed certification systems is a major objective of most national program leaders. However, to date, few countries produce more than a small percent of their seed requirements. The major barriers to establishing or expanding a certified seed program are viewed by national leaders as lack of trained personnel and lack of institutional commitment on the part of the government.

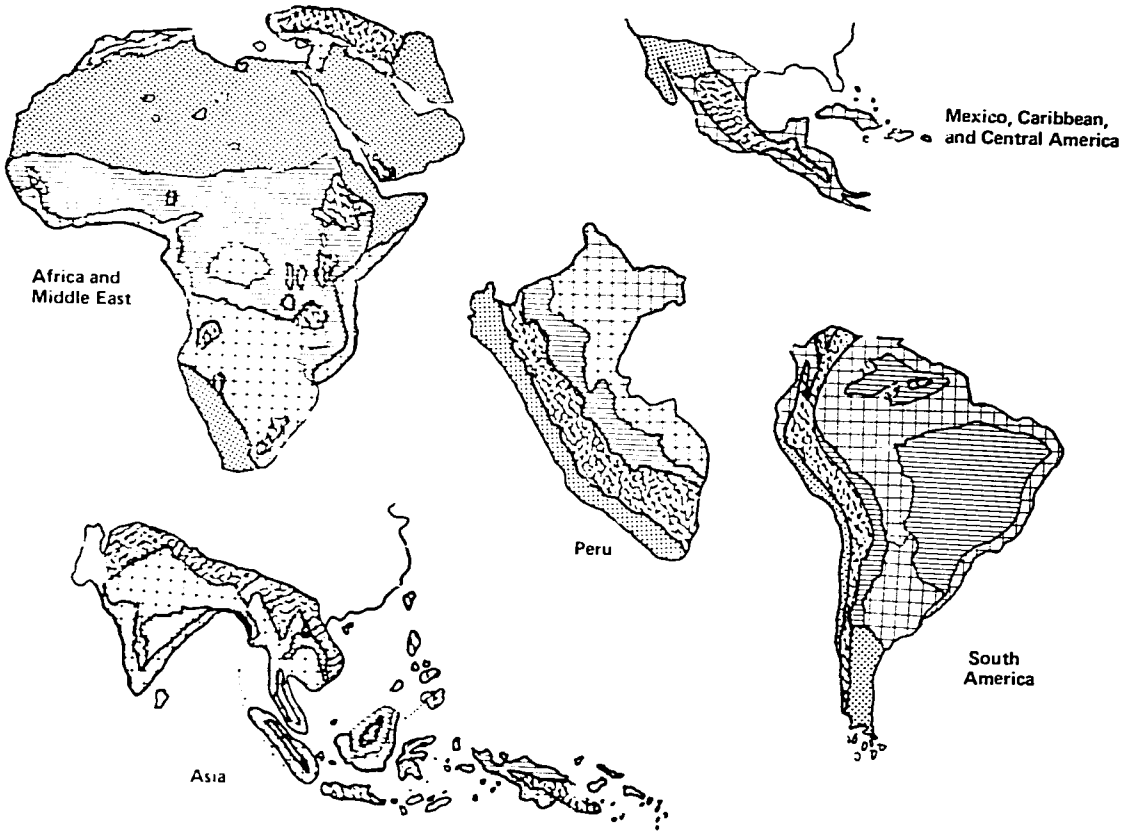
Comparative Production and Consumption Studies. During 1979 comparative studies of potato production (2-year project) and consumption (3-year project) were initiated. This work is commencing in Peru through analysis of production and consumption patterns in regions where CIP is now conducting experimental research. These regions, in turn, will be compared to other world areas of roughly similar agro-ecological conditions (Table SSD-7 and Figure SSD-3 on final two pages of this section).

Training and Workshops

During 1979 social scientists participated in courses and workshops dealing with seed potato production and use, post-harvest technology and on-farm research procedures. In February, May and October the Department conducted training on farm-level research methods aimed at optimizing potato productivity in developing countries. This training was done mainly in the Mantaro Valley, with visits to Cañete and San Ramón. In August a 3-day workshop in Lima reviewed experiences with on-farm potato research in Colombia, Ecuador and Peru.

CIP technician (standing) explains to a training group the agronomic techniques being tested for growing potatoes in hot, humid conditions.

ANALOGOUS AGRO-ECOLOGICAL ZONES: PERU IN WORLD CONTEXT



Tropical and Sub-tropical Lowlands (less than 400m)
Tropical hills and tablelands (400-1000m)
Tropical highlands (above 1000m)
Arid lands (less than 250mm precipitation)

Table SSD-7. Peruvian Potato Agriculture in Comparative Perspective.

Peruvian Case	Technology Type	Ecological Zone	Analogous World Areas	Present Role of the Potato
Mantaro Valley	Traditional production	High, cool tropics	Nepal, Himalaya, E. African Highlands	Staple or exchange item Seed production Export to lowlands
San Ramón	Incipient introduction	Mid-elevation, humid tropics	Central American, African, and Asian Hill Zones	Restricted consumption Kitchen gardens Experimental stage Supplemental vegetable
Yurimaguas	Potential introduction	Lowland, humid tropics	Lowland Asia, Central Africa	Little or no consumption Import Food Supplemental or luxury vegetable
Cañete	Irrigated, highly commercial	Arid tropics	North Africa, Punjab, India	Export to urban areas

Figure SSD-3 — Analogous agro-ecological zones: Peru in world context.

Communications Department

The Communications Department continued its major role as a production-oriented Center Support activity.

The Audiovisual unit has started to process black and white film in the CIP photo lab as well as coordinating and scheduling use of conference room, minisala, training conference room. A total of 1,500 colored slides in addition to 1,100 black and white photos were taken during the year. Duplicates made of colored slides totaled 3,000 while 1,000 high contrast black and white slides were made, mainly for presentations given by CIP staff members. Black and white photo enlargements totaled 1,100. Four hundred negatives were made with the photomechanical camera for producing offset plates while 100 screened photos were produced for halftone use. Arrival of a new storage/viewer for colored slides permits expansion of slide files.

The Department's duplicating unit made more than 170,000 photo copies and 200,000 pages of mimeographed material. Number of jobs finished with the ditto machine totaled 288 while the mimeograph job total was 533. CIP Annual Reports mailed totaled 2,589 with 2,411 other publications being sent to fill requests. Number of persons and institutions on CIP mailing lists total 2,500.

Total number of offset plates burned in 1979 was 355, including 136 positives and 219 negatives. Plates of two sizes were used. A total of 95 plates were used in last year's annual reports, divided nearly equally for the English and Spanish versions.

Communications' art/drafting unit is usually involved in nearly every production job with continual work on paste-ups, drawing, designing, lettering, Annual Report, Planning Conference Reports, 24 CIP Circulars, five training lessons, designing and preparing special CIP forms, and preparing charts and artwork for slides, overheads and publications.

Twenty-four CIP Circulars — 12 each in Spanish and English — were prepared, published and mailed out to describe various aspects of CIP's operation. In addition some 60 press releases were sent out for local as well as South American use. Personnel also did editing, scripting slide sets, translating, backgrounding visiting journalists and preparing special reports.

The text composition unit is mainly concerned with providing camera-ready copy for various publications, most of them being both in Spanish and English. Included were Annual Reports, CIP Circulars, training lessons, and in addition specialty items such as statistical charts and tables, CIP office forms, circular letters and some translation work.

Arrival of a new offset press during the year took considerable pressure off of a single, overworked press. Nearly a million impressions were run on the older press including the Annual Reports, Planning Conference Reports, Christmas cards, CIP Circulars, and CIP office forms. Nearly a half million large sheets of paper were cut for use in CIP publications and office forms.

LIBRARY

As a special potato library with emphasis on research aspects and priorities of interest to CIP, the growth of the collection in 1979 was in this direction.

Greater demand was noted in reference, loans, interlibrary loan services, special subject searches, bibliographies and current awareness services. This greater demand included came from both local and regional CIP staff.

The book collection was augmented by 436 including theses mainly on potato research.

Journal subscriptions were revised leaving 57 journal titles plus eight new journals by subscription. Library journals received by subscription, exchange and donation totals 396 titles. During the March-October period, 2,243 loans were made to CIP staff and trainees. Two hundred inter-library loans were made.

Processed reprints incorporated into the collection increased by 310 making a total of 2,289.

The following special bibliographies were prepared and distributed: Potato storage; Communications, audiovisuals, extension and training; Propagation methods; Potato processing; and Economic aspects of the potato.

A list of periodical titles in CIP's library collection was prepared and sent to the Biblioteca Agrícola Nacional as a contribution for the future Union Catalog of Agricultural Periodical Publications of Peru.

Exchange agreements exist with about 168 libraries, with 57 of these having Spanish as first language. A total of 111 libraries prefer to receive CIP publications in English. Forty-seven countries are represented in this exchange with this subdivision by continent: South America, 10; Central America, 4; North America, 3; Oceania, 2; Europe, 9; Asia, 11; and Africa, 8.

Photocopies continued to be provided for local library users from both CIP and other institutions, and externally to interested foreign institutions and scientists, and to CIP regional scientists. Local external users have access to the library collection but may not borrow unless a CIP scientist assumes responsibility for the loan or unless the loan is processed via inter-library loans. Thus photocopies are an invaluable aid to those external users who do not fit into these two categories but who need potato information because they are doing research in the field of potato agronomy.

Contacts have been made and are being followed up with CIP Huancayo personnel for the organization, planning, budgeting, and technical advising of the small library collection to be housed in Huancayo. This basic collection will only house the most important potato journals and books, together with a small reference collection and is not intended to be a regular branch library but rather an information support service to those in Huancayo, in addition to the Lima library. Regular collaborative mechanisms have already been established despite the fact that

library furniture will be purchased in 1980. Inter-library loans with Huancayo have been ongoing.

Library personnel attended several national, regional and international meetings and conferences on library-related subjects in Peru, France and England.

LANGUAGE INSTRUCTION

The number of CIP staff who took part in language instruction was 24 with an additional 11 spouses enrolled. Lessons for beginners totaled five weekly, intermediate level three lessons and advanced two lessons. Communications are through English, German, French or Spanish.

VISITORS

A total of 785 persons visited CIP and were shown the various installations during 1979. They represented 43 different nationalities. Travel agencies in Lima during the year established CIP as an "obligated visit" for tourists interested in agriculture.

Publications by CIP Scientists

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44. **Turkensteen, L. J.** 1979. Choanephora blight of potatoes and other crops grown under tropical conditions in Peru. Netherlands Jrnl. Plant Pathology. 85(2): 85-86.

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46. **Turkensteen, L. J.** 1979. Ulocladium atrum, el organismo causal de Kasahui, enfermedad foliar de la papa en el altiplano del Perú. Fitopatología 14(2)85.

47. **Werge, R. W.** 1979. Potato processing in the central highlands of Peru. Ecology and Food Nutrition 7:229-234.

48. **Wholey, D. W., and R. H. Booth.** 1979. A comparison of simple methods for estimating starch content of cassava roots. J. Sci. Food Agric., 30:158-164.

49. **Wholey, D. W., and R. H. Booth.** 1979. Influence of variety and planting density on starch accumulation in cassava roots. J. Sci. Food Agric., 30:165-170.

Research & 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 some of the following contracts has been incorporated into various Thrust reports.

Research Contracts

1. Cornell University.- "The Utilization of *Solanum tuberosum* spp. *andigena* Germ Plasm in Potato Improvement and Adaptation."
   R.L. Plaisted, H.D. Thurston, W.M. Tingey, R.E. Anderson, B.B. Brodie, M.B. Harrison and E.E. Ewing.
2. North Carolina State University.- "Breeding and Adaptation of Cultivated Diploid Potato Species."
   F.L. Haynes.
3. 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.- "Fertilización de la Papa en Trópico Húmedo."
   S. Villagarcía.
10. Universidad Nacional Agraria, La Molina, Perú.- "Effect of Various Systems of Potato Production on Yield, Pathogens, Fertility and Soil Erosion."
    Dr. Carmen Felipe Morales.

11. University of Wisconsin, Madison, U.S.A.- "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. Instituto Colombiano Agropecuario - Colombia.- "Evaluation of the Resistance to Potato Genetic Material to *Pseudomonas solanacearum*."
J. Victoria.
15. Agriculture Canada.- "Response of Tuberosum Genotypes to Environmental Stress."
D.A. Young.
16. 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 Polygenic Properties."
H. Stegemann.
17. Victoria Dept. of Agriculture, Australia.- "Potato Seed Multiplication of Germ Plasm for Southeast Asian and Pacific Countries."
P.T. Jenkins.
18. University Hohenheim (LH) Stuttgart, Germany.- "Physiological Studies on Tuberization and Growth in Potatoes."
Dr. G. Lorenzl. 1979.
19. Technical University of Berlin, Socioeconomics of Agricultural Development. 'Socioeconomic Research and Training on Potatoes."
Dr. G. Lorenzl.
20. Instituto Nacional de Investigaciones Agrícolas, México, México.- "Trabajos Experimentales de Campo."
21. CIAG-C - La Molina, Perú.- "Storage Project Administration."
L. Urquiano.

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. University of Birmingham - England.-"Consultancy in Exploration, Taxonomy, Maintenance and Utilization of Potato Germ Plasm."
J. Hawkes.
4. Universidad Nacional Agraria-La Molina, Perú.- "Consultancy on the Production of Antisera Project in the Virus."
C. Fribourg.
5. Universidad Nacional Agraria-La Molina, Perú.- "Consultancy on Maximizing Potato Productivity in Ecuador and Colombia."
S. Villagarcía.
6. Cornell University, Ithaca, U.S.A.- Support "Consultancy on Greenhouse Management."
S.W. Boodley.

7. University of Sydney - Australia.- "Consultancy on Rapid Multiplication of Potatoes."
   P. Goodwin.
8. Universidad Nacional Agraria, La Molina, Perú.- "Mejoramiento Resistencia a PVY."
   E. Fernández-Northcote.
9. Ministry of Agriculture and Food, La Molina, Perú.- "Testing of Advanced Clones for Wilt and Late Blight."
   I. Herrera.

Staff

(as of December 31, 1979, or serving a major portion of 1979)

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

Research Staff

Orville Page, PhD ..... Director

Breeding and Genetics

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

Nematology and Entomology

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

Pathology

Edward French, PhD ..... Department Head
Jan Henfling, PhD ..... Mycologist
William Hooker, PhD ..... Virologist
Carlos Martin, PhD ..... Bacteriologist
Anwar Rizvi, PhD ..... Virologist-Breeder
Luis Salazar, PhD ..... Virologist

Physiology

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

Adolph Krauss, PhD . . . . . Physiologist
David Midmore, PhD . . . . . Physiologist
Burkhard Sattelmacher, PhD . . . . . Physiologist
Lieselotte Schilde, PhD . . . . . Physiologist
Roy Shaw, BS . . . . . Physiologist
Siert Wiersema, MS . . . . . Physiologist

Taxonomy

Carlos Ochoa, MS . . . . . Department Head

Research Support

Orville Page, PhD . . . . . Department Head
Dennis Cunliffe, Ing. Agr. . . . . Field Supervisor - Lima, Yurimaguas
Marco Soto, PhD . . . . . Superintendent - Huancayo, San Ramón
Enrique Grande . . . . . Field Foreman - Huancayo
César Paredes, Ing. Agr. . . . . Field Foreman - San Ramón

Regional Research and Training Staff

Kenneth Brown, PhD . . . . . Director

Region I — South America

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

Region II — Central America, Mexico and the Caribbean

Michael Jackson, PhD . . . . . Regional Representative
James Bryan, MS . . . . . Seed Specialist (sabbatical)

Region III — Tropical Africa

Marciano Morales-Bermudez, MS . . . . . Regional Representative
Dennis Goffinet, PhD . . . . . Research Scientist (Rwanda)
Eisse Luitjens, Ir. . . . . Associate Research Scientist
Lyle Sikka, MS . . . . . Seed Production Specialist
Peter Van Der Zaag, PhD . . . . . Research Scientist (Rwanda)

Region IV — Middle East and North Africa

Patricio Malagamba, PhD . . . . . Regional Representative
Anton Haverkort, Ir. . . . . Associate Research Scientist
Brian Honess, DTA . . . . . Seed Production Specialist
S. V. Rama Rao, PhD . . . . . Entomologist
Willem Shrage, Ir. . . . . Research Scientist (Tunisia)

Region V — Southeast Asia

Gary Robertson, MS . . . . . Regional Representative
Romke Wustman, Ir. . . . . Associate Research Scientist

Region VI — India, Nepal and Bangladesh

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

Region VII — Southeast Asia

Lindsay Harmsworth, BS . . . . . Regional Representative
Richarte Acasio, MS . . . . . Research Scientist

Social Science Department

Douglas Horton, PhD . . . . . Department Head
Roger Cortbaoui, PhD . . . . . Economist
Georg Durr, MS . . . . . Economist
Anibal Monares, MS . . . . . Economist
Susan Poats, PhD . . . . . Anthropologist
Michael Potts, PhD . . . . . Agronomist
Luis Quintanilla, MS . . . . . Economist-Statistician
Robert Rhoades, PhD . . . . . Anthropologist

Training Department

Richard Wurster, PhD . . . . . Department Head
Manuel Piña, PhD . . . . . Training Officer
Rainer Zachmann, PhD . . . . . Training Officer

Regional Research Support

John Niederhauser, PhD . . . . . Consultant
Sylvester Nganga, PhD . . . . . Seed Production Specialist

Support Communications

Frank J. Shideler, MS . . . . . Department Head
Hilda Berger . . . . . Writer - Spanish
María de Boisset, BA . . . . . Photographic & A-V Technician
Carmen de Podesta, MA Inf. Sc. . . . . Librarian/Information Officer
Ayn Strattner, MS . . . . . Editor/Writer
Martha Crosby, BA . . . . . Assistant Librarian

Scientific Associates

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

Carmen Felipe Morales, PhD . . . . . Agronomist
Enrique Fernandez-Northcote, PhD . . . . Virologist
César Fribourg, MS . . . . . Virologist
Isaías Herrera, Ing. Agr. . . . . Bacteriologist
Teresa Ames de Icochea, PhD . . . . . Mycologist
Sven Villagarcía, PhD . . . . . Agronomist

Scientific Assistants

Breeding and Genetics

Juan Aguilar, Ing. Agr.*
Edgard Alvarez, MS
Walter Amoros, MS
Saturnino Vargas, Ing. Agr.
Ricardo Wissar, MS

Nematology and Entomology

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

Pathology

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

Physiology

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

Taxonomy

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

Research Support

Lauro Gomez
Nelson Meléndez, Tech. Dip.

Social Science

María Isabel Benavides, BA
Hugo Fano
Cecilia Moreno, Ing. Zootc.
Patricia Moreno, BS

Social Science Special Project (IDRC)

Jorge Alarcón, BS
Elsa Bruno
Efraín Franco, MS
Juan Perea, BS
Marcelino Raymundo, BS
Luis Tomassini, MS
Ludy Ugarte, BA

Communications Support

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

Administrative Staff

Office of the Executive Officer

Carlos Bohl, Ing. Agr.	Executive Officer
Victor Barreto, BA	Assistant Executive Officer
Fernando Canalle, Ing. Civ.	Supervisor
Georgio de Gasperi	Supervisor
Ana Dumett	Social Worker
Luis Palacios, Ing. Agr.*	Supervisor

Accounting

Leonardo Hussey	Controller
Oscar Gil, CPA	Senior Accountant
Jorge Bautista	Accountant
Blanca de Joo, CPA	Accountant
Guillermo Romero	Accountant

* Resigned during 1979.

COLERIDGE Y ASOCIADOS

THE INTERNATIONAL POTATO CENTER - CIP

FINANCIAL STATEMENTS AS OF DECEMBER 31, 1979 AND 1978

I N D E X

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

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, 1979 and 1978, 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, 1979 and 1978, and the source and application of its funds for the years then ended, in conformity with generally accepted accounting principles applied on a consistent basis.

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

Horacio Lupi
C.P.C. Matrícula No. 4835

Lima, Perú,
March 21, 1980.

THE INTERNATIONAL POTATO CENTER - CIP

BALANCE SHEET

(Stated in U.S. dollars)

ASSETS

	As of December 31, 1979	1978
CURRENT ASSETS:		
Cash on hand in banks, includes US$1,000,000 in 1978 of short-term deposits	225,377	1,412,482
Accounts receivable -		
Donors	661,295	298,390
Advances -		
Principal and support staff	50,545	140,306
International agriculture centers and other organizations	77,403	132,790
Other	198,558	112,292
	987,801	683,778
Inventories -		
Laboratory and other supplies	272,201	119,296
Vehicles and other fixed assets replaced to be sold	103,909	89,369
	376,110	208,665
Prepaid expenses and other assets	129,238	42,086
Total current assets	1,718,526	2,347,011
FIXED ASSETS:		
Buildings and construction in progress	1,624,469	1,467,092
Research equipment	614,376	554,826
Vehicles and aircraft	728,970	612,171
Furniture, fixture and office equipment	391,017	326,478
Operating equipment	115,090	86,644
Installation	599,890	532,745
Site Development	150,042	98,773
Communication equipment	52,737	29,609
Other	67,513	65,118
	4,344,104	3,773,456
	6,062,630	6,120,467

LIABILITIES, CAPITAL AND UNEXPENDED FUNDS

	As of December 31, 1979	1978
CURRENT LIABILITIES:		
Bank overdrafts	26,074	97,179
Accounts payable to vendors and international agriculture centers and other organizations	355,981	213,750
Accounts payable to donors	-	255,550
Other	137,419	75,698
Total current liabilities	519,474	642,177
GRANTS RECEIVED IN ADVANCE	-	270,000
RESERVE FOR SEVERANCE INDEMNITIES, net of advances of US$14,044 in 1979 and US$10,766 in 1978	109,406	72,854
CAPITAL AND UNEXPENDED FUNDS:		
Capital -		
Fully expended on fixed assets	4,344,104	3,773,456
Unexpended funds -		
Working funds	571,000	488,000
Core programs	328,213	717,092
Special projects	190,433	156,888
	1,089,646	1,361,980
	5,433,750	5,135,436
	6,062,630	6,120,467

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

COLEMINGE Y ASOCIADOS

THE INTERNATIONAL POTATO CENTER - CIP

STATEMENT OF SOURCE AND APPLICATION OF FUNDS

(Stated in U.S. dollars)

	For the years ended December 31, 1979	1978
SOURCE OF FUNDS:		
Operating grants -		
Unrestricted	3,330,212	3,133,629
Restricted, net of US$255,550 in 1978 payable to donors	3,452,048	2,479,319
	6,782,260	5,612,948
Special projects grants, net of US$44,051 and US$25,129 paid to donors in 1979 and 1978, respectively	540,648	598,968
Capital grants	480,387	412,514
Working fund grants	571,000	362,000
Other income, net	127,946	195,430
	8,502,241	7,181,860
APPLICATION OF FUNDS:		
Operating costs -		
Core program:		
Potato research program	1,904,342	1,599,028
Research support	620,835	453,881
Regional research and training	2,415,435	1,611,061
Library, documentation and information service	215,356	174,133
General administration	607,257	486,990
General operating costs	818,769	640,193
	6,581,994	4,965,286
Special projects	350,214	442,080
	6,932,208	5,407,366
Capital -		
Additions to fixed assets	480,387	412,514
	7,412,595	5,819,880
UNEXPENDED FUNDS	1,089,646	1,361,980

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, 1979 AND 1978

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 adjusted 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.

e. Certain accounts in the financial statements for the year ended December 31, 1978 have been reclassified to make them comparable to the current-year statements.

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 on their remunerations.

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.

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3. FIXED ASSETS

The acquisition of fixed assets in transit at the balance sheet date are shown in the balance sheet and amount to US$109,378 (US$98,850 in 1978).

4. CONTINGENCIES

A constructor has filed a lawsuit against the CIP claiming a payment of Peruvian soles 6,394,000 (US$25,293 at the exchange rate in effect at year-end) that include S/5,000,000 for damages. In management's opinion and its legal advisors' this lawsuit will not proceed for lack of evidence or proof.

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.

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SUPPLEMENTARY INFORMATION

EXHIBIT 1

THE INTERNATIONAL POTATO CENTER - CIP

ACCOUNTS RECEIVABLE FROM DONORS

AS OF DECEMBER 31, 1979

(Stated in U.S. dollars)

Ford Foundation	41,000
International Development Research Center	9,794
Belgium Government	315,243
Swiss Government	65,600
Canadian International Development Agency	19,658
Interamerican Development Bank	210,000
	661,295

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EXHIBIT 2

THE INTERNATIONAL POTATO CENTER - CIP

FIXED ASSETS

FOR THE YEAR ENDED DECEMBER 31, 1979

(Stated in U.S. dollars)

	Balances as of January 1, 1979	Additions	Replacements		Balances as of December 31, 1979
			Additions	Retirements	
Buildings and constructions in progress	1,467,092	157,377	-	-	1,624,469
Research equipment	554,826	52,561	24,012	17,023	614,376
Vehicles and aircraft	612,171	55,356	103,313	41,870	728,970
Furniture, fixture and office equipment	326,478	64,009	10,802	10,272	391,017
Operating equipment	86,644	9,753	31,238	12,545	115,090
Installation	532,745	67,145	-	-	599,890
Site development	98,773	51,269	-	-	150,042
Communication equipment	29,609	22,917	211	-	52,737
Other	65,118	-	3,963	1,568	67,513
	3,773,456	480,387	173,539	83,278	4,344,104

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THE INTERNATIONAL POTATO CENTER - CIP

DETAIL OF SOURCE OF FUNDS

FOR THE YEAR ENDED DECEMBER 31, 1979

(Stated in U.S. dollars)

CORE OPERATING GRANTS:		
Multi-purpose -		
Danish International Development Agency, Denmark	363,777	
Swiss Development Cooperation, Switzerland	270,000	
International Technical Assistance, The Netherlands	275,000	
	908,777	
Less:		
Applied to capital	340,526	
Applied to working funds	83,000	
	485,251	
Core unrestricted grants -		
Swedish Agency for Research Cooperation	754,717	
Overseas Development Administration, United Kingdom	474,463	
International Development Agency, Canada	560,950	
Federal German Government	360,806	
Belgium Government	136,127	
	2,287,063	
Plus:		
Balance from previous years	557,898	
	2,844,961	3,330,212
Core restricted -		
Agency for International Development, USA	1,500,000	
Australian Development Assistance Bureau	198,771	
Federal German Government	178,640	
Interamerican Development Bank	600,000	
Belgium Government	139,254	
European Economic Community	544,396	
French Government	100,000	
Rockefeller Foundation	22,000	
International Development Research Center	9,794	
	3,292,855	
Plus:		
Balance from previous years	159,193	3,452,048
		6,782,260

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THE INTERNATIONAL POTATO CENTER - CIP

DETAIL OF SOURCE OF FUNDS

FOR THE YEAR ENDED DECEMBER 31, 1979

(Stated in U.S. dollars)

SPECIAL PROJECTS GRANTS:		
Swiss Development Cooperation, Switzerland	151,200	
Federal German Government	77,963	
International Development Research Center	68,440	
International Development Agency, Canada	53,502	
Ford Foundation	41,000	
W. K. Kellog Foundation	35,000	
Balance from prior years, net of returns -		
Swiss Development Cooperation, Switzerland	59,449	
International Development Agency, Canada	37,084	
Ford Foundation, training and research in Colombia and Ecuador	23,599	
International Technical Assistance, The Netherlands	11,592	
International Development Research Center	10,198	
Ford Foundation	2,605	
Federal German Government, training and socio-economics	1,779	
Interamerican Development Bank	244	
Refrigeration Research Foundation	190	
Swiss Development Cooperation, Switzerland	(33,197)	540,648
CAPITAL GRANTS:		
Transferred from multi-purpose funds	340,526	
Interamerican Development Bank	100,000	
Belgium Government	39,861	480,387
WORKING FUNDS:		
Transferred from multi-purpose funds	83,000	
Balance from previous years	488,000	571,000
OTHER INCOME, net		127,946
		8,502,241

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EXHIBIT 4

THE INTERNATIONAL POTATO CENTER - CIP

SPECIAL PROJECTS FUNDS PROVIDED AND COST

FOR THE YEAR ENDED DECEMBER 31, 1979

(Stated in U.S. dollars)

Name of donors and projects	Funds provided	Disbursements: Prior years	Disbursements: This year	Disbursements: Total accumulated	Returns	Balance to date
Ford Foundation -						
Improve potato production	127,300	124,695	-	124,695	-	2,605
Training and research activities in Colombia and Ecuador	82,000	17,401	21,954	39,355	-	42,645
	209,300	142,096	21,954	164,050	-	45,250
Federal Germany -						
Training fellowships	4,000	2,221	-	2,221	-	1,779
Regional Seed Production Specialist	77,962	-	38,019	38,019	-	39,943
	81,962	2,221	38,019	40,240	-	41,722
International Technical Assistance, The Netherlands -						
Potato improvement - Region V	282,040	270,448	11,592	282,040	-	-
Swiss Development Cooperation, Switzerland -						
Potato improvement - Nepal (First Phase)	243,470	220,697	20,952	241,649	-	1,821
Potato improvement - Nepal (Second Phase)	75,230	-	63,463	63,463	-	11,767
	318,700	220,697	84,415	305,112	-	13,588
International Development Agency, Canada -						
Potato improvement - Tunisia	221,173	130,587	68,907	199,494	-	21,679
Interamerican Development Bank -						
Program A - Training	174,314	159,051	(111)	158,940	15,374	-
Program B - Agriculture	394,350	384,230	355	384,585	9,765	-
	568,664	543,281	244	543,525	25,139	-
Refrigeration Research Foundation -						
Training on potato storage	2,500	2,310	-	2,310	-	190
International Development Research Center -						
Agro-Economic research on potato production	161,235	82,597	52,024	134,621	-	26,614
Swiss Development Cooperation, Switzerland -						
PRECODEPA - First Phase	103,500	-	59,449	59,449	44,051	-
PRECODEPA - Second Phase	20,000	-	13,610	13,610	-	6,390
	123,500	-	73,059	73,059	44,051	6,390
W. K. Kellog Foundation -						
Develop training material	35,000	-	-	-	-	35,000
	2,004,074	1,394,237	350,214	1,744,451	69,190	190,433

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THE INTERNATIONAL POTATO CENTER

Schedule 1: FUNDS PROVIDED AND COSTS
For the year ended December 31,1979
(Expressed in thousand of U.S. dollars)

	Total Funds Available	PROGRAM COSTS						% of Gral. Adm.& Operat. to Direct	Unex-pended Balance	Payable to Donors
		Fixed Assets	Total Research	Reg.Res. & Training	Library Doc. & Inf.	General Administ.	General Operating			
Unrestricted Core	(1) 3,458.2		1,076.9	1,291.2	68.0	325.8	486.8	33	209.5	ø
Restricted Core										
USAID	1,500.0		572.0	557.0	69.0	127.0	175.0	25	-	
ADAA	220.4		41.9	176.0	-	-	-	-	2.5	
Federal Germany	219.6		117.0	25.2	-	15.0	2.1	12	60.3	
IDB	600.0		313.3	78.4	78.3	55.4	74.6	28	-	
Belgium	239.1		-	162.5	-	24.2	-	15	52.4	
E.E.C.	544.4		319.9	106.6	-	50.2	67.7	28	-	
Rockefeller Foundation	22.0		-	18.5	-	-	-	-	3.5	
French	100.0		78.4	-	-	9.2	12.4	28	-	
IDRC	6.5		5.8	-	-	.5	.2	12	-	
Total Restricted Core	3,452.0		1,448.3	1,124.2	147.3	281.5	332.0		118.7	ø
Total Operating Costs	6,910.2		2,525.2	2,415.4	215.3	607.3	818.8		328.2	ø
Capital Grants										
IDB	100.0	100.0								
Belgium	39.9	39.9								
Transferred from multi-purpose	340.5	340.5								
Total Capital	480.4	480.4							ø	ø
Special Projects										
Ford Foundation	67.2			22.0					45.2	
Federal Germany	79.7			38.0					41.7	
Netherlands	11.6			11.6					-	
Swiss Dev. Coop.	98.0			84.4					13.6	
CIDA	90.6			68.9					21.7	
IDB	0.2			0.2					-	
Refrigeration Res. Foundation	0.2			-					0.2	
IDRC	78.6		52.0						26.6	
Swiss - PRECODEPA	(2) 79.5		73.1						6.4	
W.K. Kellog Foundation	35.0			-					35.0	
Total Special Projects	540.6		125.1	225.1					190.4	ø
Working Funds										
Transferred from Multi-purpose	83.0									
Balance from previous year	488.0									
Total Working Funds	571.0								571.0	ø
TOTAL FUNDS AND COSTS	8,502.2	480.4	2,650.3	2,640.5	215.3	607.3	818.8		1,089.6	ø

1) Includes $127.946 from earned income
2) Net of $44.051 refund to donor in 1979

THE INTERNATIONAL POTATO CENTER

Schedule 2: EARNED INCOME AND APPLICATIONS

For the year ended December 31, 1979

(Expressed in thousand of U.S. dollars)

	Approved Budget	Actual
Sources of Earned Income		
Interests on Deposits	70	119.2
Sale of Crops & Materials	2	5.4
Sale of Fixed Assets	120	(14.0) 1)
Indirect Costs charges on Special Projects & Current Accounts	35	63.4
Adjustment prior year	-	(11.4)
Rate of Exchange adjustment	10	12.3
Other	8	8.6
Sub-Total	245	183.5
Less: Auxiliary Services Deficit	(10)	(55.6)
TOTAL	235	127.9
Application of Earned Income		
Applied to Core Operations	-	127.9
Applied to Capital	235	-
Applied to Working Fund	-	-
TOTAL	235	127.9

1) Includes $25,982 adjustment of prior year's revenue for unrealized gains.

THE INTERNATIONAL POTATO CENTER

Schedule 3: COMPARATIVE STATEMENT OF ACTUAL EXPENSES

AND APPROVED BUDGET FOR THE YEAR ENDED DECEMBER 31, 1979

(Expressed in thousand of U.S. dollars)

	Operating Unrestricted		Operating Restricted		Capital	
	Budget	Actual	Budget	Actual	Budget	Actual
Programs						
Potato Research		1,076.9		1,448.3		
Regional Research & Training		1,291.2		1,124.2		
Library, Doc. & Info. Services		68.0		147.3		
General Administration		325.8		281.5		
General Operating Costs		486.8		332.0		
Contingencies		-		-		
	3,397.0	3,248.7	3,452.0	3,333.3		
Capital						
Operating Equipment					16.0	9.7
Research Equipment					49.4	52.6
Vehicles & Aircraft					41.5	55.4
Furnitures, Fixtures & Off. Equip.					34.6	64.0
Installation & Utilities					38.5	67.1
Constructions & Buildings					116.3	157.4
Site Development					15.0	51.3
Communication Equipment					23.7	22.9
					335.0	480.4
Analysis of Variances						
Budget Surplus						
- Lower earned income	(107.1)					
- Grant shortfall	(173.4)					
- Unbudgeted additional use of carry-over funds	487.1					
- Net surplus		209.5		118.7		
Deficits						
- Covered by Core operating surplus	(145.4)				145.4	
- Net Deficits					Ø	
TOTAL BUDGET VS. EXPENSES AND APPLICATION OF VARIANCES	3,458.2	3,458.2	3,452.0	3,452.0	480.4	480.4

(COVER . . . from inside front)

About 2 metric tons of tubers are required to plant one hectare. This represents a large amount of potential food used for seed rather than for human consumption. Tubers, being of vegetative origin, become infected with viruses which spread to the next generation of plants arising from planting infected tubers. Viruses cause degenerative disorders and reduce yield. Under developing country conditions, transportation and storage of large quantities of tubers for seed may be both difficult and expensive.

In contrast, only about 65 grams of the tiny true seeds are needed to plant one hectare. This is about the same weight as a single tuber. A handful is sufficient to plant about one hectare (2.47 acres).

True seed offers several advantages, including: potential human food is not used as seed, transportation costs are minimal and it can be stored under dry conditions for several years without deterioration. Of particular importance, transmission of disease-causing organisms can be virtually eliminated through the use of true seed.

Part of the International Potato Center research program is to determine the feasibility of using true potato seed to complement the traditional use of tubers for production of consumer potatoes in developing countries.

VIII-CSC-04-O-E/2500-S/1500-(July 1980)