THE WORLD BANK GROUP ARCHIVES

PUBLIC DISCLOSURE AUTHORIZED

Folder Title:	CGIAR - G-4 - International Potato Center (CIP) - Annual reports 72/74-01
Folder ID:	1760494
Series:	Central Files
Dates:	01/01/1972 - 12/31/1974
Fonds:	Records of the Consultative Group on International Agricultural Research (CGIAR)
ISAD Reference Code:	WB IBRD/IDA CGIAR-4177S
Digitized:	04/19/2021

CGIAR - G-4 - CIP Annual Reports 1972/1974

1974

G4

annual report

INTERNATIONAL

POTATO CENTRE INTERNACIONAL

DE LA PAPA

annual report
1974

CENTRO INTERNACIONAL DE LA PAPA
APARTADO 5969, LIMA, PERU
CABLES : CIPAPA

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

*Basal portion of an Inca Chaqui-Taclla or foot plough.

TABLE OF CONTENTS

BOARD OF TRUSTEES	2
STAFF	4
FOREWORD	8
THE POTATO	10
FACILITY DEVELOPMENT	13
THRUSTS	17
Systematics	18
Utilization	27
Control - Fungi	32
Bacteria	35
Viruses	39
Nematodes	42
Adaptation to Stress	48
Nutritional Quality	53
Tissue Culture	55
OUTREACH	59
RESEARCH CONTRACTS - 1974	70
PLANNING CONFERENCES	85
LIBRARY	90
FINANCE	92

Tuber sample from CIP's germ plasm collection

BOARD OF TRUSTEES

DR. ERNST KELLER

Professor of Plant Breeding at the
Federal Technical University,
Eidg. Technische Hoshschule Zürich,
Universitätstrasse 2,
8006 Zürich,
Switzerland

DR. ATMARAM BHAIRAV JOSHI

Director,
Indian Agricultural Research Institute,
New Delhi - 110012,
India

DR. COLIN MC CLUNG

Associate Director,
Agricultural Sciences,
The Rockefeller Foundation,
111 West 50th Street,
New York, New York 10010,
U. S. A.

DR. CLIBAS VIEIRA

Empresa Brasileira de Pesquisa Agropecuaria,
Dpto. Tecnico-Cientifico,
Caixa Postal 1316,
Brasilia,
Brazil

DR. RICHARD L. SAWYER

Director General,
International Potato Center,
Apartado 5969,
Lima,
Peru

STAFF

on December 31, 1974

Administration

Richard L. Sawyer, Ph.D.	Director General
Orville T. Page, Ph.D.	Deputy Director, Research
John Niederhauser, Ph.D.	Outreach Advisor (Mexico)
Carlos Bohl P., Ing.Agr.	Executive Officer
Oscar Gil, CPC	Controller
Guillermo Romero	Accountant
William Hamann, B.S.	Assistant to the Director

Breeding & Genetics

Roger Rowe, Ph.D.	Head of Department
Nelson Estrada, Ph.D.	Breeder
Humberto Mendoza, Ph.D.	Geneticist
Juan Landeo, M.S.	Breeder
Stephanie Jackson, M.Sc.	Breeder
Zósimo Huamán, M.Sc.	Horticulturist

Nematology

Rolf Schaefer, Ph.D.	Head of Department
Parviz Jatala, Ph.D.	Nematologist
Maria de Scurrah, Ph.D.	Nematologist
Javier Franco P., Ing.Agr.	Nematologist

Taxonomy

Carlos Ochoa, M.S.	Head of Department
Matilde Orrillo, Ing.Agr.	Taxonomist
Mike Jackson, M.S.	Taxonomist

Outreach & Training

Richard Wurster, Ph.D.	Head of Department
James Bryan, M.S.	Seed Production Spec.
Michael Twomey, Ph.D.	Economist
Oscar Hidalgo, M.S.	Production Spec.
Manuel Villarreal, M.S.	Production Spec. (Mexico)
Primo Accatino, Ph.D.	Production Spec. (Lebanon)
Guillermo Giron, M.S.	Economist

Pathology

Edward French, Ph.D.	Head of Department

Julia Guzmán N., Ph.D.	Pathologist
Rainer Zachmann, Ph.D.	Pathologist
Lodewijk Turkensteen, Ph.D.	Pathologist
Roger Jones, Ph.D.	Virologist
Luis Salazar, M.S.	Virologist
A.M. Hinostroza Lekeu, Ph.D.	Virologist
Clive James, Ph.D.	Visiting Pathologist
Kenneth Proudfoot, M.Sc.	Visiting Pathologist
John Vessey, Ph.D.	Pathologist *
Liliam Gutarra, Ing.Agr.	Bacteriologist

Physiology

Kenneth Sayre, Ph.D.	Head of Department
Raymond Meyer, Ph.D.	Agronomist
William Roca, Ph.D.	Physiologist
Fernando Ezeta, Ph.D.	Physiologist

Support Department

Marco Soto, Ph.D.	Superintendent, Huancayo facility
César Vittorelli, Ing.Agr.	Field Foreman, Huancayo
Herbert Torres, M.S.	Greenhouse Foreman, Huancayo

* Left during year.

Carmen de Podestá, BA.Sc.	Librarian
Luis Valencia, Ing.Agr.	Entomologist
Elsa Franco	Publications
Jorge Palacios, Dip.	Language Teacher

Scientific Technicians

Juan Aguilar, Ing.Agr.	Breeding and Genetics
Susan Turner, B.Sc.	Nematology
Martha Carrillo	Outreach (Mexico)
Lis Ocampo, Ing.Agr.	Pathology
Ursula Nydegger, Tech.Dip.	Pathology
Ilse de Balbo, Tech.Dip.	Pathology
Norma Gonzales, Q.F.	Physiology
Rosa Mendez, Ing.Agr.	Physiology
Daniel Berrios, Ing.Agr.	Physiology (Huancayo)
Amparo de Siveroni, Q.F.	Physiology
Rosario de Roca	Physiology

FOREWORD

Development of CIP

This is the second published Annual Report of El Centro Internacional de la Papa. In 1971 an agreement was ratified with the Government of Peru marking the establishment of CIP, the fifth autonomous international Center sponsored by the Consultative Group on International Agricultural Research. The first funding through the CGIAR was received in 1972; since then CIP has made rapid progress in establishing its research, outreach, and contractual research programs.

The International Potato Center is devoted to the development and dissemination of knowledge for the greater utilization of the potato as a basic food for developing countries in the tropical and sub-tropical regions of the world. The forebearers of CIP, the Rockefeller Foundation's International Potato Program in Mexico, and the North Carolina State University's potato research program in Peru funded by USAID to collaborate with the Peruvian Potato Program, provided a legacy of research information, trained personnel, and basic germ plasm which has been integrated into CIP's strategic plan of action.

Strategy

The statutes of CIP state that to fulfill its objectives the Center will:

I Conduct research program for the improvement of potato production and other tuberous roots, both nationally and internationally;

II Collect, maintain and distribute germ plasm in order that it may be used nationally and internationally;

III Provide assistance in the development of related institutions which might be established in Peru or headquartered elsewhere;

IV Train potato technicians under the leadership of high-level scientists;

V Publish and distribute research results;

VI Establish an information center and organize a specialized library, as well as an herbarium;

VII Organize conferences, forums, round tables and seminars, both nationally and internationally concerning potato improvement activities;

VIII Participate in all other activities related to the goals of the Center.

To accomplish these objectives sound research and outreach strategies have been developed. Although Departments have been organized for administrative convenience along disciplinary lines, i.e. Breeding and Genetics, Nematology, Outreach and Training, Pathology, Physiology, Taxonomy, and Support, research projects are commonly interdisciplinary and are integrated into ten Thrusts or goals. Forty-seven research projects were either continuing or initiated in 1974. Guidance in determining Thrust objectives and priorities is provided through Planning Conferences. The concepts and expert advice of some of the world's top potato specialists thus augments and influences CIP's research policy.

In the early stages of planning CIP chose to support specific research projects at outstanding institutions and universities where expert personnel, equipment and facilities already existed. Through Core funding, administered as part of Departmental research budgets, eleven Research Contracts are being supported at universities and institutions in England, the Netherlands, Peru, Sweden, and the United States. The expertise and facilities of many outstanding teams are thus directly involved in solving research problems of mutual interest. Through Memoranda of Agreement CIP also supported projects in Bolivia, Colombia (2), Costa Rica, Ecuador, Ethiopia, Mexico and Nigeria during 1974. Through these Agreements useful data on field evaluation of clonal selections are being obtained.

THE POTATO

Biological Facts

In the 1973 Annual Report an historical perspective of the potato was presented. The following brief account of some of the biological attributes of the potato is intended merely for convenient orientation to some of the research results presented in this Report.

There are approximately 2,000 species of *Solanum* of which only two *tuberosum* subspecies of the 150 tuber-bearing types have been extensively exploited as a source of food. As the fourth most important food plant of man - after the cereals wheat, maize and rice - the potato is the most extensively grown crop which is propagated vegetatively.

The nutritious tuber is actually stem modified for underground storage. The "eyes", which are spirally arranged are rudimentary shoot buds. Following varying periods of dormancy, or after chemical treatment, several of the buds become active and elongate as shoots or sprouts. The practice of inducing sprouting before planting is known as "chitting".

The white, red, to blue skin or periderm of the tuber consists of three types of tissue, one of which has the capacity to generate more outer protective cells as the tuber enlarges. When a tuber is cut, or when invaded by certain organisms the exposed cells have the potential to divide and form a protective wound periderm. Thus, when tubers are cut for seed and allowed to cure for a short period a resistant wound periderm forms to protect the cut surface.

Tissue and Meristem Culture

The vegetative regenerative capacity of the potato is being widely used to accelerate its propagation. For the first time a CIP scientist, Dr. W. Roca, has been able to generate embryonic potato plantlets from free tuber cells grown as a suspension in liquid culture medium. This "tissue culture" technique and modifications of it will permit the production of large numbers of virus free embryo plantlets in culture flasks. These plantlets are later aseptically transferred to solid media and finally to soil in pots.

The vegetative generative capacity of the potato plant is also being exploited in a number of other ways by CIP. The technique of "meristem culture" whereby a micro sample of a shoot tip is transferred to culture medium is now a well-established method of eliminating a number of degenerative viruses. "Stem cuttings", which are branchlets 2 to 3 inches in length, are rooted giving 40 or 50 additional plants from each of which more branchlets can be excised. In one year up to one ton of tubers can be produced from a single tuber. From sections of tuber sprouts it is also relatively easy to generate small tubers in sterile culture. These cultured tubers, which have been useful in studying several diseases in the laboratory, can be used to export disease-free seed to developing countries.

"True"Seed

John Holt observed in 1795 that, "great attention is paid to raising new sorts of the best qualities from seeds......which grow upon the stems". The sexual cycle of the potato, of which the flower is the essential component, culminates in the production of green berries, not dissimilar to small, immature tomatoes. The "true" or "botanical" seed contained in these berries germinate to produce seedlings. Through the sexual cycle new genetic combinations arise so that each seed, and therefore each seedling, is genetically different. After making appropriate crosses, by the artificial transfer of male pollen from one flower to the receptive female structure of another flower, the potato breeder is then confronted with screening the seedling progeny arising from the crosses. Through careful selection of parental lines it is possible through sexual crosses to enhance particular characters such as disease resistance, yield and quality. Seedling lines resulting from a multiple crossing sequence may eventually be selected for more rigorous testing leading to the introduction of new potato varieties.

Potato clones under observation at CIP mature in 75 to 150 days. This wide range in maturity permits the selection of clones with a short interval from planting to harvest that can be used in a rotation sequence with rice or other cereals. In other situations a relatively long interval between planting and harvest reduces the seed storage period in regions where only one crop a year can be grown.

Nutritional Quality

Potatoes constitute a dietary item in over 100 countries, testifying to the wide adaptation of this crop. In terms of its nutritional potential, the potato ranks first among the 10 major food crops in calorie production per unit area per day, and second to soybeans in protein production per unit area. In per diem protein production per unit area the potato ranks fourth after soybeans, beans and peas. The superior production of both calories and protein per unit area per day over the major cereals is largely unappreciated. In addition, the potato is also an excellent source of vitamin C and the vitamin B group.

The balanced protein - calorie composition, the nutritious quality of the protein, and the relatively rapid growth makes the potato an ideal food complement to cereal crops in multi-crop sequences.

FACILITY DEVELOPMENT

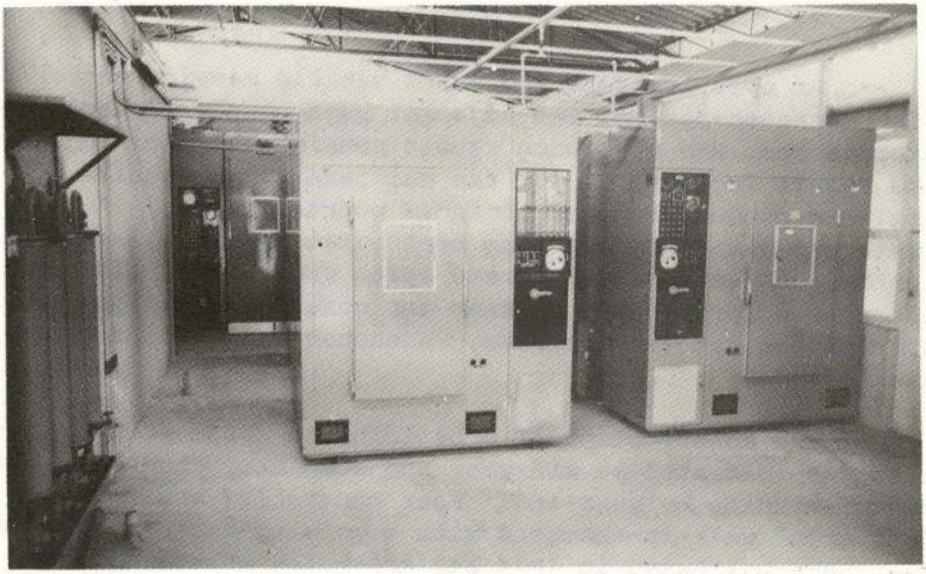
The interactions of latitude, altitude, air mass movement and ocean currents cause strikingly different climatic zones in Peru. Advantage has been taken of these unique climatic zones within 60 miles of latitude 12° S to develop three environmentally different experimental field sites. The daylength range above an intensity of 10.8 lux (1 foot candle) is 12 hours 6 minutes (June 22) to 13 hours 20 minutes (December 22).

Location	Climate	Altitude meters	Rainfall (mm)	Temperature Range C
La Molina	sub-tropic desert	240	11	8 to 30
Huancayo	temperate sierra	3,300	743	-5 to 27
San Ramón	humid tropic selva	800	2,005	16 to 32

La Molina

During 1974 additional facilities were added to headquarter installations at La Molina. Two Lord and Burnham spun fiberglass greenhouses were erected on concrete bases. Each greenhouse has an area of $80m^2$; one is air-conditioned to maintain a temperature below ambient while the other has forced air ventilation and is equipped with an oil heater for maintaining above ambient temperatures during winter.

Pre-earthquake view of CIP headquarter building, La Molina, Peru



Recently installed walk-in and reach-in controlled environment chambers

Plastic fabricated greenhouses for virus research

An open concrete and brick vehicle service center with a grease-pit and two adjacent bays, enclosed tool room, storage room and adjoining rabbit housing has been completed. The rabbit facility is for the maintenance of rabbits for antisera production used to index potato viruses. A concrete car-wash ramp has also been built beside the service center. An extensive concrete apron provides an efficient, clean area for vehicle parking and general servicing of screenhouse, growth chambers, warehouse, and soil storage bunkers.

The construction of a building to house growth chambers was initiated in mid-year and completed except for interior finishing by year-end. Four controlled-environment "Conviron" walk-in-chambers with a growing area of 36 square feet were purchased in 1974 and are being installed. One chamber is equipped to operate to -7°C to permit studies on cold hardiness. Six reach-in chambers having 9 square feet of growing area have been received and are ready for installation. Two of these can be operated down to 5°C with full light.

Intensive planning was initiated in 1974 for an extension to the headquarter office and laboratory building which was originally donated by the government of Peru. In addition to expanding laboratory and office space the new wing will house an electron microscope and ancillary equipment, conference and other facilities for the Outreach and Training Program as well as a dormitory for trainees.

San Ramon

An area of approximately four hectares at this site provides an adequate area for initial field trials of potato adaptation to the humid tropics. Early trials have confirmed that a number of clones are readily adapted to this hot humid environment. Since it is the intent to use the land at San Ramón only as a temporary site before moving to progressively lower locations in the selva, no permanent installations are envisioned at present.

Huancayo

CIP's major field research facilities are located in the high Mantaro Valley near the city of Huancayo. During 1974 construction of the following permanent buildings was undertaken:

- Single-story, six-room home for the Superintendent with attached double-occupancy rooms and dining area for eight scientists or trainees.

- A laboratory building containing four multiple-purpose laboratories, offices, library and two conference-training rooms (area, 460 square meters).

- Potato storage for germ plasm material.

- Headhouse with an office and soil storage bunkers to service six pre-fabricated greenhouses.

- Car-equipment maintenance and storage building.

These buildings will be completed and in use in early 1975. Additional greenhouses, an expanded potato storage, and staff bungalows are projected over the next year or so.

THRUSTS

"Thrust", derived from Middle English means: "to extend, as in growth". Thrust is an appropriate term to provide a mental image of an action - oriented, progressive research program. Thrusts also provide a framework for the organization of research projects into convenient units. While five Research Departments serve an administrative function of grouping personnel and allocating project funding, Thrusts serve to bridge disciplines essential for a team approach to solve reserach problems.

Every effort is made in Research to respond to the production problems encountered by Outreach. Since Outreach activities are integrated with Research, it is natural to include Outreach projects as one of the Thrusts. In summary, the Thrusts are concerned with: systematics; germ plasm utilization; control of fungal, bacterial, and viral pathogens; control of nematode and insect pests; adaptation to environmental stress; improvement of quality; village scale processing; seed production technology; and, outreach and training.

I. SYSTEMATIC COLLECTION, CLASSIFICATION, MAINTENANCE AND DISTRIBUTION OF ALL TUBER-BEARING *SOLANUM* SPECIES

Collection

The strategy being followed by CIP in the systematic collection of potato germ plasm was developed at a Planning Conference held in December 1972. The initial effort is being put into the intensive collection of native cultivars in the Andean Region. In 1974, emphasis was given to unexplored or little known zones such as the Eastern region of the Department of Puno, the highlands of Lima Department and the North-Central areas of Peru, and to regions in which the greatest genetic erosion is occurring such as in the Northern Peru and in the Sierra de Los Cuchumatanes in Guatemala.

More than 2,800 accessions of cultivated samples were collected during the present year by 10 expeditions. In addition to the CIP expeditions organized by Ing. Carlos Ochoa, the Center collaborated with an expedition led by Dr. J.G. Hawkes and funded by the government of The Netherlands.

The explorations and collections made in the Depart-

Material introduced into CIP Germ Plasm Collection in 1974

Type of Material	Donor	Collector(s)	Origin	Number of Accessions
Stocks from other collections	Instituto Colombiano Agropecuario	Lopez	Colombia	429
	Universidad Nac. Tecnica del Altiplano	Flores/Monzon/Arce	Puno	197
	Universidad Nac. Agraria (Peru)	Ochoa	Various	159
Native cultivars from 1974 CIP expeditions		Hjerting/Aguilar	Huancavelica Junin, Pasco	794
		Maycelo	Amazonas	57
	Dutch Expedition	Hawkes/van Harten/Landeo	S.Peru Bolivia	256
		Jackson	Cajamarca	211
		Huaman	Puno,Bolivia	154
		Huaman	Lambayeque, Piura,Ancash	126
		Ochoa	Arequipa,Puno	303
		Ochoa	Pasco	404
		Ochoa	Huanuco	545
		Ochoa	Guatemala	21
Wild species from other collections and from CIP expeditions	Sturgeon Bay, Wisconsin	Various	Various	44
		Hawkes/Astley	S.Peru,Bolivia	99
		Hjerting/Aguilar	Huancavelica Junin	12
		CIP Staff	Various	40
Hybrids from breeding programs	Wageningen		Holland	22
	New York		U.S.A.	26
	Wisconsin		U.S.A.	132
	C.Ochoa		Peru	3
			Total :	4,024

ment of Cajamarca, Lambayeque, Piura and Amazonas finished the field work of Northern Peru. Likewise, the work in North -Central and Central Peru represented by the Departments of Huanuco, Pasco, Junin, Huancavelica and Lima has also been finished. In Southern Peru, collections were made in Arequipa and Puno Departments as well as some collections in the Departments of La Paz and Oruro from Bolivia. This latter area will receive more attention in 1975. Rare and old native varieties from Guatemala which are facing extinction have been found in some almost inaccessible regions. Collections of these materials together with some wild species endemic or prevalent in Guatemala have been incorporated into the CIP germ plasm collection.

Systematics Research

Solanum x *chaucha* Juz. et Buk. is a triploid ($2n = 3x = 36$) species of cultivated potato that is found frequently in Andean potato fields. Knowledge concerning the natural synthesis of the species and why it is maintained in cultivated populations has potential value for potato breeding work.

To determine the frequency of triploid production, tetraploid-diploid pollinations were made in Huancayo between January and March, using 106 Andigena clones from 10 geographical areas of Peru and Bolivia. These crosses yielded 60 triploid progeny (14% of progeny counted). In certain crosses only triploids were formed; in others, they were found at a very low frequency or not at all. These suggest that tetraploids are genetically variable with regard to the ability to form triploids. Since the majority of progeny were tetraploid, presumably 2n gametes from the diploids were viable in some crosses, demonstrating their selective advantage over "n" gametes in 4x-2x crosses. In the natural situation, it is expected that triploids would be formed infrequently.

Thin-layer chromatographic patterns of floral pigments of natural-occurring triploids were compared, as were water-soluble tuber proteins, separated by disc-

Typical small fields in the Peruvian Andes. Rare samples of S. phureja were found at this location.

electrophoresis in polyacrylamide gels. Protein banding patterns were used to determine clonal duplications, and when correlated with tuber morphology, demonstrated the narrow variation of triploid potatoes. Of the 147 clones studied electrophoretically, 32 had chromosome numbers other than 2n = 36, and their electrophoretic patterns were distinct. At this time, it has been possible to assign tentatively 93 clones to 9 groups. Affinities between clones will become clearer as other morphological correlations are made, but it appears that there are relatively few different genotypes within the species.

Solanum ajanhuiri Juz. et Buk. is a cultivated diploid species of interest because of its general resistance to frost. During an expedition to Bolivia and southern Peru in 1974, the general area of cultivation of *S. ajanhuiri* was established. The species is cultivated most extensively in the Altiplano Region of Bolivia. The areas of greatest cultivation were located in the Western provinces of the Departments of La Paz and Oruro. It was also noticed that this species is widely distributed around the Lake Titicaca, in both Peru and Bolivia, but it is not extensively cultivated. It was evident that *S. ajanhuiri* had some advantages over the other cultivated potatoes which made possible its selection by the Aymaras. These advantages are mainly related to its frost resistance and good palatability. *S. ajanhuiri* is as frost resistant as the bitter potatoes (*S. juzepczukii* and *S. curtilobum*), but it yields tubers with equal or better quality than the non-bitter potatoes.

There is some evidence to support the hypothesis that *S. ajanhuiri* was derived from natural crosses between a cultivated and a non-cultivated diploid potato. *S. stenotomum* is postulated to be one of the parents because it is the most primitive diploid cultivated potato. The wild parent could be the frost resistant species *S. megistacrolobum*. The putative parents were found in Bolivia overlapping in their geographic and ecologic distribution along the area of cultivation of *S. ajanhuiri*, at an altitude over 3,900 m. and generally in places where frost is a limiting factor for agriculture.

In an attempt to synthesize *S. ajanhuiri*, crosses were made in all possible combinations using 30 different clones of *S. stenotomum (stn)* and populations of four accessions of *S. megistacrolobum (mga)*. From the data obtained, the following conclusions can be derived: Firstly, there are some barriers that prevent seed set when *mga* is the female parent. The few seeds produced are generally non-viable seeds. The high number of aborted seeds are explained on the basis of unfavorable embryo-endosperm relationship. Secondly, the hybrids are generally more easily produced when using *stn* as the female parent. In some cases, the cross was successful in only one direction. This happened independent of whether *stn* or *mga* was used as male or female parent. The morphology of the progeny will give an indication if these are the correct parents that gave rise to *S. ajanhuiri*.

Germ Plasm Maintenance and Distribution

As of December 1974, the CIP collection of potato germ plasm in Peru included 2800 entries that have been given CIP accession numbers. An additional 5000 accessions from recent expeditions were being grown and examined prior to the assignment of accession numbers. Almost all accessions are primitive cultivars that have been collected in the Andean region. As more information on these clones is developed, duplicates will be eliminated.

Accessions of the non-cultivated species are being maintained in cooperation with the U.S. Potato Collection at Sturgeon Bay, Wisconsin. New accessions are being sent to Sturgeon Bay for seed increase and subsequent distribution.

Some specifics for 1974 include: The total of 3,650 native cultivars introduced into CIP consisted of nearly 800 donated by established collections and over 2,800 from the 10 Center expeditions. New material was collected from Bolivia, Guatemala and 12 Departments of Peru. Two hundred accessions of wild species were obtained from Sturgeon Bay and the 1974 expeditions. Two hundred hybrid clones including named varieties from The Netherlands

and the U.S.A. and potentially valuable selections from Wisconsin were imported for use in breeding programs. There was a slight increase in the number of requests filled, compared to 1973 (86 vs. 76), with an increase in those received from abroad. The number of tuber lots distributed (mainly CIP internal) was 4,756 and there was a large increase in the distribution of botanical seed, especially that of hybrid origin, to over 1,500 lots.

Distribution of CIP Germ Plasm in 1974

Material	Tuber lots	Seed lots	Total
Cultivars	4,619	1,251	5,870
Hybrids	125	199	324
Wild species	12	128	140
Total	4,756	1,578	6,334

Almost 2,000 clones with CIP numbers were assigned preliminary species identification by morphological examination and the additional 100 chromosome counts received helped resolve the status of morphologically indistinct *S. chaucha*. In taxonomic work on the new collections over 800 chromosome counts, 1,700 species assignments, and synonym groupings for 3 of these collections were made. Screening data were received on resistance to cyst nematode, Thecaphora, PVX, frost and on nutritional quality.

Over 2,000 cultivars and wild species were planted at La Molina for increase and taxonomic study, and the 7,000 clones planted at Huancayo in November 1974 were more than double the number harvested in May. Open-pollinated seed was collected from 430 clones in the germ plasm field and is now available for 2,500 clones.

CIP/s germ plasm collection at Sta. Ana Station near Huancayo, Peru.

Vending potatoes in a market in Kenya

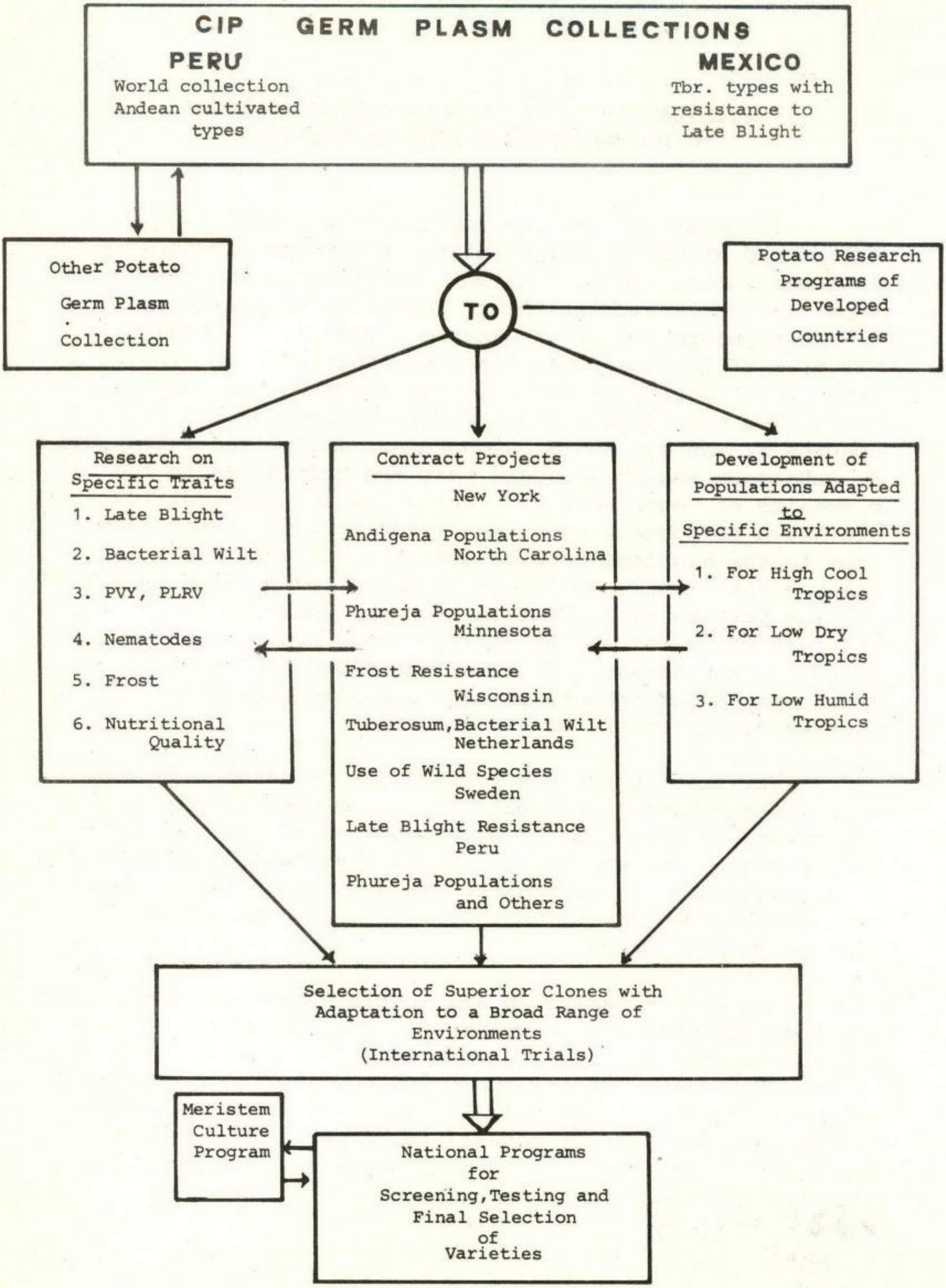
II. UTILIZATION OF THE TUBER-BEARING SOLANUMS TO PROVIDE BETTER ADAPTED POTATOES

In order to meet the challenge of providing well adapted and stable potato populations for the highland and lowland tropics, as well as for countries in the temperate zone, the International Potato Center is utilizing the broadest possible base of genetic diversity. During 1974, CIP held an International Planning Conference on "The Strategy for Utilization" and a 5-year research plan was developed. The most usable new diversity exists in the diploid species *S. phureja* and *S. stenotomum*, and in the tetraploid *S. tuberosum* subsp. *andigena* that are cultivated in the mountains of South America. While these native cultivars are known to contain a wealth of variability, their adaptation to the highland tropics limits their usefulness in other areas. Thus, an intensive selection program to modify the pattern of adaptation of these potatoes and to find the most efficient way to utilize these populations in breeding is underway. *S. tuberosum* subsp. *tuberosum* from the Northern hemisphere, is also valuable because of its past selection for yield and quality.

Utilization of such a diversity of genetic resources involves the blending of materials from many sources and the coordinated interaction of many projects of CIP and other institutions. A flow chart depicts the transfer of material from germ plasm collections to research projects and finally to national programs where they will begin to have an impact on potato yields.

The work to assemble all possible genetic resources has been described under Thrust 1. This material is now moving into CIP research in Peru and into Contract Projects. Within CIP, the intensive quest for new sources of resistance and the development of efficient screening procedures is the responsiblity of several staff members in different Departments; progress in these areas is covered under the individual Thrusts.

TRANSFER OF GENETIC STOCK WITHIN CIP



Because utilization of the genetic resources involves a need to work with large populations, part of the task is being done through Contract Projects with well established breeding programs. These programs provide CIP with additional capacity to select populations under different or special environments. These programs also have the ability to distribute tuber material of selected clones or populations to countries that cannot, because of quarantine regulations, accept clones sent from Peru. The work of these contract projects is an integral part of the total utilization effort as can be appreciated in the following report of activities in 1974.

Andigena (Neo-tuberosum) populations

The tuberization of Neo-tuberosum (*andigena* derivatives adapted to northern latitudes) has shown a dramatic increase after selection in New York by the Cornell University Contract. The percent of plants with tubers and tuber weight/plant has increased dramatically after 5 cycles of selection. In addition to selection for general adaptation and yield, these materials are being screened by scientists at Cornell University for resistance to potato virus Y, potato virus X, cyst nematode, root-knot nematode, green peach aphid, potato aphid, leaf hopper, scab, late blight and bacterial wilt. Some clones have been evaluated for heat tolerance and components of adaptation such as reaction to day length. Where acceptable levels of resistance has been found, hybrid combinations are being made.

The material from the work at Cornell is now flowing into CIP programs. In 1974, seed and tuber samples were sent to 10 countries for evaluation and to serve as a genetic base for future work. Over 14,000 seedling tubers were sent to CIP for selection under the main environments of hot dry and hot wet lowland conditions and high sierra conditions. Clones selected from these families should be superior to clones selected in New York and then sent to Peru. The clones selected at the three locations in Peru will be used to form populations for selection for improved adaptation to these specific conditions.

A replicated trial that includes samples of each of the 5 selection cycles carried out at Cornell University has been planted at Huancayo with the purpose of measuring the genetic progress achieved in terms of Andean conditions. A Neo-tuberosum population formed by 15000 clones has been planted at two locations (Huancayo and La Molina) for selection of superior genotypes. Over 200 Neo-tuberosum clones were planted at three locations for observation of performance and stability. Superior genotypes will be used as parents for the next cycle of selection.

Phureja-stenotomum Populations

Selection of the cultivated diploids has gone through only three cycles in North Carolina, but it is clear that selection has increased production under North Carolina conditions. How valuable this material will be for other programs will be determined soon in the countries that have received seed or tubers. In Peru, CIP has tested this material extensively in San Ramon and La Molina. Yields have not been encouraging and it appears that further selection is needed. The *phureja* population is a good source of genes for high dry matter, possibly protein content, and general eating quality. A research contract with the breeding program of the Ministry of Agriculture of Peru is investigating these specific traits in selected *phureja* clones.

In the period June-October, 3683 clones grouped in 72 families were grown at San Ramon. Two hundred clones with good adaptation under humid tropic conditions were selected. Thirty-two of them yielded 950 gm. or more per plant and are being used as pollen parents for a new cycle of selection which is expected to increase the frequency of genotypes with superior yield and adaptation to lowland tropics. A *phureja* population formed by 2300 clones has been planted at the three main CIP locations to select superior genotypes. A sample of 20 diploid families has been planted in a replicated trial at two locations (Huancayo and La Molina) to obtain estimates of genetic and environmental variability. These estimates are to be used in the further selection work.

Tuberosum populations

The work to develop new breeding methods by the Wisconsin contract has also been of direct benefit to CIP. The research contract has dealt with the development of ways to produce hybrid combinations which provide the maximum degree of heterozygosity in combination with proper adaptation. Selected diploid clones that produce a high frequency of 2n gametes have produced high yielding uniform progeny when crossed with tetraploid *Tuberosum* varieties. While a relatively small sample of this material, basically *tuberosum* type, has been tested in Peru, it has performed very well at the two low elevation stations and has great promise for use under these conditions. A *tuberosum* population that includes 8000 seedlings has been planted at three locations to identify superior genotypes to be used in further selection cycles. A group of *tuberosum* clones has been planted at all locations for observation of performance of stability.

Work with non-cultivated species

Breeders must also consider long range projects to bring in new sources of variation. To do this for late blight, a research contract has involved the program of the Plant Breeding Department of the Agricultural University, Wageningen, The Netherlands. This project involves the utilization of the high resistance that occurs in two wild species from Mexico, *Solanum bulbocastanum* and *S. pinnatisectum*. These species are known to have high resistance to late blight, but they have not been used because they cannot be crossed directly to the cultivated potato. Intensive crossing efforts have produced some hybrid families through bridge crosses. Seed of these crosses have been sent to Mexico for evaluation in 1975. These hybrids are many years away from usefulness in the field but their potential value is great.

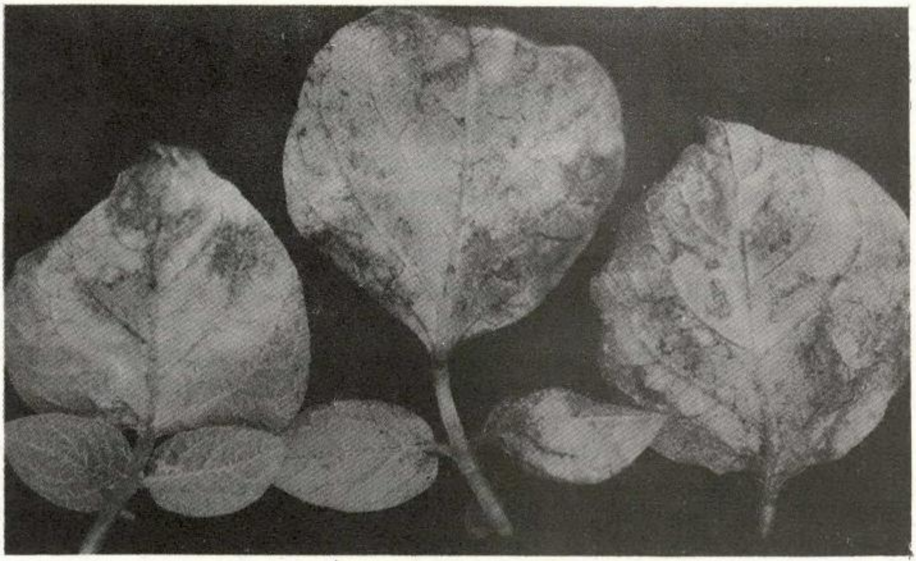
III. CONTROL OF SELECTED FUNGAL PATHOGENS

Late Blight

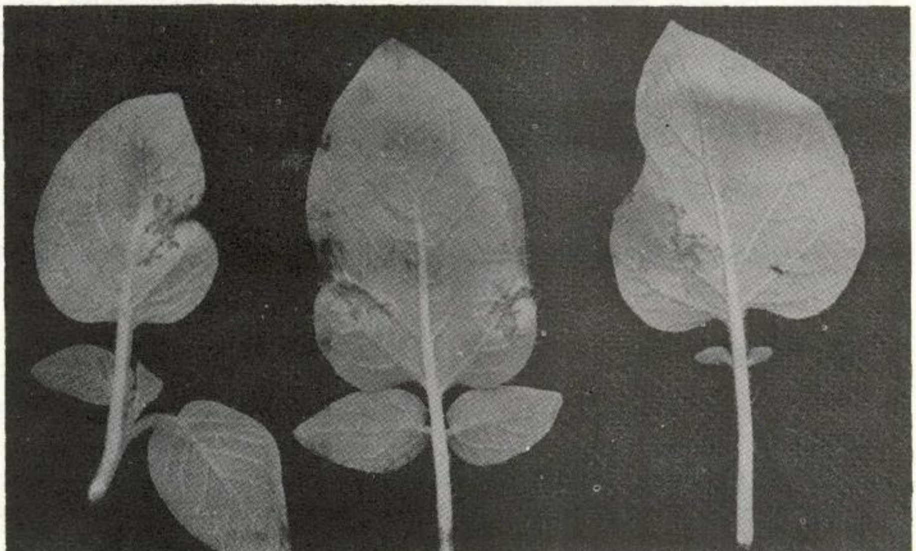
Late blight (*Phytophthora infestans*) resistant clones from CIP's Mexican Regional Program were distributed to countries that are developing a resistance program, most of them in response to the Outreach Program's efforts. A total of 170 clone shipments were made to 9 countries. CIP's International Potato Blight Testing Program continued to screen entries from European, Indian and U.S. breeding institutions.

It is recognized that resistance to a single disease is inadequate. The blight resistance program is coordinated with the bacterial wilt program. In Peru the national program has selected clones with dual resistance for multiplication and naming of varieties (expected to take place during 1975). Similar processes are taking place in other countries.

In addition to multiple disease resistance, better yields and quality are needed. To facilitate this CIP is tapping the extensive genetic capital in its germ plasm bank. CIP staff in Peru has selected 973 from 4,500 clones with differing levels of field resistance to late blight; 417 *S. tuberosum* ssp. *andigena* (135 of which are early maturing) and 92 *S. phureja* are undergoing further blight testing in Huancayo. A portion of these have been tested in the lowland humid tropical San Ramon location (where there appears to be a different response to blight). Crosses made between those early maturing, resistant and productive *andigena* clones and other potatoes with superior qualities produced 3,734 seedlings which were screened under controlled conditions for field or horizontal resistance to blight. One hundred and thirty-two clones were selected among 2,043 transplanted to the field for having good yield and tuber quality. These will be retested and utilized further in a program to develop field resistant varieties for the tropics.



Highly susceptible potato variety, late blight disease



Resistant potato variety, late blight disease

Much of the potential for increased potato production is in developing countries of the subtropical regions. The Cornell Contract is developing field resistant superior *andigena* clones in cooperation with CIP's staff at Toluca, Mexico. Forty promising clones were retested during 1974, with similar good results. It was also shown that viruses may interfere with late blight evaluations. Plants infected with either potato leaf roll virus, potato spindle tuber virus, potato virus X, or potato virus Y appeared more resistant to late blight than non-virus infected plants.

Through a contract with the Santa Elena Station of the State of Mexico, in the Toluca Valley, CIP has supported the development of superior quality, blight resistant potatoes suitable for that region and hopefully other similar geographical locations. The most advanced selection trials of 75-plant plots resulted in 191 out of 671 retained in 1974. In earlier generation 10-plant plots 235 of 656 clones were selected. Recent crosses (34 progenies) yielded 12,350 seedlings which, after two screening selections, have been reduced to 252 superior clones. In addition to this tetraploid work, a haploid program at Santa Elena has also made substantial progress. Haploids derived from *S. tuberosum* subs. *tuberosum* have been selected for blight resistance, then crossed among themselves and with diploid species. Nineteen families with a total of 92 plants were rated in 1974; many had no blight (suggesting the presence of major genes), but ten had a 2 rating, and 14 a 3 rating (0 to 5 scale of increasing severity).

Phoma Blight

A low temperature leaf disease which affected CIP's plantings in Huancayo was also found near Cuzco. Three *Phoma* fungi were isolated, one a large-spored form, tentatively named *P. macrospora*, as well as *P. exigua* var. *exigua*, and *P. exigua* var. *foveata*. All isolates of the first two fungi infected leaves and could be re-isolated, but *P. macrospora* alone produced typical symptoms. *P. exigua* was pathogenic on potato tubers. Among the 1,170 clones exposed to *Phoma* blight, 635 appeared resistant.

Black wart

During two consecutive years 38 clones from among 500 originally tested continued to show resistance to black wart *(Synchytrium endobioticum)* at Casablanca, near CIP's Huancayo field station. These clones also were tested in Northern, Central and Southern Peru at Huamachuco, Casablanca and Andenes (Cuzco) along with differentials used by the Canadian and Netherlands programs in a project in which visiting scientist Kenneth Proudfoot participated. Unfortunately, the poorly adapted northern latitude differentials did not develop sufficiently to record their interaction with the pathogen. Among the 38 clones tested 11 remained free of wart at the three locations. Three infected in Casablanca were not infected in either Andenes or Huamachuco while eight were infected at both Huamachuco and Andenes. Seventeen additional clones became diseased only at Andenes. These results suggest that races or biotypes of the pathogen are present. This will be evaluated in future work.

IV. CONTROL OF SELECTED BACTERIAL PATHOGENS

Bacterial wilt

Bacterial wilt or brown rot caused by *Pseudomonas solanacearum* is the most serious bacterial pathogen of potatoes in the tropics and subtropics. The lowland strain (race 1) is most widespread; the upland strains (race 3) infects potatoes primarily in the colder higher regions of the Andes. It is considered that to control this disease resistant varieties are necessary, and CIP's resistance breeding program is making substantial progress.

In Nigeria over 2 tons of seed have been produced of one clone that has resistance to bacterial wilt and good yield characteristics under the conditions of the Jos Plateau Region. This clone, BR63· 5, was selected out of tuber families sent to Nigeria, It is expected that this *phureja - tuberosum* hybrid will be released as a variety by the national program of Nigeria in 1975. In Peru, six clones of 24 originally selected in a program initiated by the Peruvian National Program, are being increased to assess which clones are to be released as varieties in 1975. These clones are both wilt and late blight resistant, equal or better in yield to established varieties, and some have good quality. In Costa Rica many selections have been made but need further evaluation and increase. To assist these and other countries in the task of broad scale field evaluation and basic seed production six selected clones were increased in Mexico and Wisconsin and are being distributed.

Plants that survived a seedling screening test for bacterial wilt in Wisconsin were screened for resistance to late blight in Mexico. Out of 350 clones that were tested, 50 were found to have resistance to late blight and suitable yield characteristics. These clones will be distributed to cooperators for field tests for resistance to bacterial wilt and for general adaptation and yield.

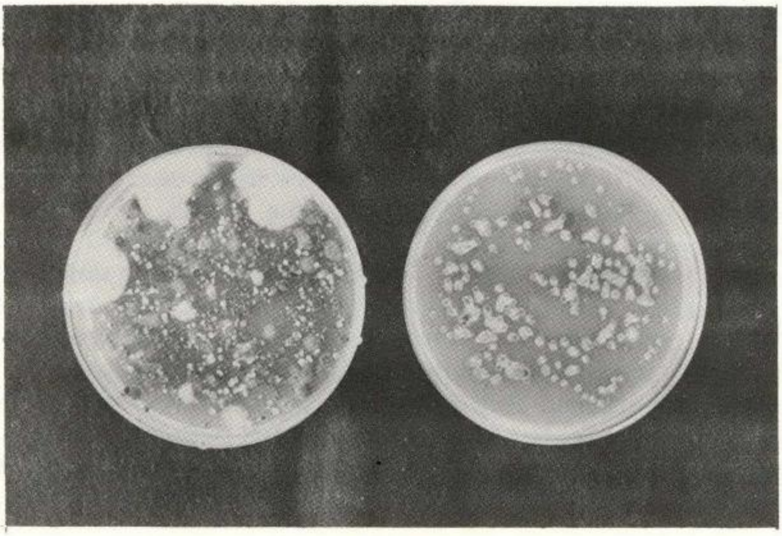
The Wisconsin contract project is continuing to screen seedling families for resistance to bacterial wilt under growth chamber conditions. Botanical seed from the Peruvian National Program was sent to Wisconsin so that hybrids that are adapted locally can be a part of the program. A Ph. D. thesis was completed that showed that resistance to isolate S206 was simply inherited, but the relationship of this resistance to K60 and S213 is still not clear. Wisconsin served as a base for the distribution of materials to 10 countries.

The control of bacterial wilt depends primarily on resistance breeding, but other considerations may lead to integrated control measures or alternatives. An important aspect to be considered is the survival of *P. solanacearum* in the soil. Investigations with race 3 have been conducted in the highlands at Huambos, Department of Cajamarca in Northern Peru, at an elevation of 2,400 m. A field occupying an area of 600 m^2 that was planted with bacterial infected seed in January 1973 showed 20% wilt at harvest time in July. The field was replanted with bacterial-free, susceptible "Renacimiento" potatoes in February 1974. By flowering time 12% wilt had developed. A second field that had been used for wilt screening work for five years was planted to the susceptible variety Merpata in February 1974. Wilting occurred in 8% of the hills. These results concur with observations in farmer's fields in the region. Wilt incidence was moderate when rotation was practiced and wilt-free seed used, but wilt was severe when healthy-appearing but bacterial-infected seed was planted.

Race 3 of *P. solanacearum* caused severe damage to a crop at Viru planted with diseased seed brought from the highlands. In a cooperative program with the Ministry of Agriculture of Peru, a field near the ocean, where a cool constant breeze blows during winter, was planted to potatoes in summer (December) 1972. Subsequently all plants were injected with a bacterial suspension which resulted in a heavy wilt infestation. When replanted in mid-winter (July) 1973 no wilt symptoms had developed by mid-September. Plants were then inoculated but remained symptomless to mid-October. Re-inoculation resulted in 52% wilt by mid-November (a warmer month). Although only 2% of the tubers showed symptoms, most of them rotted in a warm storage within 2 months.

When planted to a latin square design with whole potato tubers, cut potato tubers, eggplant, tomato and fallow treatments in late summer (end of March 1974), no wilt symptoms developed in any of these crops! The plots were all replanted with potatoes at year's end to determine if the bacterium persists in sufficient number to cause infection in summer.

Three methods of assay of *P. solanacearum* in soil by plating techniques, serology, and host plants have been reported to detect concentrations no lower than 2.5×10^6, 2.5×10^4, and 2.5×10^4 bacteria per c.c., respectively, of soil artificially infested with race 1. Assays were less discriminating with naturally infested soils, particularly with the slower growing race 3. Research was undertaken to modify these techniques to undertake more precise studies of survival of the bacterium. Cuttings of potatoes or tomatoes placed in water extracts from soil containing the bacteria were nearly as effective as reported for race 1, but not consistently so. Attempts to improve upon previously reported selective media gave promising results. An antibiotic selective medium permitted the detection of race 3 of *P. solanacearum* from artificially infested, fumigated soil at concentrations as low as 2×10^5. The selectivity of the medium can be seen in the following figure.



Comparison between Kelman's medium (left) and the antibiotic selective medium (right) in the isolation of *P. solanacearum* from soil. No fungi are present, and very few other bacteria, in the selective medium.

The selective medium contains dextrose, peptone, casamino acids, agar, pentachloronitrobenzene, actidione, vancomycin, tyrothricin, bacitracin, chloromycetin and tetrozoliumchloride.

V. CONTROL OF SELECTED VIRUSES AND AND INSECT VECTORS

Since the viruses of the potato are very numerous, the losses they cause are often difficult to assess. Virus dissemination can readily occur in the asexual tuber seed and to a lesser extent in true seed. A continuing task at CIP is the identification of viruses in the germ plasm collection and research sites utilized by CIP. To date 13 viruses have been isolated and identified. One of these is the Andean potato latent virus (APLV) which, although reported only once previously from Peruvian potatoes, has been found in both CIP's collection and in cultivated potatoes. *Epitrix* sp., a beetle occurring commonly in the andean region, has been shown to transmit this virus. So far transmission through botanical seed with APLV has not been positive. Attempts to locate potato spindle tuber virus (PSTV) have not as yet been successful.

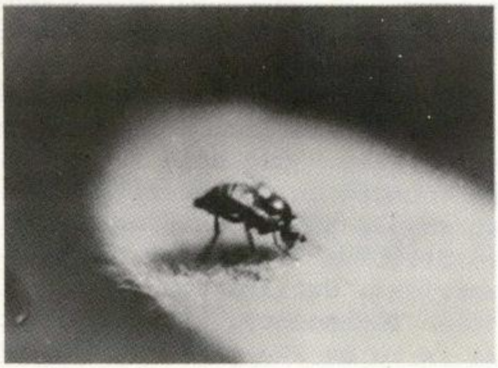
Because of the great number of virus problems it would be impractical to attempt to breed for resistance to most of them. CIP held two Planning Conferences during 1974 that focused on the question of the balance of emphasis that should be placed upon breeding for resistance versus seed programs to resolve the virus problems of developing countries: Utilization of Genetic Resources, and Seed Production Technology. The immediate solution to virus problems is to be the promotion of adequate seed programs. The long term solution is the development of resistance to the major virus problems, which will complement the seed programs. CIP will initially stress breeding for virus Y and leaf roll virus resistance.

Virus Y Resistance

During 1973 CIP's germ plasm collection, then of about 2,500 clones, was indexed for the presence of virus Y.

During 1974 the 32% that proved free were planted beside PVY - infected plants in an ideal location for aphid transmission (Arequipa, Southern Peru). Tubers from 400 of these were planted and 40 clones continued to test free. These will be inoculated by graft inoculation along with other known sources of PVY resistance, with the necrotic strain of virus Y. The best will then be selected for breeding for resistance. Clones with resistance to bacterial wilt and late blight will be crossed with virus Y resistant material in a cooperative project through the Wisconsin contract.

A new vector of the necrotic strain of PVY, the leaf miner *Liriomyza huidobrensis*, has been demonstrated. The female fly transmits the virus when it rasps the potato leaf to either oviposit or feed. This finding may account for the high transmission of virus Y in the absence of its best known vectors (i.e. aphids).



The leaf miner, Liriomyza huidobrensis, a new vector of potato virus Y

Leaf Roll Virus Resistance

Since confirming that the potato leaf roll virus (PLRV) occurs in Peruvian cultivars, observations during 1974 demonstrated that it is widespread though normally of low incidence in the fields. Symptoms in Peruvian cultivars often consist of chlorosis and stunting with little or no typical leaf rolling.

Peruvian PLRV strains vary greatly in virulence. In an attempt to locate resistance in the germ plasm collection which, because of cool growing conditions, had very few clones with symptoms, 631 clones were planted in a field trial at La Molina; 340 were rogued because of PVY infection. The remaining 291 were exposed to PLRV carrying aphids. Tubers were harvested from each plant and will be planted in 1975 to determine the presence of the virus. Varying but generally low levels of resistance selected by European and North American programs will be tested soon both in Peru and by the Instituto Agronomico do Estado de Sao Paulo in Brazil in a joint program with CIP. Later this work will be expanded by CIP staff in Lebanon and Mexico. Selected clones will eventually be incorporated into this network of tests.

Virus X Resistance

The program to select resistance to potato virus X (PVX) began by screening 2,500 clones for the presence of the virus in 1973; forty percent were found free in spite of repeated exposure in the field. A group of 350 of these were inoculated with 2 strains of PVX, 209 remaining uninfected and 24 behaving as hypersensitive to one or both strains. A sample of these was increased and inoculated with both strains on a larger scale; 20 out of 24 remained non-infectable. In 1974 the same 350 clones plus 210 more were planted in Huancayo and individually inoculated. Ten tubers were harvested from each to analyze for the presence of PVX by inoculation to *Gomphrena globosa*. Those that are still free will be considered potential sources of resistance to be compared with other determined sources, for use in breeding.

The Cornell contract has also sought resistance to PVX through field inoculations by spraying the virus mixed with carborundum under high pressure. Of 45,000 seedlings of *adigena* breeding populations exposed to a severe strain of PVX, 302 remained free of symptoms. These were retested in the greenhouse, 44 becoming infected.

Cork Disease

Cork disease remains of undetermined cause. Studies with a viral agent have given discouraging results. This approach will not be discarded, but emphasis is being placed on nematodes and fungi and their possible interaction with tobacco necrosis virus. Nematodes of the genus *Trichodorus* have been found in infected fields; it is a known vector of tobacco rattle virus which affects potato tubers with symptoms different from those of cork. The fungus *Phoma exigua* has been isolated and produces symptoms resembling corky lesions.

Antisera Production

The production of antisera was interrupted by the earthquake damage in October. However, antiserum to PVY has been produced, and production of anti-PVX, anti-PVS and anti-APLV sera is well advanced. A rabbit raising room has been built and will be equipped during 1975.

VI. CONTROL OF SELECTED NEMATODE PESTS

In order to screen for resistance to potato cyst nematodes, it is first necessary to identify the species found in the potato fields of the Andean region. At the same time host differential tests are carried out in order to determine pathotypes. This is very difficult because the Andean populations do not fit into existing classifications. Accordingly, a project to study the variability of the potato cyst nematode has been initiated. This study has two

Section of the nematology

laboratory, La Molina

components: a) collecting representative samples in areas where the cyst nematode is reported or suspected, and b) studying these collections to determine species, pathotype and distribution.

State of collection

At the present time CIP has over 120 different cyst nematode samples; 89 were collected from the following areas in 1974:

Peru: Puno 26 samples, Arequipa 4, Cuzco 3, Junin 40, Huánuco 2, La Libertad 2, Cajamarca 4; Ecuador 2, Colombia 1, Panama 4, and Mexico 1. All these samples have been reproduced in order to obtain enough inoculum for further studies. Areas that have not been adequately samples are: Colombia, Ecuador, Southern Bolivia, Northern Argentina and Chile.

Species distribution

Preliminary field observations during collecting trips and confirmatory laboratory tests carried out both in La Molina and at Rothamsted show that on the basis of female color all of Ecuador and Peru are infested with *H. pallida* (white females); however, at 15° S latitude yellow populations (*H. rostochiensis)* are found together with white. This makes Lake Titicaca an apparent dividing line between the two species. All samples collected south of Lake Titicaca in Bolivia were *H. rostochiensis* with the exception of one. Differential host plants are used to separate different pathogenic populations. As one moves from south to north in Peru populations become less diverse and more aggressive.

Nematodes from Panama and Mexico

Four different field populations from Panama's potato producing area, and one sample from Mexico were sent to CIP with the request that their pathotype be identified. The results showed that, contrary to expectation, all populations exhibited white females. Since it is thought that these nematode populations were introduced from Europe, further research is necessary to determine whether strong selection pressure occurs against *Heterodera rostochiensis* under short day conditions. This may also help to explain the current distribution of these two species.

Fifty different clones were tested for yielding capacity, as well as reaction to nematodes in an infested field in Chocón, Jauja, The yield was very low for all clones, in part due to high nematode infestation. Six clones that showed the highest yield were selected for further study. It was noted that clone 701422 slightly lowered the number of cysts in the field.

On the plants selected in 1973, four of the 13 tested continued to perform acceptably. Because the experiment did not identify tolerance precisely, it is now being redesigned for the growing season, 1975. Some 20 clones, are also being observed at Chocón in order to design a method for assessing nematode count, plant growth, and yield with a minimum amount of work. Following screening the creation of a new resistant variety requires extensive breeding work i.e. to combine resistance with other commercial traits.

Screening test Lima

Fifty-eight clones from the germ plasm collection were planted in June and July. Two evaluations were conducted. Twelve clones had resistance while 36 clones are being retested because of poor plant growth.

Screening test Cornell

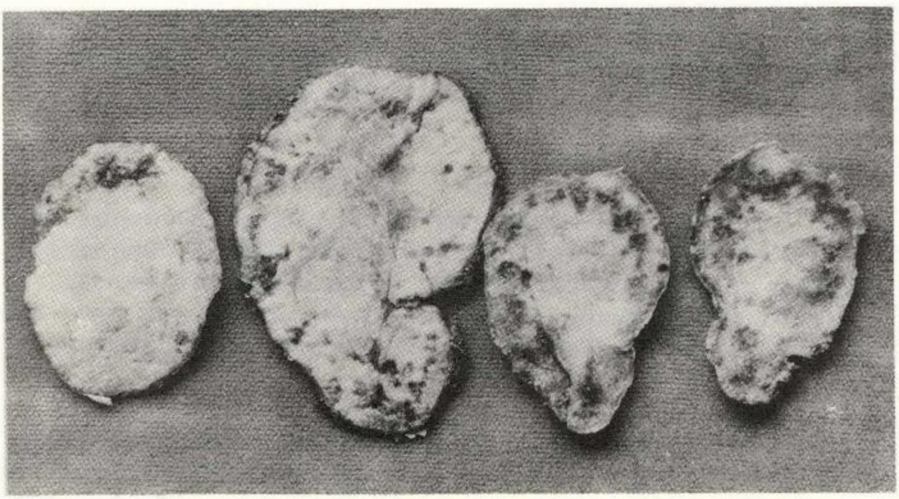
One hundred and forty clones which belonged to 48 different families were received from Cornell University. All were Katahdin intercrosses with clones of *vernei, spegazzinii, multidissectum* and *sactae-rosae* which have a high level of resistance to aggressive forms of potato cyst nematodes.

Each clone was inoculated with *H. pallida* (from Huancayo and Otuzco) and with *H. rostochiensis* (from Puno).

Most clones were very susceptible to both populations of *H. pallida*, but many showed resistance to *H. rostochiensis*. All clones that showed resistance were saved for re-evaluation. It would appear that testing at Cornell identified resistance only to *H. rostochiensis*.

Root-knot nematode

Screening for resistance to the root-knot nematode is especially important for the cultivation of potatoes in the lowland tropics. Seeds of several tuber-bearing *Solanum* spp. were sown in vermiculite. Two weeks after germination individual seedlings were transplanted and two weeks later, seedlings were inoculated with *Meloidogyne incognita* acrita. At harvest roots were soaked in water to remove soil and examined for nematode infection and data were collected. Of the 10 species and 19 selections tested, 8 selections (4 species) showed segregation for a high degree of resistance. *S. chacoense* (PI 197760 and PI 230580) and *S. sparsipilum* (PI 230502 and PI 310972) had the highest percentage of resistant progeny. Six species and 11 selections showed segregation for some degree of resistance and their roots exhibited a trace of galling and/or reproduction by the nematode. Tubers collected from the plants showing a high degree of resistance will be retested to eliminate any plant which escaped infection. It is intended to cross the nematode-resistant plants with those having high *Pseudomonas* resistance in order to combine resistance to both organisms.



Root-knot nematode damage in potato chips

Experiments were conducted into interactions of *Meloidogyne* and *Pseudomonas solanacearum*, the cause of bacterial wilt. A *Pseudomonas* resistant clones (BR 73-40) and a susceptibly variety (Renacimiento) were inoculated with *P. solanacearum* and *M. incognita acrita*.

Control plants did not receive either of the two organisms.

Pseudomonas resistant and susceptible plants inoculated with bacteria alone exhibited *Pseudomonas* symptoms in 20 and 40 percent of the plants, respectively. Symptoms occurred 21 and 36 days after inoculation of the susceptible and resistant plants, respectively. In treatments when *Meloidogyne* and *Pseudomonas* were present, 100% of the *Pseudomonas*-susceptible Renacimiento plants showed bacterial symptoms commencing 19 days after inoculation.

Nacobbus nematodes

Little is known about the biology of the "False root-knot nematode" (*Nacobbus* spp.) on potatoes and so extensive laboratory study has been necessary to investigate the life cycle of this nematode. Potato tubers collected from a heavily infested field had *Nacobbus* in 3rd, 4th and 5th stages of development. The majority of nematodes were confined to periderm and the flesh immediately below the periderm. It appears that the mode of dissemination of the nematode is through infected tubers. Roots of plants inoculated with *Nacobbus* were also examined for the presence of the nematodes. It was observed that the 2nd stage larvae attack secondary roots whereas the 3rd stage and vermiform females penetrate and feed on very small rootlets. It appears that they leave these rootlets after a period of feeding and quiescence to penetrate the secondary and larger roots where their feeding initiates the production of hypertrophied and hyperplastic cells and leads to the production of typical galls.

VII DEVELOPMENT OF POTATOES WITH WIDER ADAPTATION TO ENVIRONMENTAL STRESS

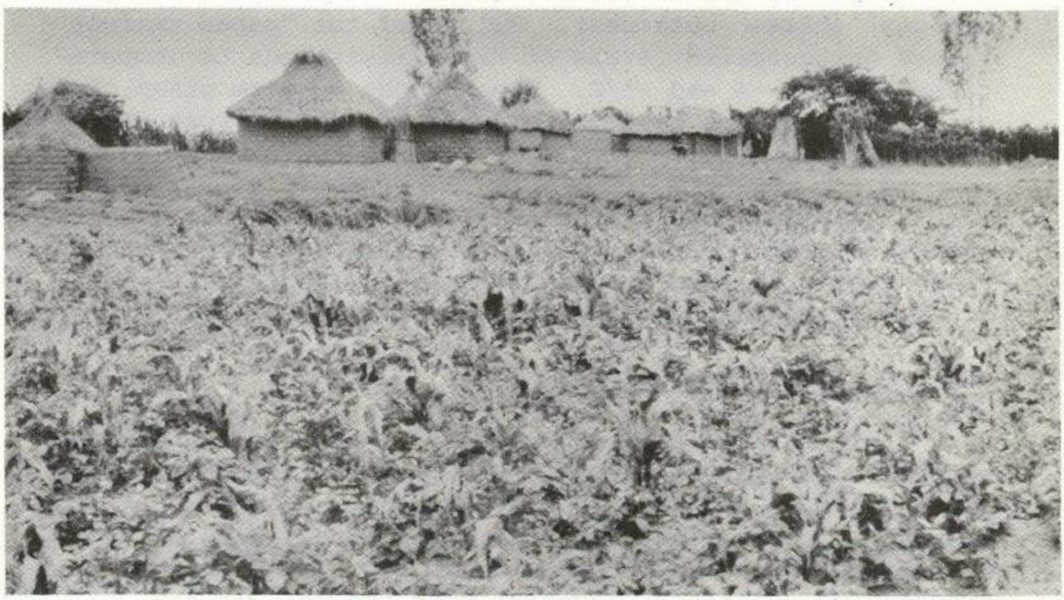
In the vast Andean region, northern India, Nepal, Turkey and certain other areas, potatoes are commonly subjected to freezing injury. CIP has initiated a selection and breeding program to obtain potato clones or cultivars with resistance to frost together with good horticultural and quality characteristics.

Frost resistance studies

The technique of measuring the lixiviate electrolytes from detached leaves exposed to low temperatures is being used to screen for frost resistance. In the laboratory the first general application of the excised leaflet test on a routine screening basis using field grown plants was initiated. A series of preliminary experiments were conducted to test several different test temperatures, variable leaflet sizes, and leaflets from plants of different ages. The results indicate that repeatable readings can be obtained for different test temperatures and that differences in leaflet size and age (within limits) do not introduce significant variability in the frost resistance readings. A test temperature of -4° C was selected for routine screening.

Fifty-six clones selected in 1973 for crossability and relative yield, and four clones of the species *S. curtilobum* obtained from the germ plasm collection were tested and 25 were found resistant to -4°C and some to -5°C. In May, 1974, 5056 seeds obtained from crosses were planted in the screenhouse and 1,513 seedlings were transplanted to the field. A representative sample of each family was taken and 275 seedlings were tested in the laboratory. Ninety-three seedlings with resistance (-4°C) were identified. Crosses were made in the screenhouse during the winter in La Molina.

A section of the research plots in a hot humid location
San Ramon, Peru



Interplanting of potatoes and corn in Tanzania

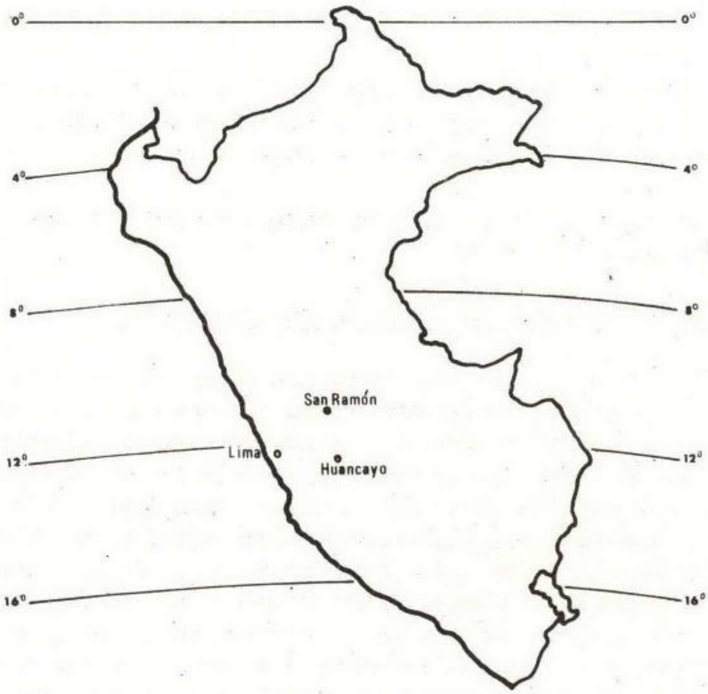
Over 5,000 seeds were obtained from back crosses of wild diploid species to the diploid cultivated species *S. phureja* and *S. stenotomum.* Crosses between F_1 triploids (*acaule* x *stenotomum*) and diploids (*phureja, stenotomum*) and tetraploids (*andigena*) produced fewer seed but are considered important for future work. Crosses between *tuberosum* or *andigena* (2n = 48) and *curtilobum* (2n = 60) produced over 2.000 seeds. From preliminary studies this method appears to be a promising approach to obtain frost resistant clones in the F_1 together with high yield and better quality of tubers. Some of the hybrids with *curtilobum* made previously showed frost tolerance in laboratory tests. Crosses between tetraploid cultivated (*tuberosum* and *andigena)* diploid resistant hybrids were also made in an attempt to obtain tetraploid progeny by the formation of polyandroids (2n gametes) in the diploid pollen parent. Considerable seed was obtained.

Routine screening was continued with a group of 100 germ plasm tetraploid clones, advanced clones, and "papas amargas" (bitter potatoes). All 17 of the "papas amargas" tested demonstrated levels of frost resistance to temperatures between -4 and -5°C. None of the 83 germ plasm clones or advanced clones that were tested possessed frost resistance to -4°C.

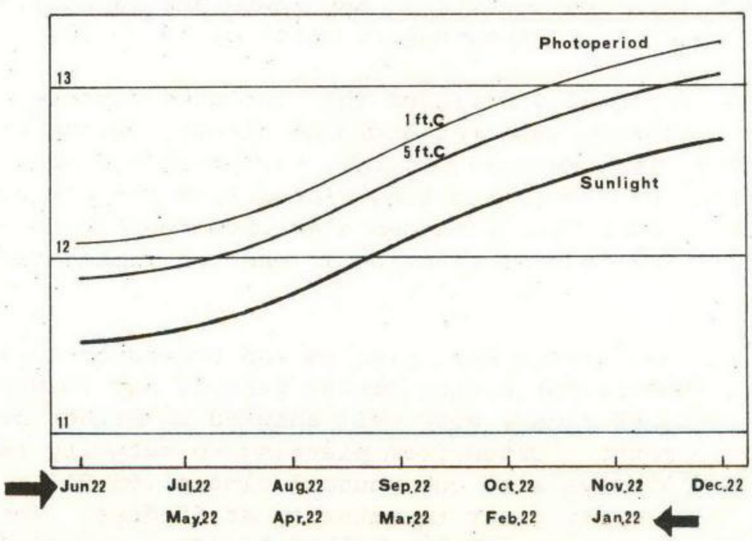
An additional 350 clones resulting from advanced crosses between cultivated clones and clones from assumed frost resistant species were screened. Approximately 35% of these clones were found to be resistant to -4°C.

Modifying Soil Temperatures

Under arid tropical conditions preliminary studies showed a very slight effect of row spacing upon soil temperatures with 1.0 meter row spacing having temperatures on average 1°C higher than the 0.7 meter row spacing. Temperatures at 10 cm. depths were up to 5°C cooler than at 2cm. depths with greater differences when the soil is dry. Yields under surface irrigation ranged from 16 to 39 metric tons per hectare. Yields were generally 30 per cent greater with 0.7 meter row spacing than with 1.0 meter row spacing.



Location of CIP research facilities in Peru



Hours (and Decimal of Hours)
at Latitude of CIP (12°S)

Specific gravities ranged from 1.035 with 1.0 meters between rows and 40 cm. spacing within rows to 1.056 for 0.7 meter between rows and 20 cm. within rows.

It is intend to extend temperature studies to soils of the hot humid tropics.

Response of Potatoes to Diverse Environments

To identify clones that are adapted to given environments or are broadly adapted to diverse environments, five principal environmental situations were selected. These included La Molina winter (May to August); La Molina summer (December to March); Huancayo summer; San Ramon winter; and San Ramon summer. All locations were within 60 miles of 12°S latitude. La Molina typifies arid coastal desert requiring irrigation, temperature range 8 to 30°C; Huancayo at 3,380 meters elevation has a temperate climate with summer temperatures ranging between 5 to 26°C, with frosts occurring May through September; San Ramon at 800 meters on the eastern slopes of the Andes has very heavy rainfall during the summer (December to March), and a relatively dry season April through October. San Ramon has basically a hot humid climate with a temperature range of 15 to 30°C.

A sample of 450 clones that included representatives of diploid clones, selected *andigena* clones, blight resistant clones from CIP's Mexican program, varieties and advanced clones from the CIP collection, clones from the CIP germ plasm collection, and bitter potatoes also from the CIP collection were chosen for initial planting in each environmental situation.

The 450 clones were planted and harvested in San Ramon and La Molina during the winter period, May to September. Approximately 60 clones were well adapted to either or to both environments. Dates from planting to maturity ranged from 89 to 150 days with one unusual clones (66 P11 - 7) yielding 1100 g per plant to maturity at 65 days. The percentage of clones in each group that yielded over 1000 g/ plant in La Molina and San Ramon were:

Group	La Molina	San Ramon
	%	%
Diploid clones	27	3
Andigena clones	26	27
Mexican clones	25	41
Advanced CIP clones	44	35
CIP Germ Plasm	28	6

The 450 clones have been planted in the remaining three environmental situations to be harvested in April or May of 1975. In addition 11 replicated Peruvian varieties are being planted at three-month intervals to more fully characterize the year-round production in a hot humid environment such as San Ramon.

VIII IMPROVEMENT OF GENERAL NUTRITIONAL QUALITY PROCESSING FOR DEVELOPING COUNTRIES

Protein

During 1974 samples of approximately 500 clones were tested in the laboratory for dry matter, crude and true protein analyses. The analysis of 240 samples was completed and another 160 were analyzed for dry matter and crude protein. Values for crude protein (total N x 6.25) ranged from 3.65 to 15.06 per cent of the freeze dried powder with an overall mean of 8.10 per cent; 13 per cent of the samples had above 10 per cent crude protein. It is interesting to note that a group of 45 clones classified as *S. phureja* had an average value of only 6.28 per cent.

Five methods were compared to determine true protein content:

1. Tuber powder extracted with 80 per cent ethanol; Kjeldahl determination.

2. Tuber powder dialyzed in buffer for 12 hr. to remove non-protein - N prior to Kjeldahl determination.

3. Extraction of powder by phenol-acetic acid-water and determination by the Potty method.

4. Protein estimated by bromphenol-blue dye-binding.

5. Ethanol extract dialyzed and N remaining in the dialyzed samples measured by Kjeldahl technique.

The 80 per cent ethanol-Kjeldahl technique was selected because of its accuracy and rapidity for the determination of true protein in freeze dried tuber powder. True protein (nitrogen of the 80% ethanol insoluble fraction x 6.25) accounted for 32 to 70% of crude protein.

The percentage of dry matter varied from 13,78 to 35.12. Total mean sugar content as percentage of dry weight before and after three months conventional cold storage was 7.65 and 10.66, respectively. Profiles of 18 amino acids in six varieties showed a range of 0.450 - 0.820 mg/g dry weight for methionine, normally considered the "limiting" amino acid in potato protein. The range found in assays of relatively few varieties indicates a potential for substantial improvement in methionine levels.

<u>Potato Processing for Developing Countries</u>

A Planning Conference sponsored by the International Development Research Centre was held in Ottawa, Canada in November, 1974, to examine methods of processing potatoes for developing countries. The participants at the Conference formulated recommendations for a plan of action that would result in scale-neutral potato processing technology tailored to the needs and resources of developing countries.

IX TISSUE CULTURE FOR DISEASE ELIMINATION, RAPID MULTIPLICATION AND DISTRIBUTION OF NEW CLONES

This thrust is concerned with the practical aspects of producing seed tubers free of viruses and pathogenic fungi and bacteria.

The potato produces true or botanical seed which, because of its heterozygous nature, has little value as a means of propagating commercial potatoes. CIP is actively involved in storing true seed for long term preservation of valuable germ plasm. True seed is also the means through which the plant breeder recovers genetic recombinations resulting from planned crosses. Aside from the above interests in true seed, CIP research is primarily concerned with providing seed tubers free of viruses for research and training needs and as foundation stock for developing countries.

During 1974 the following protocol was developing which permits the very rapid multiplication of virus-tested seed:

<u>Generation "O"</u>

Test clones to determine virus status.

Step 1 If virus "free" the clones to be processed directly into Generation 1

Step 2 Meristem and related processes to eliminate viruses

Step 3 Retesting material from Step 2 for virus status

Generation I

Maintenance of "nuclear stock" under supervision of a virologist.

Generation II

Increase in a screenhouse for effort and further generations by means of stem cuttings; under supervision of a virologist.

Generation III

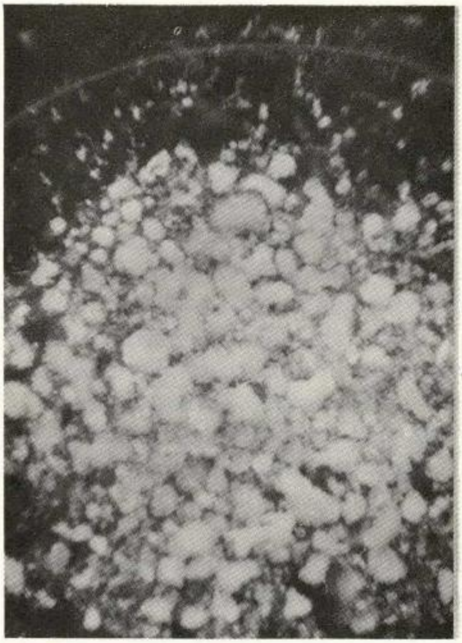
Field increase in a large terylene (dacron) screen tent by tubers and/or stem cuttings.

Generation IV and V

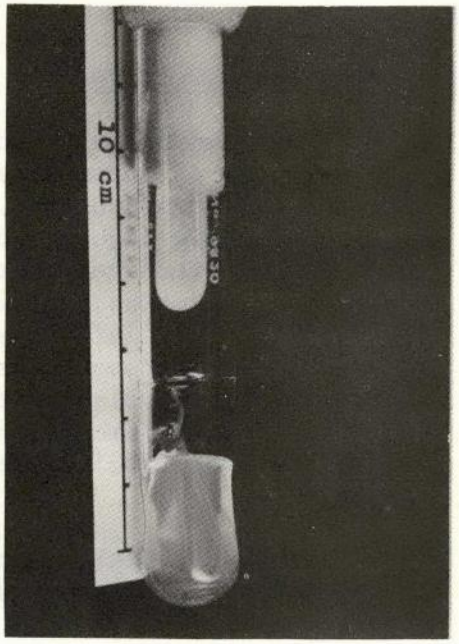
Increase at Huancayo in isolation plots.

Virus status is at present diagnosed by plant symptoms, indicator hosts, and serology. It is planned to install an electron microscope for further screening confirmation and for general virus research. A facility to house rabbits for antisera production was completed in 1974.

The establishment of virus free clones, a procedure in which it is first necessary to determine if plants have viruses, and then pass those that are infected through meristem culture before reanalyzing for the presence of virus, is well underway. Thirty-six clones were selected by CIP scientists for such treatment because of their value to the breeding and seed programs of CIP and developing countries. Unfortunately, many cultures were lost during the earthquake. However, it has been possible to proceed with large scale multiplication of 9 clones which by-passed meristem culture because uninfected material of these was detected in the initial tests.

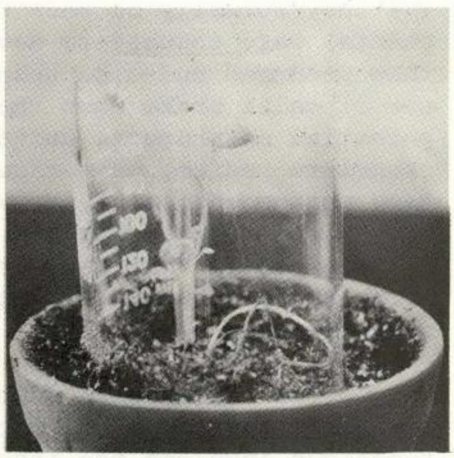


Suspension of cell aggregates from tuber tissue



Month-old meristem culture

Embryo-like structure organized from cell aggregates, above



Plantlet from meristem culture after transfer to soil

Potato Tissue Culture

The induction of somatic embryogenesis in suspension cultures of tuber tissue and etiolated shoot tissue explants has been achieved. Embryogenic units were produced in rotating liquid media. Rotation allowed the cultures to be alternately aerated then nourished; this was achieved by adapting a system of rotating discs which held "nippled" glasks. After several days the embryogenic units polarized and differentiated into heart and torpedo-shaped embryoids. It is planned to test additional potato genotypes for somatic embryogenesis as well as for the stability of the embryogenic potential through successive subcultures.

The principal advantage of this system of culture is the potential to produce hundreds of embryoids per flask.

Following a somewhat different pathway, shoot tips have been used as initial explants instead of tuber or etiolated shoot tissues. Using the same system of rotating flasks, shoot tips, instead of growing into single plants (as they normally do when cultured to obtain "virus-free" plants) were induced to develop into masses of calli which then produced bud-like spheric structures. When these masses of calli broke down their component parts functioned as potential morphogenic units which, after transfer to an appropriate medium, gave rise to root and shoot initials. Each morphogenic unit, as well as the initial hard calli, can be induced to grow and produce root and shoot primordia. It is expected that this system of culture will have a high morphogenic as well as genetic stability through successive sub-cultures.

In addition to embryogenesis in suspension cultures of tuber tissue and shoot-tip calli derivatives, a third technique involves the induction of plantlets with a rosette habit, also derived from excised shoot tips. In this latter case, rosette plantlets are induced to proliferate buds in the axils of pre-formed leaves. By further modifying the medium, the main short shoot and the axillary buds can be induced to form elongated shoots. This system constitutes another form of micro-propagation which is expected to promote a high degree of genetic stability.

X. OUTREACH

To extend technology on potato improvement into developing countries and adapt it to local conditions and to train the scientists in national programs, CIP has divided the developing world into seven regions. In each region CIP is concentrating on one or two countries where the need and opportunity are greatest. The break-throughs which are accomplished in these impact countries are expected to provide examples and be redistribution points for other countries in the region. In 1974 the seven regions and the input countries identified in each were:

Region I - South America - Peru, Brazil, Chile, Ecuador, Bolivia.

Region II - Central America and the Caribbean - Mexico, Costa Rica, Guatemala.

Region III - Tropical Africa - Kenya, Nigeria, Ethiopia.

Region IV - Middle East and North Africa - Syria, Lebanon (Egypt, Training Center).

Region V - Non-Arab Moslem Countries - Turkey, Pakistan, Iran.

Region VI - India - (States of Punjab, Uttar Pradesh) Nepal, Bangladesh.

Region VII - Southeast Asia - Sri Lanka, Indonesia, Korea.

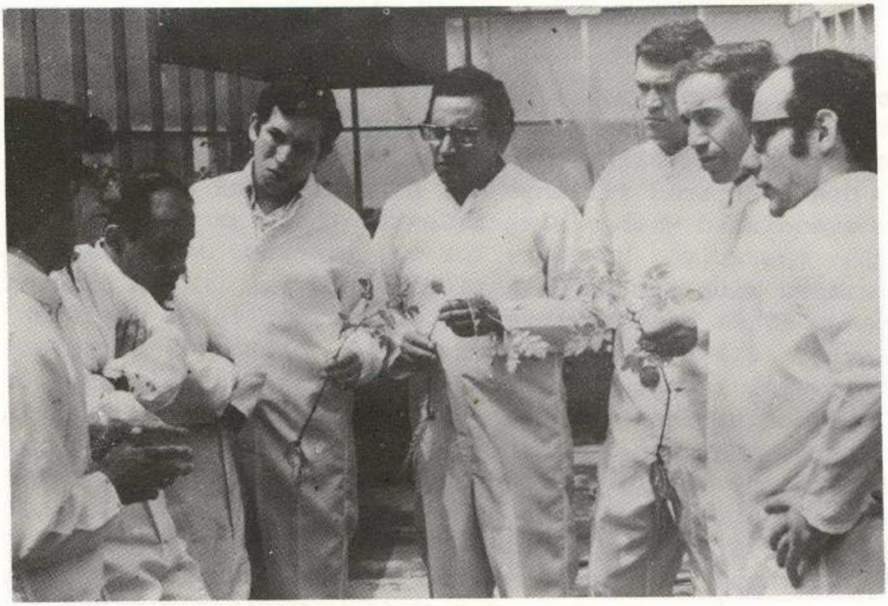
Whenever possible CIP is locating its regional personnel at sister Centers. Thus the program for

Production trainees inspecting a field near Huasahuasi in the Central Highlands of Peru

Region I is headquartered at CIP's Central Facilities. The program for Region II is headquartered at CIMMYT facilities in the Toluca valley of Mexico. The program for Region III is headquartered in Kenya and CIP personnel will probably be associated with a sister Center there as soon as it is fully operative; however, for the present, it is mainly associated with the Kenya National Program. CIP's program in Region IV is headquartered at ALAD, soon to be a sister Center. CIP's program for Region V, presently being activated will be headquartered in Pakistan, associating with the local national program and other foreign technical assistance agencies in the country. Although considerable exchange of visiting scientists has taken place in Region VI final arrangements have not been completed for the location of CIP staff in India. When this is accomplished CIP will attempt to associate with a sister Center located in India. CIP's program in Region VII, presently being activated, will be headquartered in South Korea intially. However, the regional program will probably eventually be relocated to a more tropical country of Southeast Asia.

CIP's regional programs are presently being financed by both core program and special project support. CIP has in its core program budget a production specialist for each region. A considerable expansion of CIP's training activities and assistance to national programs has been made possible by special project funding received in 1974. Special project funding from the Interamerican Development Bank is providing four additional specialists for Latin American countries. Ford Foundation special project support is providing the funding for extra attention to three countries in the Andean region, where CIP is located: Peru, Ecuador and Bolivia. Special project support has been identified to provide a production specialist in Region V and technical support in Regions III and IV.

Since CIP does not identify donors until special project grants have been signed, prospective donors for projects in development are not named here. CIP presently needs special project support for its African Program in Region III, its Region IV Program in the Middle East and North Africa, and for its Far-East Program in Region VII.



Trainees at La Molina examining soil deficiency symptoms

Peruvian and Bolivian production trainees in a course sponsored by CIP at the University of Puno, Peru

Following are the activities in Outreach and Training which have been conducted in each region during 1974.

Region I - South America

In Region I there was a considerable increase in training activities in 1974 as compared with the previous year. A total of 38 trainees from seven Latin American countries participated in three formal courses, six short courses and two visits by scientists from Colombia and Mexico. In addition, two M.S. candidates were enrolled at Universidad Nacional Agraria and a trainee from Peru attended the Third International Course on Potato Production in Wageningen, The Netherlands. CIP scientists also participated in two national potato production courses in Ecuador and Peru, in which there were 43 participants.

A two-week course on Potato Production in the Altiplano was held in Puno, Peru, in which five Bolivians and 11 Peruvians participated. Problems common to the Altiplano of the two countries were analyzed and instruction given on all aspects of potato production with emphasis on seed production. Scientists from Bolivia, Peru and CIP provided the instruction for the course.

An eight-week course on methods of diagnosing and identifying potato viruses was held at CIP facilities at Lima, Peru. There was a trainee each from Colombia, Chile, Brazil, Peru, and Cuba. The course was practically oriented so the participants could develop a working knowledge of viruses to apply to seed production programs in their respective countries.

A 15-week course on potato production with emphasis on seed technology was held in Peru. There were seven participants: Colombia (1), Chile (2), Peru (2), and Ecuador (2). The course included both theoretical and practical instruction at CIP's facilities at Lima, Huancayo and San Ramon, as well as in potato seed fields of Peru's National Program.

Trainees in soil studies sponsored by CIP in Ecuador

Trainees examining potatoes for Nacobbus nematode damage in Bolivia

Short term training to meet the individual needs of scientists from national programs was organized for scientists from Colombia, Chile, Bolivia and Peru. These visiting scientists concentrated on potato nematode problems and received a total of 19 man-weeks of instruction. In addition, two scientists from Peru and Cuba received special training in Virology and seed production.

A visiting scientist from Colombia spent two weeks at CIP facilities in Lima, working with CIP virologists on problems related to virus research and its application to seed production. Another scientist from Ecuador, after completing his M.S. degree with the Plant Breeding Department at Cornell University, spent one week at CIP facilities in Mexico. The purpose of his visit to the Toluca Valley Station was to study the CIP germ plasm collection for possible utilization of clones with late blight resistance in Ecuador.

<u>Region II</u> - <u>Central America and the Caribbean</u>

A course in potato production technology was held in Mexico during May thru September 1974. The 3 1/2 month course was held in the Toluca Valley, Mexico State, with visits to the principal potato cultivation areas in Mexico. Furthermore, technical instruction at the Agricultural College at Chapingo was given on Virology, Mycology, and Nematology. Special emphasis was given to seed production and on the development of potato varieties resistant to late blight. Seven trainees from five countries participated in the course: Mexico (2), Guatemala (1), Panama (2), Dominican Republic (1), and El Salvador (1). A similar growing season course will be held in Mexico in 1975, for a five-month period.

Thirty clones of CIP's germ plasm bank in Mexico, were sent to Costa Rica, Honduras, Panama, El Salvador, and the Dominican Republic for screening by National Programs for adaptation and late blight resistance. More intensified trials will be held in Guatemala, Costa Rica, Panama, Cuba, and two areas of Mexico, using 46 different clones in 1975.

Trainees examining bacterial wilt damage in a Kenya field

Members of a training course being conducted at Nairobi, Kenya

Region III - Tropical Africa

In 1974, CIP sponsored the Third Annual Course in Potato Production jointly with the Kenya National Program. Twenty-two trainees from seven African countries participated in the three-week course held at the National Agricultural Laboratories in Nairobi. Five CIP scientists joined the personnel of the Kenya National Potato Program and the British Potato Team to provide the instruction for the course. The course included some classroom and laboratory work, with major emphasis on practical field work including the identification of potato varieties, agronomic practices, disease control, seed production, and potato quality. The final week of the course was spent on a field trip visiting potato production areas of Kenya. A production specialist has been identified for Region III, who will be based in Nairobi with regional responsibilities throughout Tropical Africa.

Region IV - Middle East and North Africa

CIP's Region IV program was initiated in February 1974, with the stationing of our first Production Specialist in Beirut. The Region IV program developed very rapidly and established contacts with many of the potato producing countries of the Middle East and North Africa. During the year. specialists from CIP(Lima) and from the International Agricultural Center at Wageningen, The Netherlands cooperated with CIP's Region IV staff to assist national potato improvement programs in the region. In Cairo, Egypt, in May 1974, the First Workshop-Seminar in Potato Seed Production and Storage in the Arab countries was organized by CIP, and sponsored the Ministry of Agriculture of Egypt, CIP and ALAD. A total of 75 participants from nine Arab countries (Egypt, Iraq, Jordan, Lebanon, Libya, Saudi Arabia, Sudan, Syria and Tunisia) FAO, COMAP (Committee of Early Crops and Citrus of MAGHREB Countries), the Central Cooperative for Seed Production of Tunisia, ALAD, and CIP attended the Workshop-Seminar. The main subjects covered in the workshop referred to technology and problems of seed production and storage, national seed production programs, and a review of the current status of potato production in the participating countries.

A short course on Potato Diseases and Seed Certification sponsored jointly by CIP and the Lebanese Ministry of Agriculture was held at the Tel Emara Experimental Station during May. Thirty-six participants attended, representing seed certification inspectors, extension agents, potato growers and representatives of private agricultural companies. CIP, Agricultural Research Institute and American University of Beirut staff conducted lectures and field visits.

One Lebanese research assistant spent six months in 1974 working with CIP's regional representative, after which he assumed the leadership of Lebanon's National Program based at the Agricultural Research Institute.

A comprehensive group of "Increasing Yield Demonstrations" was carried out in the Bakke Valley with progressive farmers. Yields obtained were over 100% greater than the average for Lebanon and up to 50% greater than that of progressive cooperating farmers.

Short courses will be held in Jordan, Lebanon and Syria on Potato Production with emphasis on Seed Production during 1975. In addition, a short course on Potato Storage will be held in Egypt. An additional Research assistant will be identified to work 6 months with the CIP Regional Representative.

Regions V, VI and VII

In 1974, CIP scientists made contacts with national programs in Regions V, VI and VII. Trainees were accepted from these regions, special projects were developed and detailed surveys of potato production problems were made by CIP staff but no regional programs were begun in these three regions.

In 1975, CIP plans to base production specialists in Pakistan, India or Nepal and Korea to initiate regional programs in Regions V, VI, and VII, respectively.

Formal degree training courses

There are formal training programs at CIP and the cooperating universities at the Masters, Ph. D. and post-doctoral level.

Training leading to the Masters Degree

This is in conjunction with the National Agrarian University adjacent to CIP's facilities in La Molina. There were 19 scientists entered in Master Degree training courses by CIP in 1974.

Training leading to the Ph. D. Degree

This is in conjunction with institutions in developed countries where formal course work is accomplished with a major portion of the thesis work done at CIP facilities in Peru. There were eleven scientists entered in this type of training program with CIP in 1974.

Post-Doctorate Training

There were seven newly trained Ph. D. scientists on post-doctoral appointments at CIP in 1974. CIP is using some post-doctoral positions to look at future young staff members, and to train scientists for possible regional assignments as the Outreach program is expanded.

The following is a summary of Advanced Degree and Post-doctorate training conducted by CIP and its cooperating universities in 1974:

Man Years of Training for 1974 and Projected for 1975 and 1976

	1974	1975	1976
Non Degree	11.75	15	18
M. S.	16.0	23.0	27
Ph. D.	9.75	13.75	15
Post-Doctorate	6.25	7.25	9

CIP's activities in the area of socio-economics is located in Outreach. These activities center around the following three subjects:

1. The identification of where the need and opportunity are greatest in each region.

2. The determination of how CIP can best conduct its program with the target countries, and

3. The identification of evaluation procedures which can help CIP determine its effectivenesss in the target countries and the region.

Through special project support the Interamerican Development Bank is providing an economist to work specifically on these problems in Latin America. The German Government is providing special project support for economic studies in potato production in Kenya.

RESEARCH CONTRACTS-1974

Because of the importance of the potato in Europe, North America and elsewhere in developed countries, extensive research has been conducted to resolve production problems. Many of the problems are common to those faced by CIP. Through Contract Projects funded by CIP, existing facilities and capabilities at various universities and agricultural research institutes are being utilized to help solve mutual priority potato improvement problems. CIP funded four Contract Projects in 1973, and a total of eleven in five countries in 1974.

Substantial contributions by host institutions attest to the mutual commitment to Projects. For example, to CIP contracts at four universities in the United States was added US$145,000 as contributions by these institutions.

Very substantial progress has already been made by research contracted in 1972 and 1973. This is due to the relatively short lag time in initiating research by established research teams.

The following Research Contract Projects were active in 1974:

1. University of Wisconsin - "Increasing Yield and Adaptation of Cultivated Tetraploid Potatoes". S.J. Peloquin and L. Sequeira.

   Objectives

   a) Increase potato production by the use of new parental materials and breeding methods to develop higher yielding, more widely adapted varieties.

   b) Assist the International Potato Center in the development of facilities and procedures for centers of germ plasm maintenance and evaluation in Latin America.

   c) Use the haploid approach for transferring valuable germ plasm from wild *Solanum* species into improved parental clones.

   d) Investigate the genetic and biochemical systems controlling resistance to bacterial wilt.

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

   Objectives

   a) To conduct investigations to evaluate and to select within the broad range of *Solanum tuberosum* spp. *andigena* germ plasm to make it more valuable and accessible to potato breeders from the developing countries in the tropics and throughout the world.

b) To incorporate resistance in tetraploid clones to the spectrum of races of the golden nematode, *Heterodera rostochiensis* that exist in Peru.

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

Objectives

a) To isolate and identify superior clones for direct use in both the highland and lowland tropics.

b) To study the adaptation to the temperate zone of diploid Andean *Solanum* species as potential sources of new germ plasm for commercial exploitation.

c) To cooperate in studies of the extraction of diploid clones from cultivated tetraploid *S. tuberosum* (both subsp. *tuberosum* and *andigenum)* and their potential as breeding clones.

d) To conduct genetic and cytogenetic studies among the diploid species and derived diploid clones (haploid *S. tuberosum)*, and the hybrids between them.

4. University of Minnesota - "Evaluation of CIP Germ Plasm Collection for Production of Potato Cultivars with High Quality Protein and with Frost Resistance". P.H. Li and S.L. Desborough.

Objectives (Protein)

a) Evaluate genetic sources with superior tuber protein by procedures which estimate both, the protein quality and quantity.

b) Improve screening methods for protein suitable for use in a breeding program.

c) Delineate the optimum environment for the production of tuber protein.

d) Acquire knowledge concerning the genetic control of tuber protein.

e) Advise and train students in the above areas.

Objectives (Frost Resistance)

a) Identify genetic sources of frost resistance by a standard screening method.

b) Characterize the influence of environmental factors on frost resistance.

c) Study the biophysical parameters of freezing injury differences between susceptible and resistant cultivars.

d) Advise and train students and technicians in the above areas.

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

Objectives

a) To cooperate in studies of the germ plasm available to CIP in search for sources of field resistance.

b) To conduct studies of resistance with emphasis on:

(i) resistance to entrance of the parasite into the leaf;

(ii) resistance to growth of the parasite in the leaf (lesion development);

(iii) relation between leaf resistance and tuber resistance and the influence on other tuber characters. e.g. cooking quality.

c) To conduct genetic studies concerning the inheritance of components of field resistance.

d) To cooperate in studies of the adaptation of field resistant clones to temperate, subtropical and tropical conditions with emphasis on the expression of resistance.

e) To extract information from the above goals with emphasis on development of methods of selection, evaluation and other aspects of breeding potatoes resistance to late blight.

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

Objectives

a) To overcome the crossability barriers between cultivated potatoes and certain wild *Solanum* species of Mexico.

b) To produce hybrids and to evaluate their value to breeding programs, particularly as related to new forms of resistance to *Phytophthora infestans*.

7. Research Station for Arable Farming, Wageningen - "Adtation of the Potato Crop to Drought and High Temperature". D. van der Zaag.

Objectives

a) To develop a method to determine in the field the degree of stomatal closure and to establish the relationship between stomatal aperature and rate of photosynthesis (or production).

b) To use stomatal aperature data to determine the influence on production of: (i) number of irrigations, (ii) water quantity per irrigation, (iii) root development, and (iv) water holding capacity of the soil.

c) To investigate the reaction of different potato varieties and species during drought by stomatal closure.

d) To study the influence of physiological age of seed tubers and the effect of high temperatures on the ratio of haulm to tuber growth.

e) To develop methods to test seedling resistance to heat.

8. Foundation for Agricultural Plant Breeding, <u>Wageningen</u> - "Resistance Breeding Against the Potato Eelworm". C.A. Huijsman.

<u>Objectives</u>

a) To screen Dutch breeding material with resistance to different pathotypes of *Heterodera rostochiensis* to establish which pathotypes occur in tropical regions.

b) To determine the pathotypes of different eelworms in samples sent to the Netherlands.

c) To study degree, types and inheritance of resistance and the composition of pathotypes against which the resistance is valid.

d) To study the inheritance of tolerance and low susceptibility in parental lines.

e) To screen and study resistance of wild and primitive potatoes against different pathotypes.

9. International Agriculture Center, <u>Wageningen</u> - "Potato Improvement in the Middle East and North Africa". H.P. Beukema.

<u>Objectives</u>

a) To assist CIP in the development of its training program in Region IV.

b) To provide short-term consultants, courses for 5 trainees annually at IAC and regional short courses in Region IV.

10. Universidad Nacional Agraria, Lima, Peru - "Environmental Physiology of the Potato - An Approach". U. Moreno.

Objectives

a) To study the effects of adaphic and climatic factors on growth, development and metabolism of the potato plant.

b) To study the range of adaptability of the potato to different environment including certain aspects of physiological degeneration due to unfavorable environmental factors.

11. Centro Regional de Investigacion Agraria, La Molina, Peru - "Utilization of the cultivated diploid species for the improvement of the culinary and nutritional quality of the potato". F. de la Puente.

Objectives

a) To develop a program to improve the culinary and nutritional quality of the cultivated diploid species.

b) To improve the adaptation, yield and tolerance or resistance to the principal diseases of the cultivated diploids for Peru, the Andean region and other areas.

Rather than summarizing the volume of data from all Contract Project Reports, a few selected items are presented to provide a qualitative assessment of progress. Certain other items of significance are included under respective Thrusts.

Virus Y resistance

In trials at Cornell mechanical inoculation at the seedling stage proved to be a reliable means of transmitting virus

Y and resulted in accurate screening for resistance. Of 641 *tuberosum* x *tuberosum* clones tested, 170 were resistant and 196 were susceptible. This fits a 13:15 ratio, assuming random chromatid segregation and a single dominant gene conferring resistance. Plants that were resistant to mechanical transmission were also resistant when inoculated by aphids, indicating the reliability of mechanical transmission.

To determine the type of resistance, top-graft and approach-graft tests were made. Failure to recover the virus from inoculated resistant plants by either grafting method suggests that immunity is the type of resistance involved.

Heterosis

To evaluate the progress achieved through selection in the Cornell *andigena* program in 1974 remnant samples of seed from several cycles were sown to produce tubers. Only reasonably representative samples of second through fifth cycles were available.

Generation number	Number of plants	Percentage tuberized	Number of tubers	Total Weight in grams
0	233	57	342	1610
2	236	74	465	3098
3	238	75	498	3772
4	239	86	598	5015
5	229	90	614	6000

The number of tubers harvested showed an increase with each cycle; more dramatic was an increase in total weight of tubers. This trial will be grown in the field in

1975 in Peru and Ithaca. It is planned to cross each of these cycles in bulk to a common *tuberosum* tester to evaluate the "evolution" of heterosis.

Insect resistance

Potato cultivars resistant to *Myzus persicae,* the green peach aphid, *Macrosiphum euphorbiae,* the potato aphid and *Empoasca fabae* the potato leafhopper could play important roles in pest management for potatoes: a) because of the decreased availability and effectiveness of insecticides; b) in providing crop insurance to farmers in less developed countries; and c) by minimizing the disruption of beneficial insect populations.

Nine of 86 fifth cycle *andigena* clones had significantly fewer green peach aphids on them than Katahdin (P = 0.05; LSD test). Twenty-one of the same clones had significantly fewer potato aphids than Katahdin while seven clones had fewer numbers of both aphid species. Clones with relatively small numbers of aphids probably do not represent escapes, as the aphid populations were larger, e.g. from 44 peach aphids on the most resistant clones N 551-17, to 562 on N 522-23 the most susceptible.

Preliminary results have also shown that potato leaf hopper members were significantly lower on 9 to 57 fifth cycle *andigena* clones also tested under the Cornell Contract. Thirty-five clones had less hopperburn than the Katahdin control.

Nematode screening

Prior to testing clones in Peru for resistance to aggressive pathotypes of *Heterodera rostochiensis* and *H. pallida,* 7504 clones were screened at Cornell in 1974. A *Solanum sanctae-rosae* derivative crossed onto Katahdin was the outstanding new tetraploid family, segragating 45 resistant to 4 susceptible. Several other crosses onto Katahdin involving *S. sanctae-rosae, S. spegazzinii,* and *S. vernei* gave resistant progeny with segregation ratios approximating 1:1. Many of these clones have excellent size and shape.

Several of the new diploid introductions (1497 tested) contained genes for resistance to pathotype A of the golden nematode. One entry of *S. spegazzinii* and one of *S. vernei* appear to be homozygous for resistance. A list of the best family of each species and their segregation ratio follows:

Solanum Species	Resistant	Susceptible
chacoense	27	3
gourlayi	3	0
infundibuliforme	7	0
kurtzianum	45	14
spegazzinii	61	0
venturii	8	0
vernei	55	0

One hundred nineteen of the best interspecific diploid clones, based on two or more years of screening in New York State, were sent to CIP for testing against the four nematode populations established there.

Bacterial Wilt

During 1974 research continued at the University of Wisconsin into factors controlling resistance in cultivated tetraploid potatoes to race 3 of *Pseudomonas solanacearum*, the cause of bacterial wilt. The segregation ratio in F_1 hybrid progenies from crosses between resistant and susceptible parental clones was distributed in a bimodal pattern. Resistance to race 3 is a highly heritable, dominant characteristic. An hypothesis was developed that requires four dominant independent genes for resistance. There was good agreement with this model in 14 out of 20 crosses tested as indicated by the X^2 values. With the use of this model it was possible to predict reasonably well the resistant:susceptible ratio that should be obtained with the cross 1386.22 (R) x 5536.7 (S); predicted 19:56, observed 17:58. In 6 out of the 20 families however, the R:S ratios obtained differed significantly from those expected on the basis of the proposed model. Tests on families that did not fit the four-gene hypothesis are being repeated under carefully controlled conditions - particularly for plant vigor which influences resistance markedly.

Just prior to inoculation of progeny from the cross 1388.30 x 1386.12 with isolate S-206, lateral shoots were excised from each plant, rooted, the plants grown to the pre-bud stage, and inoculated with isolate K-60. The resultant R:S ratio (52:44) corresponded very closely to that predicted by the model ($X^2 = 0.16$, $p = 0.68$). That 41 individual plants from this progeny differed in their reaction to isolate K-60 and S-206 indicates clearly that an independent, rather than an additive mode of inheritance is involved.

Late Blight

In laboratory assessment of field resistance carried out under Contract at Svalov, Sweden, a micro-plot technique (1 cm^2 leaf area) was devised to assess the infection efficiency of a standard isolate of *Phytophthora infestans*. The technique relies upon a device which atomizes a zoospore suspension of 50 spores per mm^2 at 1-5 kp per cm^2 onto a defined leaf area of 1 cm^2 by means of a timed impulse. Inoculated leaflets are incubated in plastic boxes lined with water-soaked foam plastic coated with tissue paper and a plastic net. Infections are assayed after 4 days incubation at 100% R.H., + 15°C and constant light.

The precision of the micro-plot technique permits an analysis of the following components of field resistance: resistance to entrance (IE_v), resistance to invasion (LES) and, resistance to sporulation (CON).

In preliminary greenhouse trials with 76 dihaploid and 55 tetraploid clones the possibility of analysis of the components for resistance to late blight was investigated.

In general IE_V probably most closely reflected field tests. Values for LES and CON were less reliable under greenhouse conditions. IE_V increased with longer day length i.e. during winter greenhouse studies in Sweden. Haemacytometer counts of spore production were more uniform than counts by an automatic electronic counter. In summary, clones with comparable phenotypic total field resistance apparently inherit the resistance with differential efficiency. It seems possible to separate the components of resistance.

Research was continued into correlation between polyphenol oxidase (peroxidase) activity and foliage resistance to late blight. As shown in the table below there is an indication of a positive correlation:

Clone number	Peroxidase activity mg/min/g	Invaded leaf area after 5 days (cm^2)
H A 143	1.68	.43
P 201	2.99	.59
H A 139	3.44	.82
H A 141	4.79	1.33
H A H 6	4.84	1.22
P 192	5.52	1.68
H A 117	9.99	2.83

It was confirmed that zoospore liberation as well as germ tube growth seem to be stimulated by gibberellic acid up to 10^{-2} ppm, above which it becomes increasingly toxic.

Five different methods were tested to study the resistance of tubers to late blight. No method was entirely satisfactory since all involved inoculation of cut surfaces before or after a suberization interval. The method described by Schober and Hoppnes, Potato Res. 15:378-383, 1972, gave reproducible results in general agreement with field observations. Variance analyses and heterogeneity tests indicate the method may be useful in the search for linkages with foliage components for resistance.

Drought stress

Four Contract Projects were initiated by scientists in Wageningen, the Netherlands, in 1974. Mention will be made only of progress in the project to compare methods of assessing water stress in the potato plant as related to short drought periods.

Experiments were conducted under controlled conditions to determine with the Bintje variety whether: 1) leaf water potential determined with a pressure chamber; 2) stomatal diffusion resistance determined with a porometer; or 3) the relative water content in leaves are related to soil moisture levels and photosynthesis.

Correlation coefficients relating these factors 3 and 6 weeks (W) after tuber initiation were as follows:

	% soil moisture		Photosynthesis rate	
	3W	6W	3W	6W
1. Leaf water potential	.85	.88	.85	.68
2. Stomatal resistance	.73	.59	.79	.28
3. Relative water content	.61	.67	.62	.57

Soil moisture content was determined gravimetrically and photosynthesis rate by infra-red gas analysis. The data indicate that the pressure chamber technique used to determine leaf water potential responded most closely to changes in soil moisture and photosynthesis. Leaf water potential appears to respond rather sensitively to levels below 23 per cent soil moisture - when soil water potential decreases to values lower than an optimum of -0.5 bar. Transpiration, and consequently photosynthesis, in potatoes is generally reduced at a much lower moisture stress in leaves than in many other crops, e.g. -10 bar, cereals; -3.5 bar, potatoes.

Frost hardiness

Nuclear Magnetic Resonance has been used to investigate the amount of ice formed in leaf tissue during the freezing process. At the University of Minnesota it was observed that the killing temperature for six different potato varieties ranged from -2.5 to -5.5°C. For potatoes it appears that the most hardy plants can tolerate the greatest amount of ice. In wheat the fraction of liquid water, approximately 25%, was the same at the killing point. It appears that the potato survives freezing by tolerating ice while wheat survives by avoiding ice. About 2.0g of water per gram dry sample remains liquid at the killing point of potato.

In general, potato cultivars can be grouped into resistant and susceptible types based on their ability to withstand freezing temperatures. Based on percent leaching, that is:

$$\frac{\text{The conductance of leachate after freezing}}{\text{The conductance of leachate after killing}} \times 100$$

e.g., Chata Blanca de Huasahuasi (CIP N° 702514, *Solanum tuberosum* spp. *andigena)* survived only to -2°C, while Ticahuasi (CIP N° 720019, a hybrid of *S. tuberosum* ssp. *tuberosum* x *S. tuberosum* ssp. *andigena)*, survived to -3°C. *S. acaule* was resistant to -5°C (23°F). Plant age, tissue age, leaf hydration and plant growing location did not appear to significantly influence resistance to freezing.

Potato Proteins

Bromphenol blue (BPB) dye was used in studies sponsored at Minnesota as a rapid screening method for total protein estimation of freeze dried samples of 104 potato selections. Proteins in Red Pontiac tubers were fractioned by two methods. Tuberin was the main fraction by one method, while albumin was about half of the total protein by the other. The amino acid composition of protein fractions obtained by both methods was quite similar. Albumin, globulin, glutein and residual protein except prolamine were well balanced in essential amino acid and quite comparable to FAO reference protein. Methionine was the limiting essential amino acid and the biological value of albumin, globulin, glutelin and residual protein did not vary significantly. In conclusion, all the fractions except prolamine, which is a negligible portion of total protein, are of high nutritional quality. The protein in Red Pontiac on the whole is high quality. For the analysis of total N, protein - N and non-protein - N in potato tubers of different clones for a large number of samples, the combined procedures of alcohol extraction of the samples and N determinations by Kjeldahl are indicated. Alcohol insoluble N in residue is then referred to protein - N. Protein content can be calculated from protein - N times the factor 6.25 (or 7.50). The protein content calculated from protein - N obtained after alcohol extraction agreed well with the results obtained by other methods. No correlations between the levels of protein - N and protein - N as percent of total N were observed among the andigena clones in which the protein - N as percent of total N ranged from 40 up to 77.8. From the physiological standpoint, the level of protein - N as percent of total N may indicate the efficiency of potato plants to utilize the available nitrogenous sources for protein synthesis; hence, it may be used as one of the criteria of selection of clones for breeding material or for cultivation for high protein production. Electrophoretic methods have been used for the detection of biochemical gene markers. The dehydrogenases, phosphatases and oxidases also were examined in potatoes; results were inconclusive. Short periods of low temperature exposure, or longer periods of cool temperature growth did not cause a decline or 'run-off' of potato leaf polyribosomes. In fact, polyribosome levels were higher in the leaves of plants grown in the cool temperature regimes. The ribosomal RNA levels were higher in cool grown leaves after day 12 of treatment, while the protein and amino acid levels did not exhibit a dramatic change. The preservation of polyribosomes during low temperatures is probably a mechanism for efficient protein production in cooler conditions. Low temperatures stimulated an increase in tuber nitrogen. The greatest increases in nitrogen were noted in the glutamate family of amino acids, i.e. glutamate, proline and arginine. The protein content and composition of clones changed with temperature and the level of alpha-keto acids was lower in cool grown tubers.

Yield in autotetrapolid potatoes

In research at North Carolina a model of overdominant gene action was evaluated to explain heterosis for yield in the auto-tetraploid potato. Various experimental results were analyzed on the basis of overdominance versus dominance of favourable alleles. Analyses suggest a close positive correlation between heterozygosity and yield. The implication of the proposed overdominant model to potato breeding would be that substantial genetic improvement in yield should be made by increasing the genetic diversity of the parental clones. However, the alien sources of germ plasm should undergo previous selection for adaptation. A proper balance between heterozygosity and adaptation, mainly to photoperiod, should maximize heterosis for yield.

PLANNING CONFERENCES

CIP invited 63 experts from 31 countries to attend Planning Conferences to assist in developing five-year plans of research within specific Thrusts. To the present CIP has sponsored eight International Planning Conferences. The general Conference strategy has been to invite a team of up to twelve experts in a particular component of potato production to meet for a one-week period with CIP scientists. Prior to a Conference a position paper is prepared by one of the invited participants who also co-chairs the Conference with CIP's Director of Research. The position paper outlines the present level of technology for a specific conference subject. It is circulated a month prior to a Conference and provides participants with a reference to which they can react. An Agenda is also circulated indicating topics to be discussed and assigning participants to selected topics.

The participants at a Conference have a mandate to develop a plan of action including the identification of priorities. The plan must have a satisfactory balance of research activities between those requiring a long-term effort before breakthroughs can be anticipated and those requiring a shorter term before a desired result can be expected. Five year plans for CIP activities take into consideration research being done or planned at other institutions. Thus CIP Planning Conferences have a potential to influence program planning at other institutions.

Through Planning Conferences CIP management is attempting to utilize the best available expertise to help structure its research activities. The initial eight Conferences have been concerned with individual research components or Thrusts. Future conferences are being planned to integrate compatible research components. The first integrated component Conference, "Adaptation of the Potato to the Lowland Tropics", is to be held in association with the Sixth Triennial Conference of the European Association for Potato Research in Wageningen, The Netherlands, during September, 1975. Components essential to the successful production of potatoes in lowland tropical environments will include resistance to organisms causing bacterial wilt and late blight as well as physiological adaptation to tropical conditions.

CIP has published separate Reports on the following Planning Conferences:

1. Potato Bacterial Wilt December, 1972

Participants from ten countries in a Planning Conference on the Utilization of Genetic Resources, April 1974

2.	Germ plasm Exploration and Taxonomy of Potatoes	January, 1973
3.	Late Blight Strategy	August, 1973
4.	Potato Protein Quality	November, 1973
5.	Nematode Control Strategy	February, 1974
6.	Environmental Stress - Cold Hardiness	February, 1974
7.	Strategy for Utilization of Genetic Resources	April, 1974
8.	Seed Production Technology for Developing Countries	October, 1974

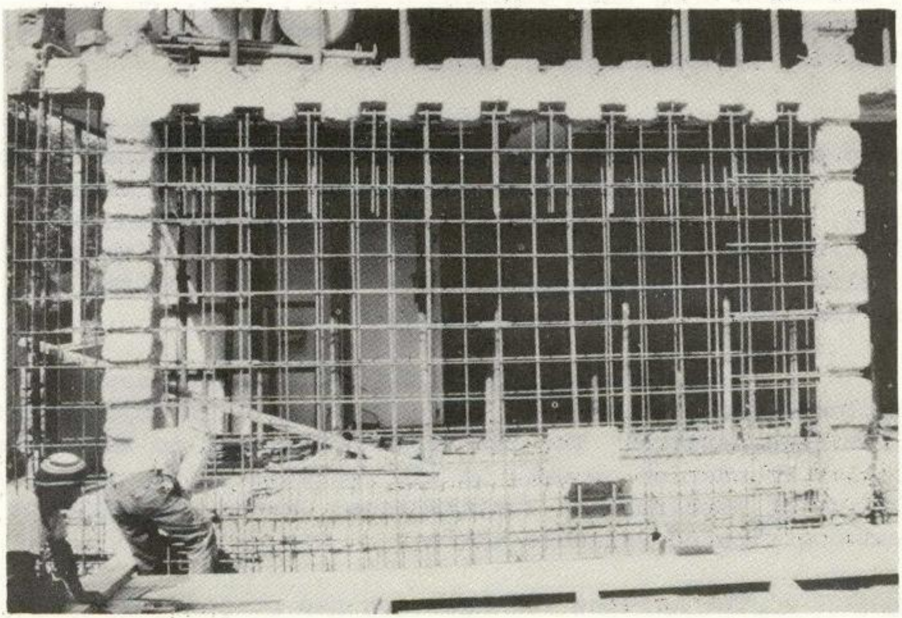
A composite Report abstracted from the first seven of the above Reports has also been published.

EARTHQUAKE

At 9:21 on the morning of October 3, 1974, a severe earthquake caused damage of approximately US$100,000 to CIP facilities. Fortunately, because of rapid evacuation of the building no CIP personnel were injured. Lasting two minutes and 15 seconds it was reported to have a strength of 7.7 Ritcher as measured in greater Lima. However, because of the nature of the terrain and geological deposit in the La Molina district, experts have estimated the strength of the quake to be above 8.0 Richter in the vicinity of CIP headquarters.

Donors quickly provided special support to repair the earthquake damage. The building was of the fluid-motion earthquake resistant design. It is being repaired on a rigid design basis which gives far more resistance and protection, but it is also more costly. It requires heavily reinforced concrete plates on both end walls as well as mid-building transverse and longi-

*Example of earthquake damage to CIP headquarters
The central column in this picture is the right-
hand column in the picture below*



Repairs to provide a rigid wall structure tudinal plates. The extensive repairs has affected seriously the use of some office and laboratory space and eliminated the only available Conference room. Because of extensive damage to nearby University buildings, the space CIP had expected to use in the National Agricultural Library is no longer available.

LIBRARY

The library will complete its second year of operation in April, 1975. 1974 proved to be an active year for the library as evidenced by the number of daily consultations.

Sixteen new journals were obtained to total 46 journals by subscription as well as more than 150 journals by exchange or donation. The reprint collection was almost doubled and many more reprints remain to be processed. Space-saving, lightweight furniture was installed; present shelving is almost fully occupied.

International exchange of publications was initiated and established with institutions in: Australia, Brazil, Canada, Chile, Colombia, Ecuador, Egypt, France, Germany, India, Mexico, Nigeria, Philippines, Taiwan, and U.S. institutions. Local exchange has also been activated. Two bibliographies were published and the third one for 1974 is in the process of being published.

A meeting of Librarians representing seven International Centers was held early in August, in Colombia at CIAT headquarters. The librarian Consultant to the Rockefeller Foundation as well as AID representatives from the Office of Research and Institutional Grants were present and contributed valuable advice.

The meeting was held for the purpose of achieving mutual understanding of the objectives of the International

Center librarians; analysing common problems and possible solutions; and, adopting informal collaborative mechanisms to assist scientists, trainees and national institutions at little or no cost.

An earthquake on October 3, 1974, caused considerable change in plans for the library, aside from delay in fulfilling committments. CIP cooperative relationship with both local libraries, the Experiment Station Library and the National Agricultural Library, will have to be reviewed in consideration of the conditions now prevailing. The Experiment Station library was so severely damaged that it had to be totally demolished. Presently, all library material is stored in the basement of a partly completed building. The Station library is thus inoperative for an indefinite period. The National Agricultural Library suffered less damage but the third and fourth floors have been evacuated. The left wing of the fourth floor was allocated to CIP for storing selected publications. The transfer of these publications was planned to take place in December 1974, but this is now not feasible. No definite date for reconstruction of these floors has been established.

LANGUAGE INSTRUCTION

Instruction in Spanish is being given by Mr. Jorge Palacios to English and German speaking scientists, technicians, and wives, as well as English lessons to Peruvian personnel, and wives.

Twelve foreign staff and seven wives have received Spanish lessons, while three Peruvian staff members and one wife have been tutored in English in 1974.

A five hours-a-day working schedule provides individual instruction to most of the students.

"AÑO DE LA MUJER PERUANA"

Moreno, Patiño y Asociados

Asociados con

Price Waterhouse Peat & Co.

Las Begonias 441 — San Isidro
Lima - Perú
Correspondencia: Apartado 2869

March 27, 1975

REPORT OF INDEPENDENT ACCOUNTANTS

To the Board of Directors
Centro Internacional de la Papa

In our opinion, the accompanying balance sheet of Centro Internacional de la Papa at December 31, 1974 and the related statement of source and application of funds for the year expressed in United States dollars, present fairly, on the bases stated in Note 1, the translation of the Peruvian sol statements mentioned below. The bases of translation are consistent with those used in the preceding year. Our examination of the financial statements expressed in United States dollars was made in conjunction with our examination of the Peruvian sol statements.

We have also expressed our opinion dated March 27, 1975 that the Peruvian sol statements of Centro Internacional de la Papa for the year ended December 31, 1974, not submitted herewith, present fairly the financial position of the center at that date and the source and application of funds for the year, in conformity with accounting principles generally accepted applied on a basis consistent with that of the preceding year. Our examination of these statements 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.

Moreno, Patiño y Asociados

Countersigned by

J. A. Patiño B. ------------------(partner)
J. Armando Patiño B.
Public Peruvian Accountant
Registration No. 1245

CENTRO INTERNACIONAL DE LA PAPA

BALANCE SHEET (Note 1)

ASSETS

	At December 31, 1974 US$	1973 US$
CURRENT ASSETS		
Cash	567,874	243,793
Accounts receivable from donors (Note 4)	626,338	2,175
Other receivables		
Advances to third parties for research work	22,373	4,057
Staff advances	10,320	11,075
Other	17,160	6,389
	676,191	23,696
Inventories (Note 2)	43,730	-
Prepaid expenses	15,251	3,426
Total current assets	1,303,046	270,915
FIXED ASSETS (Note 3)	833,837	396,326
	2,136,883	667,241

LIABILITIES, CAPITAL BALANCES AND UNEXPENDED FUNDS

	At December 31, 1974 US$	1973 US$
CURRENT LIABILITIES		
Accounts payable	19,910	74,486
Institute of International Education, balance of remunerations payable to scientists and others	14,674	20,805
Other liabilities	5,524	11,093
Total current liabilities	40,108	106,384
DEFERRED LIABILITIES		
Reserve for indemnities	27,047	11,642
GRANT RECEIVED IN ADVANCE (Note 4)	350,700	70,000
CAPITAL BALANCES AND UNEXPENDED FUNDS		
Capital grants		
Capitalization of fixed assets	833,837	396,326
Unexpended funds (utilized in excess) of grants received	(93,799)	56,711
	740,038	453,037
Working capital grants	184,575	-
	924,613	453,037
Unexpended operating grants, per accompanying statement		
Core	5,961	26,178
Special projects	788,454	-
	794,415	26,178
	1,719,028	479,215
	2,136,883	667,241

CENTRO INTERNACIONAL DE LA PAPA

STATEMENT OF SOURCE AND APPLICATION OF FUNDS (Note 1)

	For the year ended December 31, 1974 US$	1973 US$
SOURCE OF FUNDS (Note 4)		
Operating grants		
Unrestricted	1,327,408	831,492
Restricted, including US$ 25,375 unexpended in 1973	466,467	218,294
	1,793,875	1,049,786
Special projects grants	814,041	-
Earned income, net	4,053	803
Capital grants for:		
Acquisition of fixed assets, including US$ 56,711 unexpended in 1973	343,711	312,883
Working capital	184,575	-
Total funds	3,140,255	1,363,472
APPLICATIÓN OF FUNDS		
To Core programs		
Potato research program	701,169	450,591
Research support	132,125	93,604
Conferences and training	531,518	289,196
Library and information services	16,762	9,697
General administration	285,890	150,838
General operating costs	124,502	30,486
	1,791,966	1,024,412
To special projects (Note 4)	25,587	-
Total operating costs	1,817,553	1,024,412
To Capital		
Capital expenditures:		
Net increase in fixed assets	437,511	256,171
Working capital	184,575	-
	622,086	256,171
Unexpended balances		
Unrestricted funds	3,961	803
Restricted funds	2,000	25,375
	5,961	26,178
Capital grants	(93,799)	56,711
Special projects	788,454	-
	700,616	82,889
Total application of funds	3,140,255	1,363,472

CENTRO INTERNACIONAL DE LA PAPA

NOTES TO THE FINANCIAL STATEMENTS
DECEMBER 31, 1974

1 OPERATIONS AND SUMMARY OF ACCOUNTING POLICIES

The Centro Internacional de la Papa (CIP) was constituted in 1972, in accordance with an Agreement for Scientific Cooperation between the Government of Peru and North Carolina State University, United States of America, signed in 1971.

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

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

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

The principal accounting policies are as follows:

a) Grants received and their application are accounted for on an accrual basis. Restricted operating grants and unrestricted grants are accounted for in the period indicated by the donor and, when grants are used abroad, the expenditure is accounted for on the basis of advices received.

   In accordance with the instructions of the Consultative Group on International Agricultural Research, the unexpended fund balances at year-end, if authorized by donors, may be treated as income in the next year in order to absorb the corresponding expenses.

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

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

b) Bases of translation

The books and accounts of the CIP are maintained in Peruvian soles. The exchange rate between the Peruvian sol and United States dollar has remained unchanged since the inception of the CIP's operations in 1972. Consequently, all amounts in the financial statements have been translated into United States dollars at the free exchange rate of S/. 43.38 to US$ 1.

c) The inventories are stated at amounts determined as follows:

Used vehicles for sale	-	Acquisition cost
Spares and materials	-	Estimated actual value

Up to 1973 the spares and materials were charged directly to the different program accounts when purchased. The effect of this change in accounting principles is not significant.

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

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

e) Indemnities payable upon severance to the local staff for service time are provided in full in accordance with the legal dispositions of Peru.

2 INVENTORIES

	US$
Used vehicles to be sold transferred from fixed assets at their acquisition cost (Note 3)	11,980
Spares and materials	31,750
	43,730

3 FIXED ASSETS

The movement of fixed assets during 1974 is as follows:

	Balances at 1.1.74 US$	Additions US$	Retirements US$	Balances at 12.31.74 US$
Operating equipment	19,408	8,457	-	27,865
Research equipment	89,604	198,557	504	287,657
Vehicles	89,244	87,047	11,980	164,311
Furniture and fixtures	32,101	16,179	-	48,280
Buildings, constructions and installations	126,606	121,711	337	247,980
Other	39,363	18,752	371	57,744
	396,326	450,703	13,192	833,837

During 1974, the CIP started the construction of an operating station in Huancayo, Peru and a workshop and cooling plant in the district "La Molina" (Peru) estimated to cost US$ 223,144. Work in progress of US$ 93,476 has been already debited to the respective fixed asset accounts.

4 GRANTS RECEIVED

The grants corresponding to 1974 are summarized as follows:

	Grants of 1974	Unexpended grants in 1973	Total
	US$	US$	US$
Operating grants	1,768,500	25,375	1,793,875
Capital grants	287,000	56,711	343,711
Working capital grants	184,575	-	184,575
Special projects grants	814,041	-	814,041
	3,054,116	82,086	3,136,202

These grants comprise:

	US$
a) Received and administered by the CIP	
Rockefeller Foundation, including US$ 2,175 unexpended in 1973	152,175
International Development Agency - United States (USAID)	550,000
International Development Agency - Denmark (DANIDA), including US$ 56,711 unexpended in 1973	256,711
International Development Agency - Sweden (SIDA)	206,185
International Development Administration - United Kingdom (UKODA)	116,958
Netherlands government, including US$ 23,200 unexpended in 1973	203,200
International Development Agency - Canada (CIDA)	331,360
Government of Switzerland, received and deferred in 1973	70,000
World bank/International Development Association	65,000
Interamerican Development Bank (IDB)	250,000
	2,201,589
Donations for special projects	814,041
Carried forward:	3,015,630

	US$
Brought forward:	3,015,630
b) Received and administered by another institution	
Grants by the German Government for the pathology investigation program administrated by Deutsche, Forderungsgesellschaft fur Entrvicklunslander (GAWI)	120,572
	3,136,202

The unexpended balance of the special projects grants at December 31, 1974 was comprised of the following:

	Committed grants US$	Application US$	Unexpended balance US$
Interamerican Development Bank (IDB)	577,000	2,703	574,297
Ford Foundation	120,000	11,245	108,755
West Germany Government	102,041	10,872	91,169
International Mineral Corporation (IMC)	15,000	767	14,233
	814,041	25,587	788,454

A portion of the IDB grant amounting to US$ 506,338 and all the Ford Foundation grant of US$ 120,000 have not been received yet and are shown in the Account receivable from donors.

THE INTERNATIONAL POTATO CENTER

Schedule 1 - Funds Provided and Cost of Individual Grants

For the Year Ended December 31, 1974
(US$ thousands)

			EXPENSES CHARGED							
		Grants	Research	Research Support	Conf. & Training	Library Doc. & Info.	General Administ.	General Operating	% of Support & Gral. Operat. to Direct	(Overspended) or Unexpended Balance
Unrestricted Core	(1)	1,332	467	102	416	14	229	100	48	4
Restricted Core										
Netherland Government		180	62	14	57	2	31	14	48	
West Germany Government		111	106	5	-	-	-	-	5	
I.D.B.		150	54	11	47	1	26	11	47	
Unexpended balance from 1973		25	12	-	11	-	-	-		2
Total		466	234	30	115	3	57	25		6
Special Projects			S.P.							
Ford Foundation		120			11					109
West Germany Government		102	9		2					91
I.D.B.		577			3					574
I.M.C.		15	1							14
Total		814	10		16					788
Capital Grants			fixed assets							
I.D.B.		100	100							-
West Germany Government		9	9							-
Unidentified Sources (Multi-purpose)		177	271							(94)
Unexpended balance from 1973		57	57							
Total		343	437							(94)
Working Capital										
Unidentified Sources (Multi-purpose)		185								185
TOTAL GRANTS AND EXPENSES		3,140	1,148	132	547	17	286	125		885

(1) Includes earned income of $ 4,000

THE INTERNATIONAL POTATO CENTER

Schedule 2 - Detailed Schedule of Earned Income

For the Year Ended December 31, 1974

(US$ thousands)

	Actual
Sources of Earned Income	
Retained Income - prior year	1
Insurance premious & discounts	2
Indirect Costs charged on Special Projects	1
	4
Application of Earned Income	
Applied to Core Operation	4

THE INTERNATIONAL POTATO CENTER

Schedule 3 - Comparative Statement of Actual Expenses and Approved Budget

For the Year Ended December 31, 1974
(US$ thousands)

	Core Unrestricted		Core Restricted		Special Projects		Capital	
	Budget	Actual	Budget	Actual	Budget	Actual	Budget	Actual
Programs								
Potato Research		467		234	15	1		
Research Support		102		30				
Conferences & Training		416		115	724	16		
Library, Documentation & Info. Services		14		3				
General Administration		229		57				
General Operating		100		25				
Total	1,332	1,328	466	464	739	17		
Capital								
Revolving Funds							1	-
Operating Farm Equipment							14	8
Research Equipment							161	198
Furniture, Fixture & Off. Equip.							-	16
Vehicles							45	75
Constructions & Buildings							117	97
Site Development & Install.							1	24
Other Assets							4	19
Total							343	437
Earthquake Repairs					75	9		
Total					814	26		
Analysis of Variances								
Budget Surpluses:								
Unexpended balance		4		2		224		
Current Assets		-		-		564		
Total		4		2		788		
Deficits:								
Carry-over 1975								(94)

1973

64

annual report

INTERNATIONAL POTATO CENTRO INTERNACIONAL DE LA PAPA

annual report

1973

CENTRO INTERNACIONAL DE LA PAPA
APARTADO 5969, LIMA, PERU
CABLES : CIPAPA

The International Potato Center (CIP) is a scientific institution, autonomous and non-profit making, established by means of an agreement with the Government of Perú with the purpose of developing and disseminating knowledge for greater utilization of the potato as a basic food. International funding sources for technical assistance in agriculture are financing the Center.

*"Portador de Papa" — 4th Century A. D. Nazca Culture

CONTENTS

Board of Trustees	2
Staffing	4
Forward-Origin of CIP	6
Objectives	7
The Potato-Historical	8
Location of CIP	9
CIP - Toluca	16
General Program in Research	17
Thrusts:	17
Systematics	18
Utilization	22
Control-Fungi	29
Bacteria	35
Viruses	38
Nematodes	43
Adaptation to Stress	48
Protein Yield	55
Seed Production	58
Outreach	61
Contract Projects - 1973	67
Contract Projects - 1974	68
Library	69
Finance	71

Potato Hydroponics - Lake Titicaca

CIP BOARD OF TRUSTEES

DR. ERNST KELLER

Professor of Plant Breeding at the
Federal Technical University,
Eidg. Technische Hoshschule Zürich,
Universitätstrasse 2,
8006 Zürich,
Switzerland

DR. ATMARAM BHAIRAV JOSHI

Director,
Indian Agricultural Research Institute,
New Delhi - 110012,
India

DR. COLIN MC CLUNG

Associate Director,
Agricultural Sciences,
The Rockefeller Foundation,
111 West 50th Street,
New York, New York 10020,
U. S. A.

DR. JOSE VALLE-RIESTRA

Director-Proyeccion de Servicios,
Universidad Nacional Agraria
Apartado 456,
La Molina, Lima,
Peru

DR. RICHARD L. SAWYER

Director General,
International Potato Center,
Apartado 5969,
Lima,
Peru

STAFFING

(December - 1973)

Principal and Supporting Scientists

PhD	Richard Sawyer	Director General
PhD	Orville T. Page	Director of Research
Ing. Agr.	Carlos Bohl P.	Executive Officer
PhD	Edward French	Head of Department
PhD	Roger Rowe	Head of Department
PhD	John Niederhauser	Associate Head
PhD	Richard Wurster	Acting Head
PhD	Julia Guzmán N.	Pathologist
PhD	Nelson Estrada	Breeder
PhD	Raymond Meyer	Agronomist
MS	James Bryan	Seed Production Specialist
MS	Carlos Ochoa	Taxonomist
PhD	Michael Twomey	Economist
PhD	Kenneth Sayre	Physiologist
PhD	Rolf Schäfer	Nematologist
CPC	Oscar Gil Y.	Controller
Mr.	Guillermo Romero	Accountant
PhD	Rainer Zachmann	Mycologist
PhD	María de Scurrah	Nematologist/Breeder
PhD	Ana M. Hinostroza	Virologist
PhD	Roger Jones	Virologist
PhD	Marco Soto	Superintendent-Huancayo
PhD	William Roca	Physiologist

MS	Luis Salazar	Virologist
MS	Manuel Villareal	Regional Training Officer
MS	Oscar Hidalgo	Regional Training Officer
Ing. Agr.	Juan Aguilar	Agronomist
BS	Carmen de Podestá	Librarian
Ing. Agr.	Luis Valencia	Entomologist
Ing. Agr.	David Baumann	Field Supervisor
Ing. Agr.	Lis de Ocampo	Assistant Plant Pathologist
BS	Rosa Mendez T.	Laboratory Technician
MS	Stephanie Tribble	Geneticist
PhD	Fernando Ezeta	Physiologist
PhD	Humberto Mendoza	Breeder
BS	Norma Gonzalez	Laboratory Technician
PhD	Pen Hsiang Li	Physiologist
PhD	Kenneth Evans	Nematologist
PhD	Kenneth Proudfoot	Pathologist
PhD	John C. Vessey	Pathologist
MS	Michael Jackson	Taxonomist
Ing. Agr.	Javier Franco	Nematologist
MS	Zosimo Huaman	Breeder
PhD	Lodewijk Turkensteen	Mycologist
PhD	Parviz Jatala	Nematologist
PhD	Robert Lüscher	Breeder

FOREWORD

ORIGIN OF CIP

El Centro Internacional de la Papa is a relatively new institution. On January 20, 1971, an organizational agreement was signed with the Government of Peru marking the establishment of CIP as an autonomous institution. The first funding for program activities was received in 1972 but due to the late assignment of money most expenditures and staff additions were not made until the last part of that year. Since then, CIP has made rapid progress in the development of facilities, the staffing of positions and the initiation of program activities.

CIP is a single-crop institute devoted to the tuber-bearing Solanum species, the white or Irish potato. Peru has had a strong potato research program for some years, assisted originally by North Carolina State University under a grant from U. S. AID. This gave the initial impetus to the establishment of CIP. Through research contracts CIP has also linked with advanced potato improvement work at other North American and European institutions. This combination has had the effect of providing CIP with ready, ongoing projects so that initial progress has been much more rapid than could otherwise have been realized.

OBJECTIVES

The basic objectives of the Center are to

a) Increase the yielding capability and efficiency of production in the developing countries where the potato is being grown, and

b) Extend the geographical range of the potato, including the lowland tropics.

In pursuing these objectives in which resistance to disease and pests is an important factor, CIP can be expected to make major contributions in the form of disease-resistant germ plasm which will be of significant value not only to the developing countries but also to the developed temperate-zone countries.

The statutes of CIP state that to fulfill its objectives the Center will:

a) Conduct research programs for the improvement of potato production and other tuberous roots, both nationally and internationally;

b) Collect, maintain and distribute germ plasm in order that it may be used nationally and internationally;

c) Provide assistance in the development of related institutions which might be established in Peru or headquartered elsewhere;

d) Train potato technicians under the leadership of high-level scientists;

e) Publish and distribute research results obtained;

f) Establish an information center and organize a specialized library, including an herbarium;

g) Organize conferences, forums, round tables and seminars, both nationally and internationally, concerning potato improvement activities;

h) Participate in all other activities related to the goals of the Center.

THE POTATO - HISTORICAL

The potato has been established as a crop plant for at least two millenia in the Andean sierra and altiplano, with its center of exploitation in the puna of the Lake Titicaca region. Symbolic representations of the potato occurred on pottery in the Proto-Chimu period of the second century A. D. suggesting that the potato was a familiar food of the coastal peoples for generations before adorning their pottery.

The Spaniards introduced the potato into Europe about 1570 and from Spain it was carried to Italy and Germany. The potato arrived in England a decade later from a different source and was first cultivated in Scotland as a crop in 1740. The potato became a popular food in Ireland following its introduction sometime before 1663. The population explosion resulting from an abundance of an easily grown food contributed to the disastrous famines in 1845 and 1846 when a blight fungus destroyed the crop. The introduction of the potato into North America in 1621-22 was probably by way of Bermuda where it had been grown since its transfer from England in 1613.

The successful transfer of the potato from tropical to temperate latitudes, and later to tropical regions of

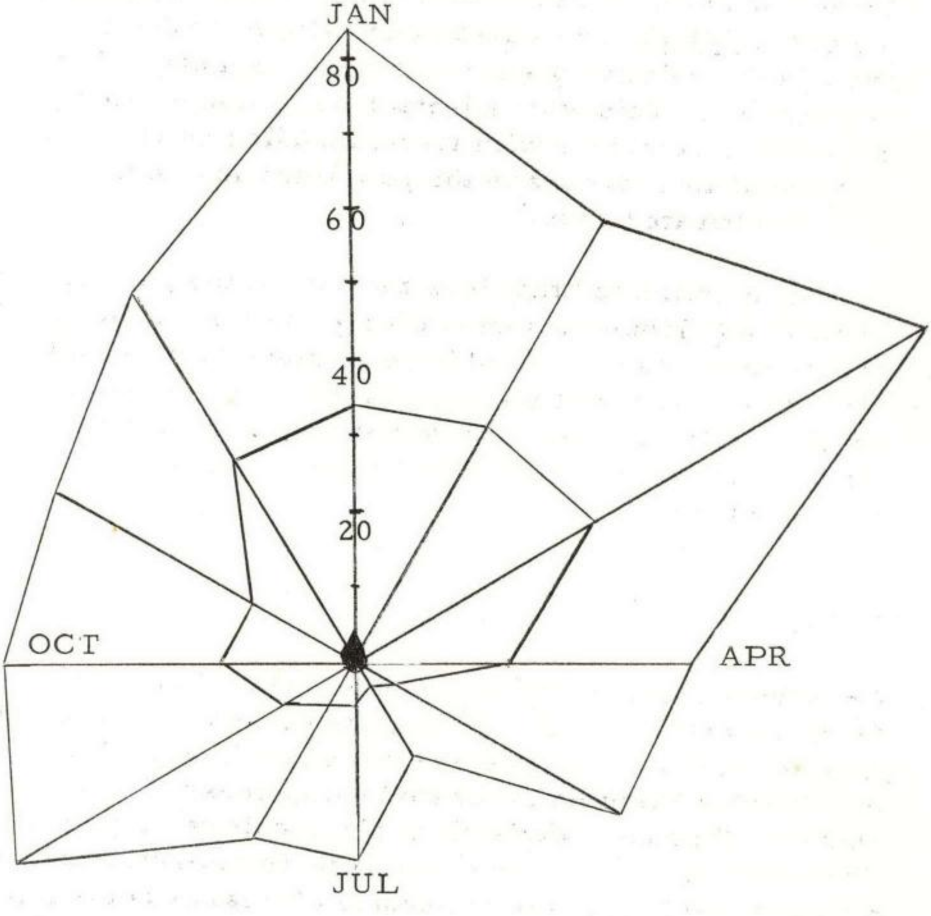
Africa and Asia, has been due to the selection of clones adapted to the long days of a temperate growing season or to the selection of day-length insensitive clones. From eons of natural selection in cool Andean habitats, the genus Solanum was also generally well adapted to grow in the relatively short frost-free seasons of northern regions. This wide adaptability to temperature and day length, combined with its outstanding nutritive and yield qualities, has made the potato the fourth most widely cultivated crop.

Yet, it is estimated that less than 1% of the genetic variability in Solanum has been utilized in the development of existing varieties. Making wider use of genetic materials, and especially prospecting the germ plasm for multigenic field resistance to pests and diseases can make enormously valuable contributions toward solving many problems.

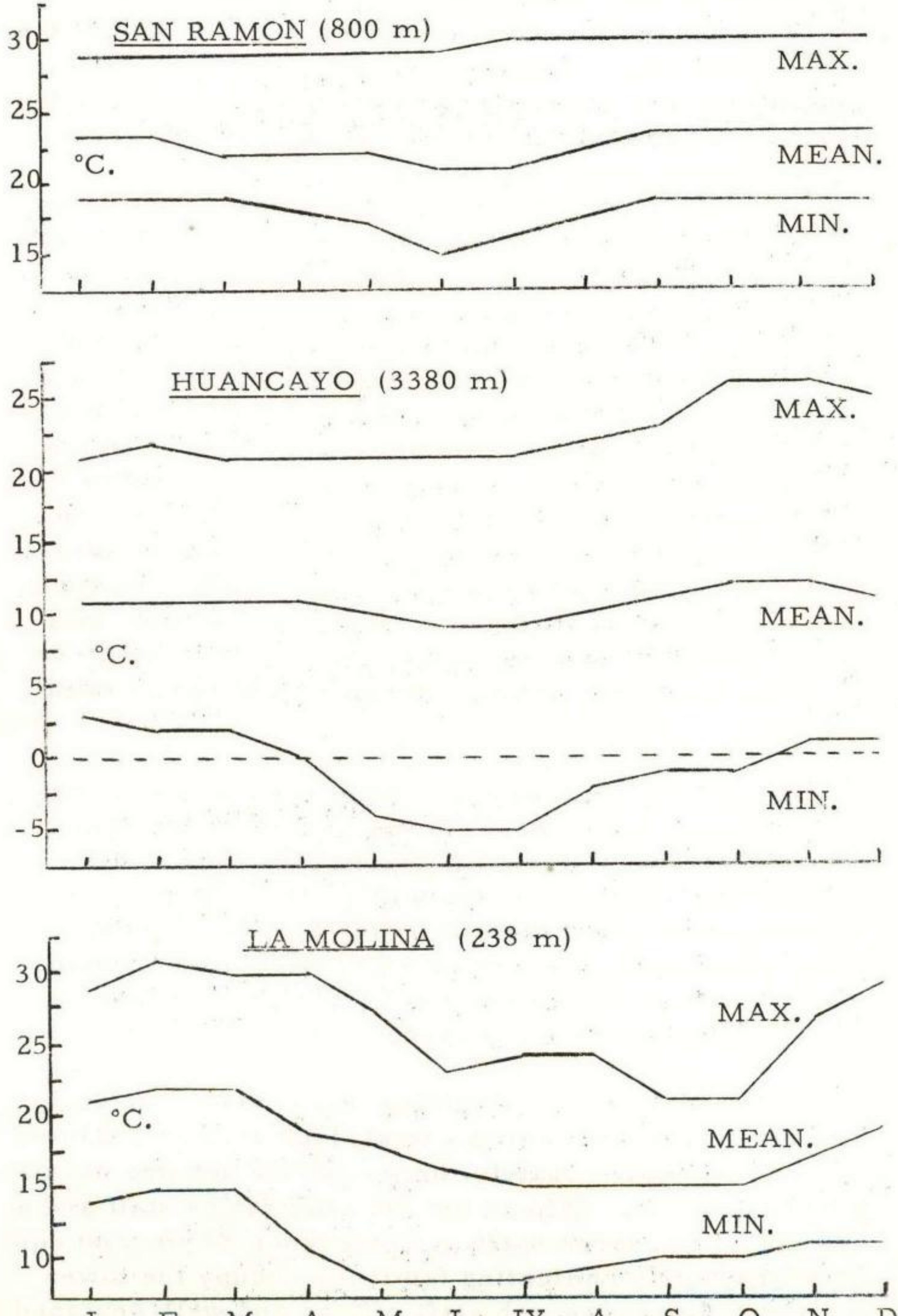
LOCATION OF CIP

Crop breeding commonly has been carried out remote from the center of origin and genetic diversity of a particular crop plant. In contrast, the facilities of CIP have been strategically located with access to the sources of genetic variability of the cultivated potato. The location of CIP in Peru facilitates collecting germ plasm material, and maintenance of a large collection in an environment which closely approximates that in which the plants occur naturally. In studying disease and insect resistance, selected clones can be exposed to the variability of indigenous pathogens and pests which have evolved with their solanaceous hosts over long periods of time. Cultivated native clones also provide a valuable genetic heritage directly useful in a sophisticated modern breeding program.

In addition to being located in the center of origin of the



Five-year average precipitation (mm) at three principal experimental plot areas: San Ramon (outer); Huancayo (middle); and, La Molina (inner) perimeters.



Monthly Average Temperatures (1968-72)

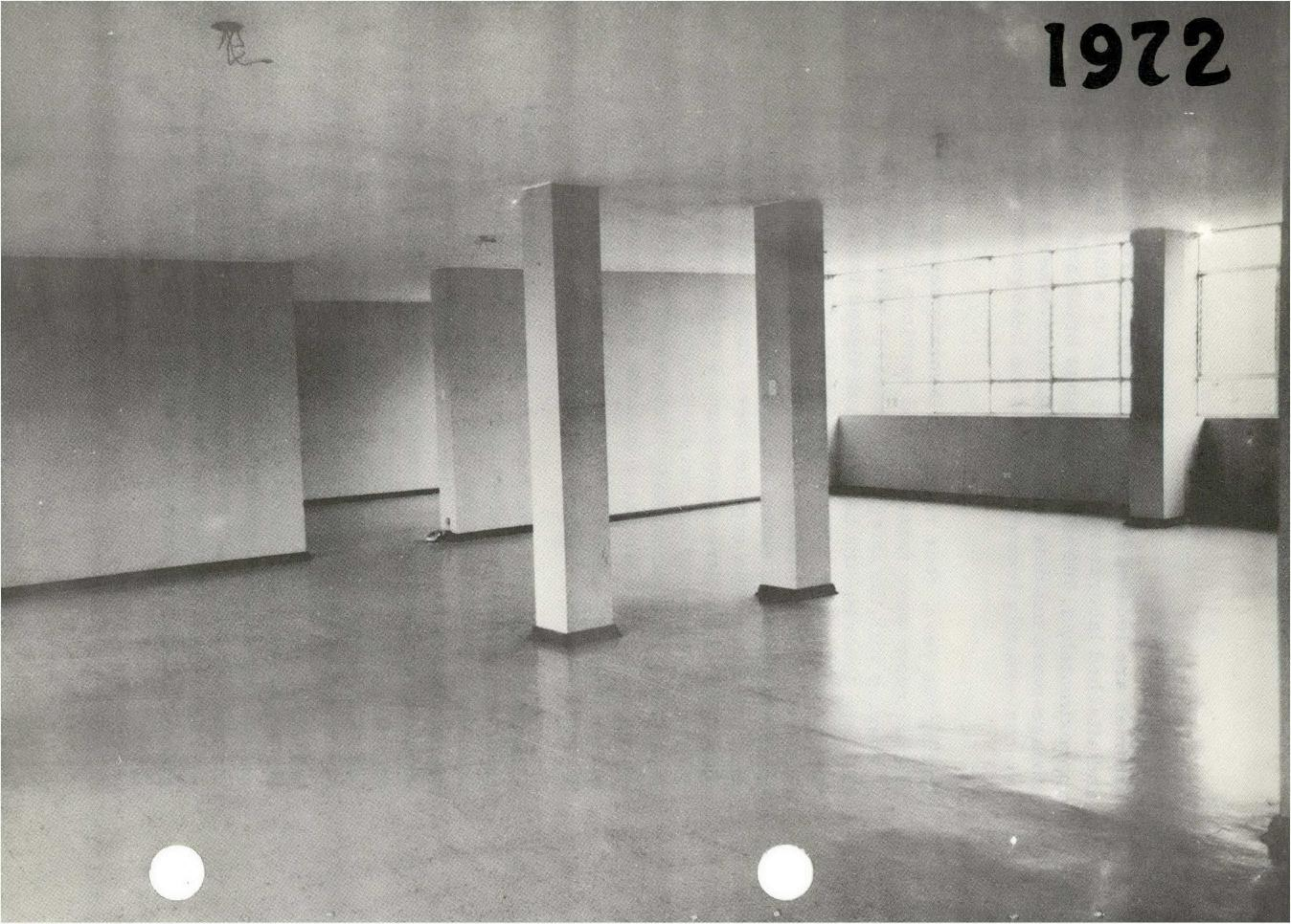
cultivated potato, the Peruvian facilities of CIP are also strategically positioned to provide a range of environmental stresses. Experimental field plots are located between 11° and 12° south latitude, within a north-south distance of less than 60 miles, which provides essentially uniform short-day conditions at all sites. CIP plots near the coast at La Molina are in one of the world's driest deserts with an average annual precipitation of less than 0.5 inches. At Huancayo, frost is predictable through April to September in the high altitude plots (10,000 feet) while low (1.5 inches) to high (12 inches) seasonal monthly rainfall and high daytime temperatures, characteristic of hot humid tropical jungle, prevail at the San Ramon station. Thus extremes of heat, cold, drought, and precipitation, as well as favorable climatic conditions for potato production, are at hand for large-scale stress studies. Choices of season and site combination permit year round evaluation of the adaptability of clones to specific climatic variables likely to be encountered in growing potatoes in developing countries located in tropical and sub-tropical regions.

The central headquarters of CIP in the La Molina district of Lima are adjacent to the Estacion Experimental Agricola, Ministerio de Agricultura, and to the Universidad Nacional Agraria of Peru. The proximity of these institutions permits ready access to excellent library facilities, as well as an agreeable environment for the interchange of ideas and training of personnel in all aspects of potato research.

The main headquarters building is a modern two-story concrete structure having a total floor area of 1,230 m^2 situated on approximately three-quarter hectare of landscaped grounds. Offices for Administrative staff and a number of Research staff, a Conference room, and communication and duplicating facilities occupy the lower floor; library, research staff offices and well-equipped laboratories are located on the upper floor. Screenhouses and attached laboratory facilities having a total area of approximately 1,500 m^2, a spacious brick and concrete storage-work building and a small care-taker's home are conveniently located close to the headquarters building.

During the year, four research laboratories and a preparation room were furnished and services installed. In keeping with the integrated research philosophy of CIP, the laboratories have been designed for flexible, multi-purpose use. Initial purchases of microscopes, balances, refrigerators, incubators, cold storage units, transfer hoods, an autoclave, glassware, and general chemical and media supplies were made. Such major equipment as an ultra-centrifuge, a refrigerated centrifuge, a recording spectrophotometer, and a freeze dryer were also purchased. Despite minor inconveniences normally associated with the development of laboratory facilities, laboratory research was commenced during November-December, 1973.

A large portion of a five-hectare site at Santa Ana (Huancayo) was planted to select germ plasm material during October. At this location, which was granted to CIP by the Ministerio de Agricultura, a permanent laboratory, storage, and personnel housing complex is to be erected, according to plans developed during 1973. The temporary use of land for field experiments was also granted at San Lorenzo and on the Experimental Station, both sites located in the Mantaro Valley. Extensive blight test plots were planted in San Lorenzo while plots devoted to taxonomic studies were planted at the Mantaro Station. A modest car pool was operative during the year to transport personnel between La Molina, Huancayo and San Ramon as well as to provide essential local services at all sites.


1972


1973

CIP-TOLUCA

In addition to Central research laboratories located in Peru, in 1972 CIP assumed control and responsibility for facilities and programs relating primarily to late blight testing previously supported by the Rockefeller Foundation. The facilities, located at the CIMMYT Experimental Station, in the Toluca Valley, Mexico, consist of four hectares of test plots, office and work area, a greenhouse, seed storage, and a training classroom.

Exposure in the field at Toluca provides a screen for late blight field resistance perhaps unequalled elsewhere in the world. During the past 20 years over 160,000 seedlings and selections have been tested for blight resistance at Toluca for potato breeding programs in 29 countries. Under the auspices of CIP the International Potato Blight Testing Program is being continued. During the past year, and in 1972, potato breeding programs in the United States, Canada, England, Holland, West Germany, Sweden and Japan have made use of the Toluca test sponsored by CIP. In addition to performing a valuable blight testing service of international scope, the Toluca facilities are also used for testing and maintaining selected blight resistant lines for the CIP Outreach program. As part of the Outreach objectives in Central America, training programs are also regularly conducted at CIP-Toluca.

GENERAL PROGRAM IN RESEARCH - 1973

The Research Program of CIP has two basic components:

A. Research conducted at CIP facilities

B. Research contracted at selected institutions

Through this inter-locking approach CIP has been able to initiate Projects very quickly, particularly Contract Projects where facilities and expertise already exist for solving problems.

Projects conducted at CIP, as well as Contract Projects, are formally outlined with respect to title, leaders and assistants, justification, detailed objectives, present state of knowledge, and detailed methods, materials and facilities required. These Projects are the units of research designed to fulfill the following designated Thrust objectives:

THRUSTS

1. Systematic collection, classification, maintenance, and distribution of all tuber-bearing Solanum species.

2. Utilization of the tuber-bearing Solanums to provide better adapted potatoes for developing countries.

3. Control of selected fungal pathogens.

4. Control of selected bacterial pathogens.

5. Control of selected viruses and insect vectors.

6. Control of selected nematode pests.

7. Development of potatoes with wider adaptation to environmental stress and insect pests.

8. Improvement of general nutritional quality, protein yield, and carbohydrate-protein balance in potatoes; the development of economical, scale-neutral methods of storage and processing for developing countries.

9. Seed production technology for developing countries; tissue culture for disease elimination, rapid multiplication and distribution of new clones.

10. Outreach Program (and affiliated Socio-Economic Projects) concerned with training personnel, the adaptation of research, and the efficient distribution and utilization of the potato in developing countries.

SYSTEMATICS

During 1973 CIP conducted two field expeditions in Peru that collected 714 accessions in the Departments of Ancash and La Libertad in May and an additional 330 accessions from the Department of Lima during the favorable collecting period of June and July. The strategic location of CIP close to the center of origin, diversity, and early cultivation of the potato has greatly facilitated the organization of collecting expeditions. Five expeditions, including a Dutch-British collecting party, are planned for 1974.

A vigorous start has been made in classifying accessions; approximately 566 taxonomic determinations as well as 287 chromosome counts have been completed.
Eighty hybrid clones of potential breeding value were introduced from Europe and Mexico; 600 accessions have been donated from Chile, Colombia and Sturgeon Bay, Wisconsin. At present, CIP has more than 5,000 tuber-bering *Solanum* accessions. A measure of the poten-

tial value and interest in the collection is the fact that approximately 8,000 samples were distributed for testing to 31 scientists around the world in 1973.

Basic studies into the origin and taxonomy of triploid potatoes in native cultivations in Peru are being studied through controlled diploid-tetraploid crosses. Successful crosses have been achieved with an unexpected high frequency of triploid progeny indicative of a potential for triploids to act as bridges in gene-flow between diploids and tetraploids.

Some evidence has been obtained that Solanum ajanhuiri could arise between the cultivated species, S. stenotomum, and the wild species, S. megistacrolobum. The three species overlap in their geographical distribution and ecology along the Andes of southern Peru and Bolivia. S. ajanhuiri is a frost-resistant species and it seems likely that it might inherit this characteristic from the highly frost-resistant S. megistacrolobum. Many morphological characters appear to be intermediate between S. stenotomum and S. megistacrolobum.

Although S. ajanhuiri has been reported to be a male-sterile species, several lines of evidence determined at CIP do not support this report. Pollen stainability ranged from 13-30%. In crosses using S. ajanhuiri as a male parent the berry set was 10% with an average of 11 seeds per berry and 16% parthenocarpic berries. These results indicate low pollen fertility rather than male sterility. However, since there are a greater number of successful crosses when S. ajanhuiri is used as a female parent, berry set approximately 50%, it is apparent that this species can be best utilized in breeding as a female parent. Intraspecific crosses involving nine clones of S. ajanhuiri have been made.

A berry set of 43%, with 6-18 seeds per berry, was obtained in reciprocal crosses between S. stenotomum and

S. megistacrolobum. Although many ovules seem to be fertilized they do not mature beyong the formation of seed coats, indicative of some fundamental barriers in the formation of viable seed. Some seeds burst before reaching maturity and relatively few seeds develop completely.

In early November, nearly 4,000 clones, 15 tubers of each when possible, were planted for observation and maintenance at Santa Ana, Huancayo. In addition, 750 cultivars were increased at La Molina for distribution in early 1974; 70 clones of wild species were grown for observation in screenhouses. Open pollinated seed was collected from plants grown earlier in the year at Huancayo. In keeping with the policy to convert certain lines to true seed, seed from 2,200 clones is now available for long-term storage.

Planning Conference on Germ-Plasm Exploration and Taxonomy of Potatoes

In January, 1973, a Planning Conference was held in La Molina to examine priorities and recommend an action program for the next five years on germ-plasm exploration and taxonomic research. A report was prepared in which discussions and recommendations were summarized, pointing out priorities and indicating the individuals and organizations from whom cooperation might be sought, in addition to the research envisaged at CIP headquarters.

In the Introduction to the Report it was stated:

> "....breeders are turning to the use of wild species and primitive cultivated forms to solve problems of disease resistance and adaptation to a wide range of environmental conditions."

"Unfortunately, this reservoir of genetic variability, which until a few years ago had been taken so much for granted, is now diminishing at an alarming rate. The old highly complex pattern of diversity is, paradoxically, being replaced by the newly bred cultivars which are themselves derived from it. Such an erosion of genetic diversity is a process that must be halted, if breeders are to continue the production of new varieties now and in the future."

It was agreed that the first task of the Planning Conference should be to examine the priorities for exploration, country by country, for wild and cultivated species. Priorities were established, A, B, or C in descending order, A being the most important, under the following headings:

- I Genetic erosion in progress or threatened.
- II Plant breeding needs based on knowledge of the species and/or areas concerned.
- III Lack of living material, in comparison with known distribution area. Taxonomic interest.

	Wild			Cultivated		
	I	II	III	I	II	III
Venezuela	B	C	A	B	?	A
Colombia	A	C	B	A	B	C ?*
Ecuador	?	C	A	A	B	A
Peru	B	B	A	E**	A	A
Bolivia	C	B	B	A	B	B
Argentina	C	B	C	A-E	C	A
Chile	C	C	B	N	C	N***
Uru-, Para-, Brazil	C ?	C?	B	N	N	N
Mex-, USA, Guat.	C	A-B	A-B	E	C	C ?
Central Am.	C	C	B	N	N	N

* Needs further assessment
** Emergency
*** No interest

The 18 taxonomic series into which the tuber-bearing species of the genus Solanum have been divided, were each discussed by the participants at the Planning Conference. Priorities A to C were assigned for taxonomic research. It was recommended that the highest priority ("A") be given to taxonomic research on the following series: Conicibaccata; Piurana; Tuberosa (wild species) from Ecuador, Peru and Bolivia; Tuberosa (cultivated species) from all Andean countries. In view of their importance in plant breeding, it was recommended that special emphasis should be placed on taxonomic research in this group.

Series recommended to be assigned a "B" priority were: Acaulia, Demissa, Megistacroloba. Priority "C" series were Morelliformia, Bulbocastana, Pinnatisecta, Commersoniana, Circaefolia, Longipedicellata, Polyadenia, Cuneolata, Ingaefolia and Olmosiana. The highest priority research is to be in the cultivated members of the series Tuberosa; no priority interest was indicated for members of the series Juglandifolia and Etuberosa.

The development of an International Board for Plant Genetic Resources is being followed with interest by CIP personnel responsible for systematically collecting, classifying and maintaining an ever-increasing number of Solanum accessions.

UTILIZATION

The interlocking of CIP projects and Contract projects is exemplified by integrated research designed to most effectively utilize Andean cultivated diploid species and cultivated andigena tetraploid species.

1. Breeding and Adaptation of Cultivated Diploid Potato Species-North Carolina State University Contract Project.

From crosses of S. phureja x S. stenotomum, designed to isolate and identify superior diploid clones, two populations were identified: (i) a segregating population of 9200 seedlings of 57 families, of which 36 were beginning cycle -4, 3 in various intermediate stages of selection, and 18 new families; (ii) a tuber planting of 2470 clones representing 56 families, 40 of which had completed cycle -3 of selection and 16 newer families. In addition, twenty-four clonal selections from 1972 were grown in quantity and evaluated in August, 1973. All tuberized under long days. Twenty of these were reselected and 19 new clones were isolated for individual study in 1974. Tuber size, tuber number and percentage of segregates tuberizing continued to improve in the selected families. From the seedling population and 10 new tuber introductions 2360 tuber clones from 67 families were selected. These 2360 clones will comprise population (2) in 1974. Seeds were harvested from the tuber population and will be used to produce a seedling population of 9,500 segregates in 1974. Selected clones will be evaluated for chromosome number. It is hoped to select cultivated diploids for general adaptability to new potato growing regions and for day-length insensitivity.

Resistance to frost stress has a high priority in breeding being undertaken by CIP. Three clones of S. ajanhuiri are being investigated as diploid sources of frost resistance. Populations of crosses of S. ajanhuiri to Peruvian phureja and stenotomum clones were grown in the field in North Carolina. Unfortunately few tuberized even as late as October and none tuberized earlier. Crosses of the sources of resistance with better adapted phureja clones will be made in 1974.

Selections from adapted populations in North Carolina were grown in both highland and lowland tropics of Peru in 1973. Selections representing 43 families from N. C. State were superior in performance to the native clones at the jungle location at San Ramon. Thirteen selected clones were produced. It is recommended that a growing season, September to January, might put more stress on populations than the June-September season employed in 1973 at San Ramon.

2. The Utilization of Solanum tuberosum spp. andigena Germ Plasm in Potato Improvement and Adaptation-Cornell Contract Project.

Advanced Population (Sixth Cycle)

Seed Production: - The sixth cycle of this andigena germ plasm material was first grown in the field in 1972 as single-spaced hills and selected for tuber appearance and yield. All hills of family N-503 were retained based on superior blight resistance recorded at Toluca. All clones from other families and 88 of the N 503 clones were planted in the greenhouse during the winter (1972-73) and pollinated with bulk sets of andigena pollen-one for resistance to late blight, one for elite appearance sets, one for PVY resistance and one for resistance to root knot nematodes. Seeds were produced on 264 of 402 clones. During the summer of 1973, open pollinated seeds were harvested from an additional 175 clones, including several N 503 clones. Over 145,000 seeds were collected from N 503 clones alone.

Disease Resistance: - Greenhouse tests under controlled temperature and humidity yielding 515 clones with resistance to Phytophthora blight. When tested in Toluca all clones resistant in Ithaca to races 0; 1, 4; and 1, 2, 3, 4 had lesions in Mexico, although 74 had intermediate general resistance and 50 clones had high levels of resistance. Clones N 503-128 and N 503-129 were outstanding for resistance being rated 1 on a 0-5 scale. Three field tests of 47 andigena clones and 13 tuberosum clones with general resistance, and 10 susceptible check varieties were made at two locations in New York State and one in West Virginia. The general resistance of the andigena clones was outstandingly superior to the tuberosum resistance.

Root knot reaction for 357 clones was determined in a greenhouse during the summer, 1973. A range in resistance, from 1 to 10 was observed among clones of individual families. Thirty-two clones which rated 1-2 were considered resistant to a mixed population of _Meloidogyne incognita_, _M. hapla_, _M. javanica_, _M. aeranaria_ and _M. incognita acrita_.

A total of 385 clones were inoculated with PVX in the field, while 587 clones were exposed to natural infection by PVY. Tubers from PVX plots will be sprouted and the foliage rubbed on _Gomphrena globosa_ to indicate infection; this will be completed by spring, 1974. Plants from tubers harvested from PVY plots will be tested against seedling 41956 or _S. demissum_ in the greenhouse during the winter. Preliminary evidence is that a single locus is involved in PVY resistance.

Insect Resistance: - Results of evaluating test plots of various andigena clones for resistance to leafhopper, aphids, tarnished plant bug and the Colorado potato beetle were equivocal. Within each family represented by more than 4 clones, populations of insects and ratings of damage ranged widely. Clones within a family were neither all resistant nor all susceptible nor consistently at a level in between. Although the results indicate some resistance in andigena germ plasm, Katahdin controls, presumably genetically alike, also showed wide variations in insect populations and damage.

Tuberization under Warm Temperatures: - Preliminary experiments were carried out in controlled growth chambers to determine whether these might be used to simulate environmental differences between high and low altitudes in the tropics. Four, cycle -5 andigena clones previously screened for heat tolerance at Rio Piedras, Puerto Rico, were grown under 12-hour light at either 70° or 80° F; 12-hour dark temperatures were 10°F cooler. The andigena clones and a Katahdin control produced longer haulm internodes and smaller leaves under an 80°-day, 70°-night cycle. There was also a reduction in tuber yield under this regime. Clone N 558-36 which appeared to be the most tolerant to high temperature in the growth chamber also yielded relatively well in Puerto Rico.

Second Cycle Population

Tuber Production: - Seedling tubers of this generation were produced in the greenhouse in 1972 and were planted in the field in New York in May, 1973. Under temperate zone conditions only 539 of 807 accessions produced clones with tubers in a population of 23,531 hills. A base for second cycle consists of 1615 clones from 539 accessions which tuberized. The origin of the accessions to be planted for study in 1974 is as follows:

Origin	N° of accessions	N° of clones
Argentina	81	298
Bolivia	56	136
Chile	10	52
Colombia	61	180
Costa Rica	1	5
Ecuador	10	21
Mexico	20	71
Peru	176	416
CPC	80	269
IR-I crosses	44	167
	539	1615

Resistance to cyst nematode: - This part of the Cornell program has been broadened to include 30 new introductions added to the diploid species already being studied (Solanum multidissectum, S. sanctae-rosae, S. speggazinii, and S. vernei) as well as 57 introductions of 20 additional diploid species of Solanum. Greenhouse and field increases of these introductions resulted in approximately 900 clones which tuberized successfully; these will be screened for resistance to race A of Heterodera rostochiensis and concurrently increased for CIP trials.

Nearly 3,000 clones resulting from interspecific crosses of diploid Solanum clones with resistance to race A (with zero cysts per root ball) were screened in 1973. Crosses involving S. sanctae-rosae gave the highest percentage of resistant progeny, generally 90% or higher. Field increases of 2,081 entries are intended for CIP cooperative trials.

CONTROL-FUNGI

Late Blight (Phytophthora infestans)

Late blight of potato is one of the most destructive diseases of this basic food crop since the disease was discovered in the 1840's. It is among the most important of all plant diseases and has received a great deal of attention through research and extension. In spite of advanced knowledge concerning late blight, it is still a major problem and can be a limiting factor in potato production in developing countries.

The causal fungus, Phytophthora infestans (Mont.) de Bary, is biologically adapted to thrive in most environments where the potato is cultured. It is well adapted for widespread dissemination through the air or through movement of infected tubers. Infected tubers are the major source of survival in developed countries; the destruction of such inoculum foci is an essential element in control.

The protection of foliage by fungicides has been developed to a high state of technology in many countries where modern fungicidal chemicals and expensive, sophisticated machinery permits effective control. However, in many developing nations there is relatively little use of fungicides. Although hand sprayers are used by some small growers, control is generally unsatisfactory in the rainy seasons when the potato is commonly grown in tropical countries. More importantly, the subsistence farmer seldom has money to purchase sprayers and fungicides, even if available.

The greatest promise for control of potato late blight in developing countries relies upon the introduction of resistant varieties. The knowledge that adequate resistance to the pathogen is available gives confidence that this promise can become a reality. This is particularly true when resistance is controlled by a series of multiple genes which appear to be additive in effect and inherited in a polygenic fashion. This has been termed "field resistance" and is apparently stable in the face of the variable pathogen. It consists of a complex of factors including resistance to entrance of the fungus and resistance to growth and sporulation of the parasite; additional factors may also play a role. Field resistance is race non-specific and is apparently not subject to being overcome by pathogenic recombinants of the blight fungus.

Field resistance offers a positive method of providing international control of potato blight. Accordingly, CIP is utilizing field-resistant clones developed through the breeding program sponsored by the Rockefeller Foundation at Toluca, Mexico. Approximately two-thirds of

1200 clones having varying levels of field resistance were screened in 1973 by CIP since assuming responsibility for the Toluca program. Further screening to reduce the present inventory of blight-resistant clones at Toluca is projected for 1974. It is anticipated that selected blight-resistant clones from Toluca, screened for other agronomic attributes, will be used to fulfill early obligations of the Outreach Program of CIP. A total of 2,700 clones submitted by eight breeding institutions were under trial at Toluca in 1973 as part of the CIP- International Potato Blight Testing Program. Procedures for entry to the CIP - IPBT program at Toluca have been formalized. The pedigree of all clones submitted for test must be provided and CIP reserves the right to utilize any clones to help developing countries (the naming of varieties is not a CIP objective, so that no clone could be selected for varietal release by CIP).

An aggressive program for the selection and breeding of clones with high levels of resistance to late blight was initiated at CIP-Peru in 1973. Approximately 2,780 germ plasm accessions were planted in March in non-sprayed blight plots in Huancayo. The development of a severe blight epidemic permitted the selection of 973 andigenum clones with useful levels of field resistance. A planting at La Molina of 816 selections from Huancayo resulted in a further selection of 135 clones with combined blight resistance and early maturity. These were re-planted in San Lorenzo in December, 1973, together with all additional clones (1,295) of Solanum andigenum, S. phureja, S. stenotomum and S. goniocalyx belonging to the germ plasm collection, as well as 318 clones obtained from selection from Mexico with high levels of blight resistance. In accordance with recommendations arising from the Late Blight Project Planning Conference Report - "Late Blight Strategy", a standard set of 16 differential hosts were also planted at the blight plots in San Lorenzo.

Segregating populations of diploid clones were tested in cooperation with the North Carolina Contract Project. Eighty-five resistant clones, having other desirable agronomic characteristics, were selected from 945 accessions planted at La Molina.

Fourteen differential R-gene hosts were inoculated with spores of isolates of P. infestans collected from Cajamarca, Huancayo, Porcon, Canta and La Molina. Only races 0 and 2, 4 were detected. The limited number of races detected was probably due to the general absence of race-inducing demissum crosses. Because of the potential pathogenic adaptation of P. infestans when maintained on a specific susceptible variety, and because of the known loss of pathogenicity when this fungus is cultured on artificial medium, fresh spores collected in the field from a wide spectrum of blighted clones offers an optimum range of pathogenic variability for screening of seedlings in the screenhouse. The successful culturing of Phytophthora on tuber slices may be useful in maintaining pathogenic heterogeneity; this technique will be further evaluated.

Late Blight Strategy

A Planning Conference sponsored by CIP was held at CIMMYT El Batan, Mexico during August 22-27, 1973. A position paper prepared by Dr. Vilhelm Umaerus served as a background for wide ranging discussions by 14 Conference participants from 8 countries. A comprehensive Report of the Conference edited by Dr. E.R. French, Head, CIP Pathology Department, has been published. Strategy recommended for the development, monitoring, and maintenance of sources of resistance to blight are detailed in the Report.

Wart (Synchitrium endobioticum)

Wart or Verruga was first described in Europe in 1896. Since that time it has been introduced from Europe into

North America, India, South Africa and New Zealand. The disease is probably indigenous to the Andes and has been reported from Peru, Bolivia, and Chile. Wart is favored by temperatures below 18°C during the growing season and by an annual rainfall of at least 700 mm; the greatest incidence in the Sierras occurs between 3,000 and 4,000 meters.

Since the 1940's races of Synchitrium have been identified in Germany, Newfoundland, Russia and India. The number of races reported as occurring in these locations varies, but some 16 have been claimed for Russia. It is essential that CIP develop a screening procedure to determine whether races of the fungus occur in Peru and also to evaluate "immunity" and field resistance to races likely to be encountered in developing countries.

Trial plantings of varieties used to differentiate races in Europe were made at Casa Blanca and Cuzco. The plants developed poorly with only a few tubers being produced under the short-day conditions in Peru. If European differentials are to be used in race determinations in Peru it is apparent that growing conditions must be modified to enhance tuberization. Alternatively, a new set of differentials which tuberize under Peruvian conditions might be developed, or resistance to races of Synchitrium evaluated elsewhere.

Using accessions in the germ plasm collection which were "immune" or field resistant in previous tests at Casa Blanca, a crossing program has been initiated to combine wart resistance with late blight and nematode (Heterodera) resistance. In addition, intercrosses between wart-resistant clones were also made. Some 150 crosses were successful and seed are to be planted in 1974 at CIP and also in Newfoundland for screening against the wart races occurring there.

At Santa Ana 110 flowers from 20 clones were emasculated and left unprotected to see whether pollinations would occur by natural means. No berries were obtained from any of the emasculated flowers and thus it seems that cross pollination may be of limited occurrence.

Rhizoctonia (R. solani)

This fungus may kill the tips of sprouts before emergence or cause cankers that girdle and kill sprouts. Tubers may develop in tight clusters and are small, numerous and misshapen; black selerotia commonly occur on the surface of tubers. Because of its widespread occurrence and destructive nature Rhizoctonia is one of the most important fungal disease of potatoes.

In recent tests at CIP, only 4 isolates of 240 tested were found to be pathogenic to both seedlings and mature plants grown from tubers. An additional 300 isolates are being tested. If a good correlation can be established between seedling and mature plant testing, mature plant testing can be minimized. At present, the different types of mature plant resistance observed in S. spegazzinii and S. vernei are being evaluated.

Variability resulting from heterocaryosis and sexual recombination permits ready adaptation of R. solani to changes in environment and, potentially, to overcoming host resistance. Since the formation of new heterocaryotic combinations is dependent upon hyphal anatomosis, hyphal compatibility studies have been initiated. A technique has been devised which permits observations on the frequency of anatomoses and assessment of the relative compatibility of selected isolates.

Smut (Thecaphora solani)

This extremely destructive disease, also referred to as "gangrena" and "buba", results in up to 80% of crop loss. First discovered in Venezuela in 1932, it has since been reported in Peru, Bolivia, Ecuador, Colombia, Panama, and Mexico. The fungus attacks *Solanum tuberosum*, *S. andigenum*, *S. stoloniferum* and *S. goniocalyx* resulting in the formation of black masses of chlamydospores in tuber tissue. While smut was originally thought to be confined to the cool regions of the Sierras, it is now well established and of epidemic severity in the warm, irrigated coastal region of Cañete, Peru.

The chlamydospores of *T. solani* are believed to persist for many years in the soil. To minimize introduction of the fungus into experimental plots of CIP, a rigorous set of sanitation procedures has been devised. The Ministerio de Agricultura, Peru, has been advised of these procedures and encouraged to adopt practical sanitation regulations.

CONTROL - BACTERIA

Bacterial Wilt (*Pseudomonas solanacearum*)

This disease limits potato production wherever it is present in tropical and subtropical regions of the world. To increase the range of adaptation of the potato to warmer areas, breeding for resistance to *P. solanacearum* offers the only known practical method of control. In certain areas "low temperature" strains of the bacterium are a serious threat even at latitudes several thousand feet above the 4,000 - 6,000 foot normal range of the pathogen.

High levels of resistance have not been found in *Solanum tuberosum*, although some clones are less susceptible than others. The discovery that certain Colombian clones of *S. phureja* have a high degree of resistance to three isolates of P. solanacearum suggest that this species of potato might contain sources of resistance to all known strains of the pathogen. Genetic studies indicate that wilt resistance is inherited through a series of dominant genes that are easily transferred. To facilitate genetic studies through a more rapid screening procedure, a technique for the root inoculation of seedlings has been developed.

The Development of Potato clones with Resistance to Bacterial Wilt (Pseudomonas solanacearum) - Wisconsin Contract Project.

Resistance to isolates K60 and S123 of race 1 is controlled by three dominant and independent genes in S. phureja. In order to determine the mode of inheritance to a race 3 isolate, six parental clones and 16 hybrid families of S. phureja have been tested by stem inoculation with isolate S206.

A high level of resistance was demonstrated by four of the parental clones, 1386. - 12, - 15, - 22 and - 26. One clone 1388. 30 exhibited an intermediate level of resistance and clone 1339. 28 was completely susceptible.

Distribution of disease index ratings among segregating progeny in the 16 hybrid families tested were generally bimodal, i. e. most individuals tended to be either very resistant or very susceptible. Resistance in S. phureja to the race 3 isolate S 206 was not inherited in the same manner as resistance to race 1 isolates. The low incidence of resistant individuals in both R x R and R x S hybrid families, despite the high level of resistance exhibited by parental clones, suggest that more than 3 genes are involved. It is apparent that resistance to race 3 of P. solanacearum evolved independently of resistance to race isolates.

Work completed in 1972 indicated that the concentration of a partially purified bacterial inhibitor from tubers of five clones of S. phureja and S. tuberosum was not related to levels of resistance to P. solanacearum. However, inhibition by crude extracts was correlated to resistance levels in the same Solanum clones. Research is continuing in an attempt to determine whether more than one inhibitory compound is present in crude extracts. Based on NMR and mass spectral data, a cyclic terpenoid has been proposed as one of the inhibitors. A knowledge of the specific inhibitors involved would be extremely useful in guiding a breeding program for resistance to bacterial wilt.

A seedling inoculation test has been developed to select wilt-resistant clones from large seedling populations. From progenies of crosses of wilt resistant x late blight resistant parents selected by seedling inoculation, 11 clones out of 90 had superior resistance in the field in Costa Rica in 1973. Tests at Cartago, C.R., included plantings for late blight exposure at 3,200 m, and sampling of bacterial wilt resistance at 1,400 m. Field tests at 1,400 m gave the highest late blight incidence and adequate tests levels of bacterial wilt. Eight clones that combined resistance to blight and bacterial wilt were selected in the field. Three clones, MSIE-7, MS18-4, and MS35-22 had adequate combined resistance, good tuber type and acceptable yields. These and several other clones are being increased at high elevations for additional tests. In Peru, clones that have high levels of bacterial wilt have been increased for broad-scale testing for adaptation prior to release. In all, 12 countries are now known to be using the phureja source of resistance.

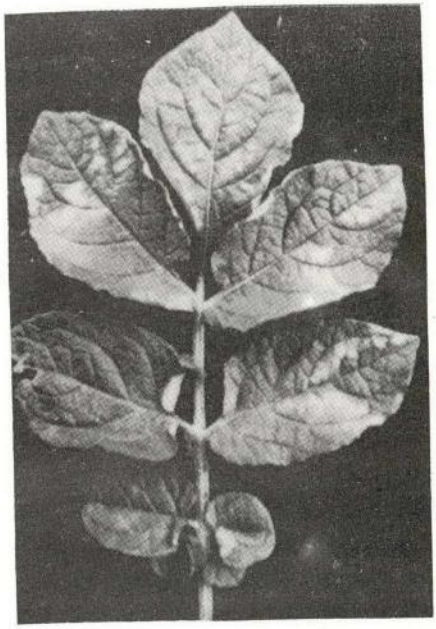
CONTROL - VIRUSES

One of the most immediate objectives of CIP virus research is to free selected clones of viruses, insofar as this is feasible. Late in 1973 a program was initiated to produce "virus-free" meristem cultures, under the conditions of limited equipment then available. Meristems were cultured in solid media (Morel and Muller modification) supplemented with gibberellic acid. In preliminary trials meristems were successfully cultured and after 8 weeks contamination levels were relatively low (15%). The use of meristem culture techniques, with and without heat treatments prior to meristem excision, will be one of the principal methods used in producing certified seed stock.

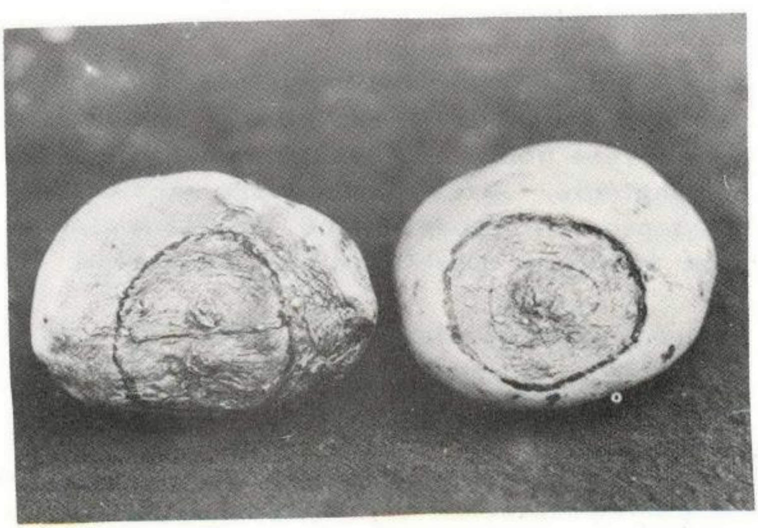
The indexing of selected clones for virus and the multiplication of "virus-free" material is an important function relative to the distribution of seed stock by Outreach. In December, several Peruvian cultivars from basic seed were planted ready for indexing and "virus-free" stock of the Peruvian variety Ccompis (freed from viruses by meristem-tip culture) is being multiplied. Tubers in storage awaiting indexing include Synchitrium - and Phytophthora-resistant lines imported from Germany. CIP also has "virus-free" tubers of several varieties from Scotland which give a characteristic reactions to soil-borne viruses; these are awaiting multiplication.

Initial work is well in hand on a number of specific potato viruses including: potato spindle tuber virus (PSTV); andean potato latent virus (APLV); potato leaf-roll virus (PL RV); potato virus X (PVX); potato virus Y (PVY); potato virus S (PVS), as well as a new virus, SB-4.

PSTV Although hardly any potato plants with spindle tuber-like symptoms have been seen in recent visits to the Sierra of Peru, symptoms of this virus in po-



Potato Mop Top virus



PMTV (?) in tubers

tato vines are often obscure. Some tuber material that may be infected with PSTV has been collected and two isolates (mild and severe) of PSTV have been obtained (from North America) to use for comparison with any andean isolates we may obtain in the future. Upon receipt of seed of the best indicator species Scopolia sinensis screenhouse work will be initiated.

APLV An isolate which appears to be APLV has been obtained from the Cuzco region of Peru. Chenopodium amaranticolor is to be tested as an indicator host for APLV.

PLRV Symptoms are well known in potato plantings on the coast of Peru and reach their highest incidence in the region of Tacna where Solanum tuberosum is grown. PLRV-like symptoms sometimes occur in the Sierra, particularly in varieties such as Ticahuasi.

PLRV has been transmitted from Ticahuasi plants grown from tubers collected in the Sierra to Physalis floridana using aphids (this requires confirmation). Other experiments are in progress.

In recent visits to the important potato seed growing area of Huasahuasi in the Sierra, leaf and tuber samples were collected from plants with leaf roll-like symptoms. A few clones were seen with PLRV-like symptoms in a part of the CIP germ plasm collection; tubers of these have been requested.

Some material with PLRV resistance has been received from Germany which will be evaluated under Peruvian conditions.

PVX About 2,500 clones from CIP germ plasm were evaluated by indicator hosts and serology to detect infection by these two viruses. PVX were found in ca. 60% of the clones and PVY in 68%. The PVY-free clones were planted in a field in Arequipa to record field transmission. Only 500 PVX-free clones were planted in a field in Huancayo for inoculating with two strains of PVX (X_3 and X_4 from C. Fribourg, U. S. A.). 350 clones previously tested have been again included in this experiment to determine the consistency of the results obtained. Twenty clones were separated for inoculating with strains of PVX because they remained free after 2 attempts to infect them.

PVY Five groups of strains were obtained from 168 isolations made in different places of Peru: H-13 (4.7%), CC-5 (18.4%), STR-T (61.3%), S-8 (12.5%) and V60394 (2.9%). The properties used to differentiate these groups were: Symptoms in N. tabacum "Samsun", transmission by aphids, physical properties of tobacco infected sap, serological reaction to a PVY antiserum, cross-protection tests and symptoms in potato cultivars. STR-T, which is the most frequent strain in the potato crops, is not transmitted by aphids in controlled conditions.

CC-5 represents a tobacco veinal necrosis strain of PVY and it is found widespread in the south of Peru.

H-13 seems to be an intermediate between CC-5 and S-8 because it shares some properties of both.

V60394 was found only in 5 samples (3 of them S. immite, 2 unidentified); the symptoms in S. immite are lamina-like enations on the leaves.

S-8 has the properties of the PVY (common str.) reported in the literature.

PVS and SB-4

Isolates from different samples of potato plants showing symptoms of virus S have been collected from different localities in the Sierra. Tubers of some plants from the germ plasm collection showing symptoms of virus S, have been requested.

New isolates of SB-4 were obtained from the variety Antarki growing in Huasahuasi. Their host range was studied 5 times in different weather conditions of the year. Species in the family Leguminosae, Chenopodiaceae, Solanaceae and Amaranthaeceae were local and systematically infected.

New determinations of physical properties gave the following results:

Dilution-end point:	10^{-3} to 10^{-4}
Thermal inactivation point:	65 - 70°C
Longevity in vitro:	3-4 weeks

Correlations made by testing field samples show that the main symptom SB-4 causes is yellowing and small necrotic spots on the leaves.

Electron micrographs obtained by Dr. B. D. Harrison (Scottish Horticultural Research Institute) and in the Hospital del Rimac, Lima, show isodiametric particles ca. 30 mm in diameter.

These viruses resemble those of the NEPOVIRUSES group but serological tests in agar or liquid failed to show any relationship.

There are studies under way to assess the possible viral origin of "cork disease" of potato. Attempts at isolation of virus directly from cork-affected tubers and from the roots of weeds collected from cork-infested land, have so far met with little success. However, a virus which resembled in some properties RNA isolates of tobacco rattle virus (TRV) was isolated from plants grown from cork-affected-tubers, but not from plants grown from normal-looking ones of several local varieties. There appears to be a direct correlation between occurrence of cork disease in a field and presence of Trichodorus, the vector of TRV. Also when maize or wheat precede potatoes in infested fields the incidence of cork disease is very high, which could be because maize and wheat are very good hosts of Trichodorus.

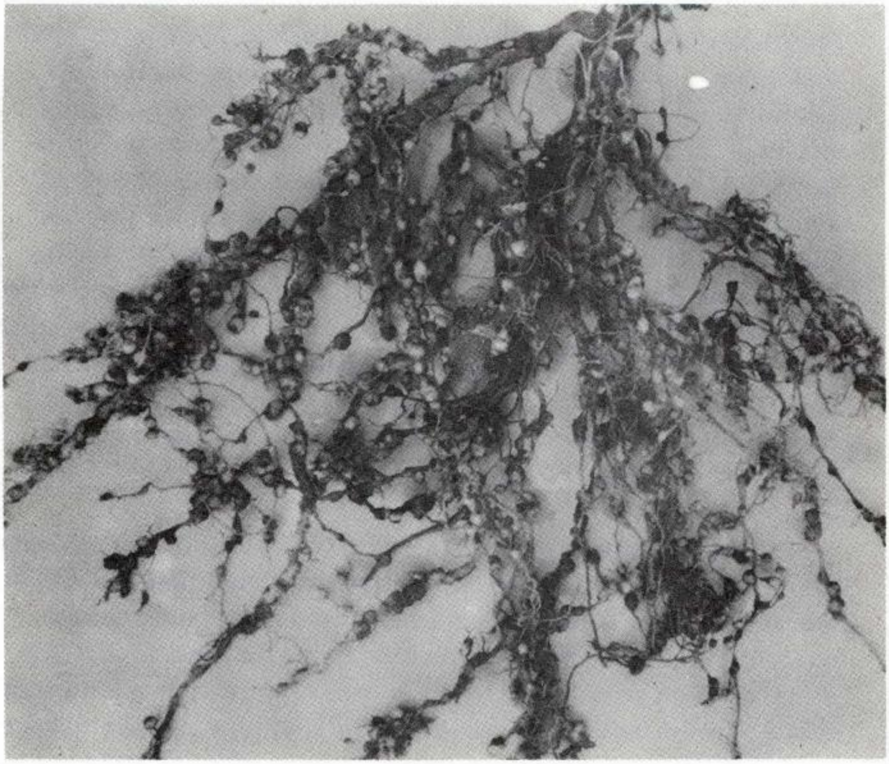
Potato mop-top virus (PMTV) is another possible causal agent of cork disease in addition to TRV. So far, PMTV has been isolated from leaf/tuber material from Junin, Apurimac and Cuzco. In the zone at Huasahuasi where cork-infested land occurs, PMTV was found in the soil (7/9 of the fields tested) and PMTV symptoms were common in the potato plants (in one instance 25%). However, not all cork-infested fields are infested with PMTV.

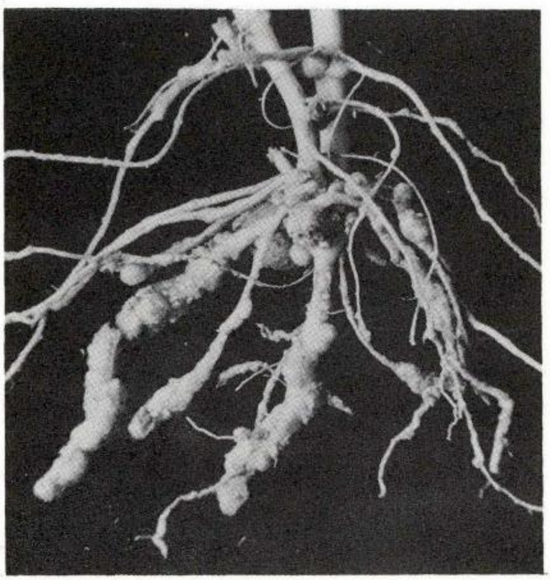
At the present, 2 field experiments are in progress at Cuzco and many soil and tuber samples have been accumulated from different localities in the Sierra ready for screenhouse tests.

CONTROL - NEMATODES

Cyst Nematodes (Heterodera rostochiensis; H. pallida)

During a 6 month period over 200 collections were made of which 115 were cyst-positive. Some 50-60 positive collections are to be evaluated at Rothamsted, England, relative to population composition with different degrees





Damage to potato roots by Nacobbus (upper) and Meloidogyne species of nematodes of geographical isolation. In the field, if the crop is of the correct maturity, it has been possible to distinguish between the two species of Heterodera. Throughout Peru, north of Lake Titicaca (and probably Ecuador and Colombia) H. pallida is the dominant cyst nematode. There are sporadic occurrences of H. rostochiensis - 2 fields in Colombia, some fields near Arequipa and several fields south of Puno near Lake Titicaca. To the south of the Lake, there are larger numbers of H. rostochiensis, although H. pallida still appears to predominate. Since approximately two thirds of all European infestations are H. rostochiensis, the predominance of H. pallida in areas of Peru and Bolivia that have been surveyed is an interesting contrast.

A Canonical Variate analysis of morphometric data on 3 pathotypes from the two cyst species was run on the Rothamsted computer in December. This showed that the best characteristics for separating rostochiensis from pallida were stylet lengths of adult males and females; and, stylet length, head width and length, and tail width at the anus of larvae (with female stylet length the best). A small morphometrics study of four CIP test populations and two populations representative of British "A" and "E" pathotypes was carried out using only the best characteristics selected by C. V. analysis. Two groups were identified: Puno grouped with British "A" (H. rostochiensis) and the others grouped with British "E" (H. pallida). However, there was some variation between populations, e. g. the stylet length of Puno larvae was 1.62 μ greater than that of British "A", and the difference between British "A" and "E" pathotypes was only 3.06 μ. In a preliminary electrophoretic study of water-soluble protein band patterns, a British H. pallida population produced different protein patterns than two Peruvian H. pallida populations. The two Peruvian populations, one from Otuzco and the other from Huancayo, produced different electrophoretic patterns from each other.

During 1973 in two tests, 900 clones were screened against four cyst nematode populations. One clone of S. raphanifolium (2n=24); 3 clones of S. acaule (2n=48); and 1 clone of S. sparsipilum (2n=24) have resistance against the four Andean pathotypes of potato cyst nematodes tested. Following a further confirmatory test these species will be used in crosses with cultivated species.

Studies have also been made on the role of tolerance as distinct from resistance, to potato cyst nematodes. In spite of nematode attack, 90 clones, which were planted in 12 hill plots in a heavily infested field at Chocon (Jauja), outyielded Renacimiento by as much as 5-fold. (In the absence of nematodes, Renacimiento, would normally outyield these selections). Accessions G-0171, G-1330, and G-2115 showed outstanding tolerance to natural levels of cyst nematode infestation.

Root-Knot Nematodes (Meloidogyne sp.)

In a preliminary taxonomic identification made in November at La Molina, M. incognita and M. hapla were found in a 4:1 ratio, respectively. A planting at San Ramon of 57 clones showed only very minimal and sporadic galling in 9 clones. This was probably due to the high soil moisture at this jungle site which inhibited penetration of root-knot nematodes.

A study has been initiated to determine the importance of the false root-knot nematode (Nacobbus sp.) to potato culture in Peru. These nematodes have a wide host range-onion, lima bean, corn, oats, peas, etc.; it is not known whether the species which attack potatoes also attack other crops. Microscopic examination of Nacobbus collected near Puno indicate that the specimens are morphologically different from N. dorsalis and N. aberrans, the two valid species of this genus.

Max - Planck Institute - Dr. Hans Ross

Botanical seed of 12 families which were second and third backcrosses to Solanum oplocense which has resistance to H. pallida were sent to CIP from the Institute. Tubers were obtained from seedlings and these were screened in Huancayo in January-March, against nematodes from Huancayo. Only two families showed resistance in two tests. These will be retested in January, 1974, with different populations of nematodes and if resistant they will be incorporated into breeding programs.

U. S. D. A. Breeding Program - Dr. R. Webb

332 tubers were obtained belonging to four families derived from S. vernei. These were tested in October, 1972, at La Molina and the resistant selection again tested in August, 1973, at La Molina. Fifteen clones have given resistant readings during two consecutive years. These will be retested with different populations of nematodes and those clones showing continued resistance will be incorporated into breeding programs.

ADAPTATION TO STRESS

Although the potato is widely grown in tropical and subtropical regions, the absolute limits of environmental stress under which an economical crop of potatoes can be grown are unknown. Some environmental factors which may cause destructive physiological stress in potatoes include still undefined limits of cold, heat, drought, toxic soil conditions, altitude (re: ultraviolet tolerance, O_2 tension) and insect predation. The first and last of these factors have been selected for special study by CIP.

Cold Hardiness

Frost is a major factor limiting potato production in the Andean region of South America and northern India. Since a number of Solanum species exhibit marked cold tolerance a project was initiated by CIP in 1973 to breed plants having increased cold tolerance along with several other selected agronomic improvements. Selections of S. acaule, S. commersonii, S. multidissectum, S. chomatophilum, S. vernei and other species brought from Sturgeon Bay are being crossed with several cultivated Peruvian varieties and species including S. andigena and S. stenotomum. Research is underway to establish whether the relative hardiness of excised leaflets reflects accurately the relative cold hardiness of whole plants, as well as to verify that significant acclimation does not occur to the extent so as to invalidate relative cold hardiness ratings.

The conductivity of electrolytes leached from injured cells after exposure to a freezing temperature was used to evaluate resistance to low temperature stress.

Prior to freezing tests 20 x 200 mm test tubes, weighted to maintain a vertical position, were equilibrated at 0°C for 2-3 hours in a low-temperature bath. Two sample leaflets were placed in each chilled test tube and held at 0°C for at least one hour before lowering the bath temperature to -0.5°C. Thirty minutes after the bath temperature had reached -0.5°C, leaflets were "inoculated" by touching with a very small piece of wet cheesecloth.

Each tube was held for at least 30 minutes at a given freezing temperatures. The freezing temperature profile of a clone was determined by exposing a series of leaflets of the clone to a temperature range of -2.0 to -6.0°C at -0.5°C increments. Following rewarming at 0°C for at least one hour, leaflets were transferred individually into flasks containing 100 ml of distilled deionized water for collecting electrolytes.

Electrolytes were collected by shaking flasks for one hour at room temperature. After removal of a leaflet, the conductance of electrolytes was measured by a conductivity bridge. Subsequently leaflets were completely killed by placing them on a block of dry ice or in a deep freeze for at least one hour and, again, the electrolytes were collected in their corresponding flasks. The conductance was determined again after removal of the dead leaflet.

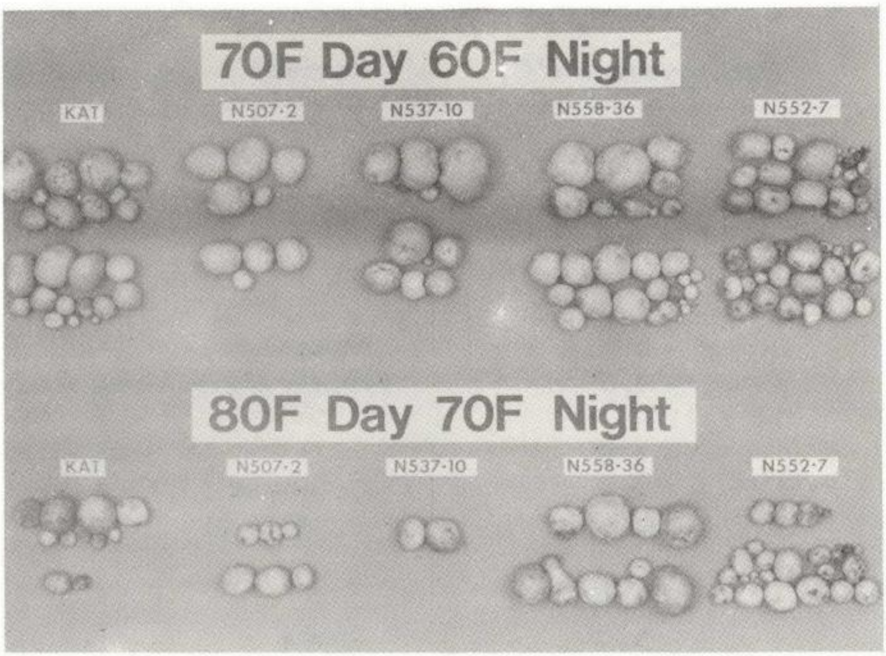
Percent leaching, that is:

$$\frac{\text{Conductance of leachate after freezing}}{\text{Conductance of leachate after killing}} \times 100$$

was a quantitative index of freezing injury. Normally an index of 50% is indicative of a killing temperature.

Prior to quantitative measurements of killing temperatures, preliminary experiments were conducted to determine the influence of water stress on cold hardiness. Month-old plants of several varieties of potato were stressed by withholding water until wilting of lower leaves was apparent. No effect of water stress on the level of cold tolerance was observed in comparison with water-stressed and control leaves of the varieties tested. In another series of experiments it was also determined that there was no significant difference in cold hardiness in comparisons of young and old leaves.

Potato plants of two varieties were grown at three contrasting field sites to determine the effect of location on cold hardiness. At the Chicala field air temperatures ranged between 10-15°C during the day and 4-7°C during the night. In contrast, at La Molina, during the growing season day temperatures ranged between 20-24°C and night temperatures 11-15°C. The temperature range at Matucana was intermediate. Despite the variables normally encountered in such field experiments, the survival



Yield of single plants of four andigena clones and Katahdin in growth chambers, 12-hour days temperature of Antarki and Ranrahirca leaves was above -3.5°C at all three locations.

Survival Temperatures of Some Commonly Grown Potato Varieties in Peru

Temperature (°C)	Variety	% Leaching
* - 2.0		25.9
- 3.0	Mariva	56.1
- 4.0		100.0
- 2.5		10.8
* - 3.5	Huagalina	17.8
- 4.5	(89.1% H_2O)	61.2
- 4.0		22.3
* - 4.5	Ccompis	21.5
-5.0	(90.4% H_2O)	71.1
- 4.0		35.9
* - 5.0	Rucki	37.1
- 6.0		54.6

* Survival temperature of specific varieties. Rucki is a "bitter" potato variety.

The native people in the Andes have selected a long time ago the "papas amargas" to make chuño. These potatoes are frost resistant and have originated from primitive species S. ajanhuiri (2n=24), S. juzepczukii (2n=36), S. curtilobum (2n=60). Selections of more resistant clones are being used in crosses to diploid and tetraploid clones.

Initial trials to select potato genotypes adaptable to hot humid tropical conditions have been conducted at San Ramon. Of 56 clones evaluated N503-93 gave superior yield (710 grams/hill).

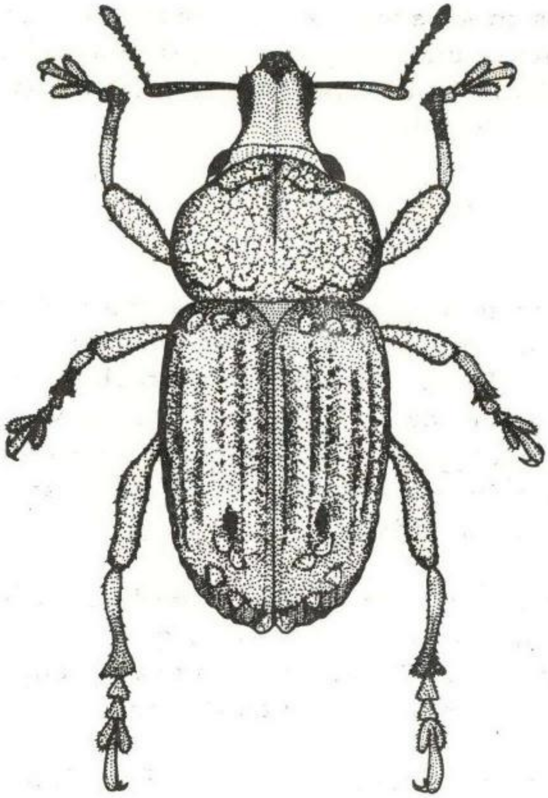
Entomology

An active entomology program was started in 1973, aimed initially at obtaining an inventory of insects destructive to potatoes in Peru. An extensive collection of potato insects has been made. The Andean weevil, Premnotrypes suturicallus, and leafhoppers are potentially very serious pests in experimental field plots at Huancayo and San Ramon, respectively.

Attention has also been directed while making field sweeps at collecting and identifying naturally occurring parasites and predators. The following numbers of six species have been collected at Huancayo and Casa Blanca:

Winthemia sp.	45	Huancayo
Prosopochaeta setosa	18	"
Incamyia sp. I	16	"
Incamyia sp. II	21	Casa Blanca
Eriopsis connexa	8	Huancayo
Blenmies sp.	4	"

The aphid, Myzus persicae, an important vector of PVY, PVS, and potato leaf roll, also frequents plants other than potato, which serve as alternate hosts. Surveys have been made to determine the species of plants serving as alternate hosts of M. persicae as well as other potato infesting aphids in the Mantaro Valley. At present 388 slides of at least 20 different species of aphids have been prepared and are being identified. Pressed specimens of host plants are being identified in collaboration with the Agrarian University of Peru.



The Andean Potato Weevil - adult, larvae and pupae

Research was initiated in the screenhouse at La Molina, in November, 1973, to assess the interrelationships between the physiological state of the potato plant and populations of M. persicae relative to cold, drought, soil salinity and disease stresses on the host. Apterous forms of M. persicae are being used.

PROTEIN YIELD

The potato is one of the most important food crops in the world. Per hectare it possesses greater food value than the cereal crops. In the production of dry matter content, per hectare, it is superior to legumes and is only exceeded in this respect by corn to the extent of about twenty percent. Nutritionally the potato is probably the best balanced of the major food crops in that it provides calories and nitrogen in proportion to human requirements, as well as adequate levels of a number of vitamins.

Through an intensive week-long Planning Conference held in November, 1973, a rigorous set of guidelines was established to assay potato protein, qualitatively and quantitatively. Routine analyses are being made of 80% ethanol-extractable non-protein nitrogen (35-60% of total tuber nitrogen); Kjeldahl nitrogen; total protein; and, percent moisture.

Simple methods for the approximate determination of soluble protein in potato tubers are being examined by Dr. G. E. Hoff of Purdue University. Because of the large number of clones to be evaluated for protein content, it is important that determinations be rapid, inexpensive, and relatively free of personal errors. A press juice method, whereby the refractive index of potato (tuber) juice is expressed in terms of percent sucrose equivalents and geometrically equated as an expression of soluble protein, has been found to correlate well with the Lowry method.

Analyses of Amino Acids in Peruvian Varieties

	Chata Blanca de Huasahuasi 702514	Ccompis	Pinaza 702445	Huagalina	Ruckii 702444	Renacimiento 720026	Ticahuasi 720019
CM cyst?	.932	.972	1.439	.745	1.212	.660	.959
asp acid	2.186	3.598	5.203	2.700	5.984	5.121	3.541
threo	.818	1.397	1.868	1.089	2.216	2.010	1.391
serine	1.306	1.937	2.328	1.372	2.399	2.455	1.838
glut acid	1.044	2.170	2.833	1.836	3.882	4.082	2.309
pro	.616	1.051	2.131	1.157	2.128	1.931	1.604
gly	1.020	1.441	1.877	1.098	2.038	1.870	1.415
ala	.943	1.453	1.754	1.148	1.824	1.957	1.272
1/2 cyst	-	-	.209	.080	.258	.181	.047
val	.401	.715	1.224	.723	1.554	1.395	.955
meth	.457	.630	.806	.453	.821	.770	.602
iso	.261	.067	.933	.567	1.136	1.061	.674
leu	1.565	2.518	3.489	1.916	3.969	3.445	2.389
tyro	.568	.984	1.345	.690	2.145	1.908	.971
phenyl	1.613	2.034	2.620	1.413	2.670	2.324	1.958
hist	.316	.410	.655	.527	.685	.805	.629
lys	1.254	1.928	2.813	1.577	3.370	2.776	2.235
arg	.808	1.316	1.821	.961	2.447	1.826	1.793
AA total mg/gm	16.108	24.62	35.348	20.052	40.738	36.567	26.581
Total % Potty protein	4.35	4.54	4.86	2.78	4.49	4.21	3.24
*Total Protein (% dry Wt.)	4.40	4.58	4.97	3.05	4.92	4.59	3.96

*Kjeldahl determination after removal of non-protein-N by 80% ethanol.

A close correlation has been established between total protein by Kjeldahl determination after removal of non-protein nitrogen by 80% ethanol and total protein assayed by the Potty method by Dr. Sharon Desborough, University of Minnesota. Protein determinations have been made on 20 native cultivars from Bolivia, 60 from Peru, and 20 hybrids.

Protein Content, Clones Grown in Huancayo

	True Protein (% dry weight)*		
Source of Clones	Maximum	Minimum	Mean
Bolivia	8.76	3.96	5.80
Peru	11.86**	3.76	6.03
Hybrids	11.73***	4.53	6.12

* True protein: Protein nitrogen x 6.25. A more precise factor for potato protein is 7.50. Mean moisture content, 75.7%, after 4 months storage.

** Accession No. 1088

*** Accession No. 20013

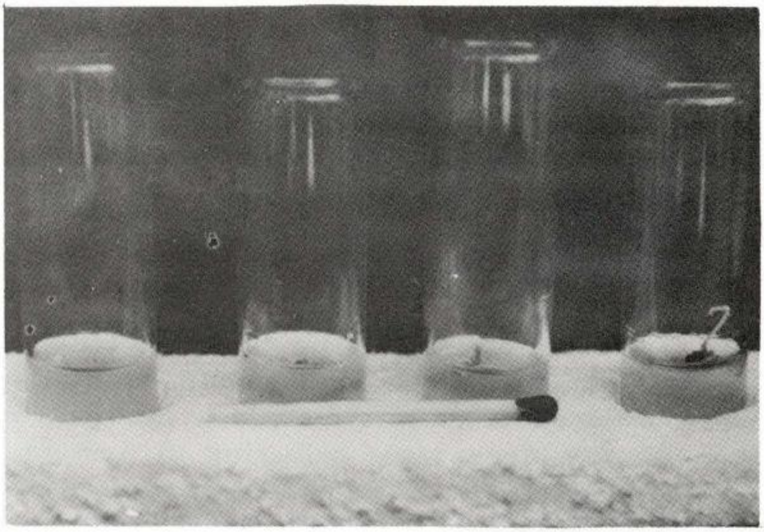
In comparisons with certain animal proteins, potato protein tends to be somewhat deficient in the sulfur-containing amino acids particularly methionine. Fortunately, there appears to be no negative correlation between methionine levels and yield. A very high heritability of methionine has been observed: in 320 tetraploid clones, "available" methionine varied between 0.9 and 2.2% of total tuber nitrogen x 6.25, or from 94-282 mg per 100 g dry matter. Amino acid analyses of several Peruvian varieties indicate a wide range in methionine levels (45.3 -80.6 mg/100 gm) in Andigena clones, encouraging the hypothesis that methionine levels can be improved by selective breeding.

Techniques have been devised to estimate the Relative Nutritive Value of potato protein by rapid, inexpensive biological assays. Enzymatic digestion coupled with a microbiological assay using a highly proteolytic strain of *Streptococcus zymogenes* has proven to be an extremely useful analytical technique for methionine. "Available" methionine assayed with *S. zymogenes* agreed very well with chick ($r = 0.97$) and rat ($r = 0.92$) assays. Promising results were also obtained by Dr. R. Luescher in a microbiological assay of cystine with *Clostridium perfrigens*. This bacterium has almost the same amino acid requirements as the rat, providing an assessment of human nutritional requirements through available correlative rat data.

An increase in the sulfur-containing amino acids is especially important because the food legumes and the new yeast protein grown on oil are very low in these amino acids. An increase in the sulfur-containing amino acids is at least equal to an increase in protein quantity; less dietary protein can be augmented by improved protein quality.

SEED PRODUCTION

There are two principal objectives in clonal certification by CIP: 1. To produce seed of varieties, clones and tuber families possessing characteristics of value to be sent to developing countries for resistance and adaptability studies in a relative pathogen-free state that conforms with the import regulations of a specific country.
2. To produce seed of good quality for CIP research projects in Peru.



Meristem culture - the way to clean seed

Seed storage

Commencing in late 1973 several Peruvian cultivars from basic seed were planted ready for indexing and seed of the variety Ccompis is being multiplied. Initial seed to fulfill Outreach objectives is being indexed to confirm resistance to wart, late blight and several virus diseases. CIP also has tubers from Scotland awaiting multiplication which produce plants having characteristic reactions to soil-borne viruses. A range of clones having resistance to late blight and good yield potential are available from CIP-Toluca for immediate use.

Facilities for meristem and tissue culture were being installed in December, 1973. In October, meristem cultures were initiated on a limited scale to test procedures in preparation for large-scale culturing of meristems. Meristem cultures are to be used as a routine procedure for freeing potato clones from viruses. Plantlets, derived from culturing meristem excised from selected clones, will be grown under quarantine condition to a size to permit serological and indicator plant tests to insure freedom from specific viruses. If proven free of viruses, plants will be further propagated under rigidly controlled conditions for subsequent distribution and multiplication.

OUTREACH

The basic objective of Outreach is to implement the goal of CIP to raise the productivity of developing countries where need and opportunity are the greatest. To achieve a production break-through in developing countries Outreach personnel are working with national leaders to create a capacity in selected countries to utilize the technology developed by the Center. In 1973 the philosophy and strategy of the Outreach program was outlined in a draft paper which will serve as the initial guideline for future development of the Outreach program.

For its regional approach in Outreach, CIP had divided the world into seven zones which are:

ZONES AND SELECTED IMPACT COUNTRIES

I South America - Peru, Brazil, Chile, Ecuador, Bolivia

II Mexico, Central America and the Caribbean - Guatemala, Costa Rica

III Tropical Africa - Kenya, Nigeria, Ethiopia

IV Middle East and North Africa - Algeria, Lebanon, (Egypt-training centers)

V Non-Arab Muslim countries - Turkey, Pakistan, Iran

VI India - States of Punjab, Uttar Pradesh, Nepal

VII Southeast Asia - Sri Lank, Indonesia, Bangladesh

Trainees on two continents - Mexico and Kenya

By the end of 1973, CIP had Outreach staff members in Regions I, II and IV and held training courses in Regions I, II and III. Although CIP staff-members visited the other regions, no programs have yet begun in Regions V, VI and VIII. Selected impact countries are being, and will continue to be reviewed as CIP capabilities for assessment are expanded.

The program for zone I is headquartered at CIP's Central facilities in Peru. The program for zone II is in the Toluca Valley at the facility which was formerly The Rockefeller Foundation International Potato Program. The program for zone IV was activated in 1973 and is headquartered at the Arid Lands Agricultural Development Program in Lebanon.

Short-term Training Courses:

A major responsibility of the Outreach Program is training personnel to staff national potato programs. In 1973, the Outreach Program conducted the following training courses:

Region I - South America

The first course in potato seed production was held in Lima in January/March 1973. The six-week course emphasized practical training in the sierra as well as instruction at La Molina, in Physiology, Pathology, Entomology, Soil and Storage problems related to potato seed production.

In addition to regularly scheduled training courses, specialized training was offered to candidates from the Middle East (Algeria) and Bolivia. The trainee from Algeria spent three weeks in Peru on October for specialized training in Seed Production, Virology, Entomology, Bacterial and Fungal diseases. The trainee from Bolivia received specialized training in chromosome counting techniques and management of germ plasm collections. CIP Outreach personnel also collaborated with the Peruvian National Potato Program at La Molina in organizing training courses for farmers in Barranca and Cañete (April 1973). A large number of CIP staff participated in two major Peruvian potato production symposia. CIP's regional training officer helped develop and coordinate these symposia.

Region II - Mexico, Central America and the Caribbean (Mexico)

A course in potato production technology was held in Mexico in July/August 1973. The seven-week course was held in the Toluca Valley, Mexico State, with visits to the principal potato cultivation areas in Mexico. Furthermore, technical instruction at the Agricultural College at Chapingo was given on Virology, Mycology, Nematology. Special emphasis was given to seed production and on the development of potato varieties resistant to late blight. Seven trainees from five countries participated in the course: Mexico 2, Guatemala 1, Honduras 2, Cuba 1, Algeria 1.

Region III - Tropical Africa

CIP sponsored a short course in potato production jointly with the Kenya National Potato Program. Twenty-five trainees from seven African countries participated in the two-week course held in Nairobi. The Kenya National Potato Program, O.D.A. and CIP jointly provided the instruction for the course which emphasized varietal identification, disease control, seed production and potato quality. Plans are being finalized to activate this regional program in the first part of 1974 and place a CIP scientist in Kenya.

Formal Training Courses:

There are formal training programs at CIP at the Masters, Ph. D. and post-doctoral level.

A. Training leading to the Master Degree.

This is in conjunction with the National Agrarian University adjacent to CIP's facilities in La Molina. There were eight scientists entered in Master Degree training courses by CIP in 1973.

B. Training leading to the Ph. D. Degree.

This is in conjunction with institutions in developed countries where formal course work is accomplished with a major portion of the thesis work done at CIP facilities in Peru. There were five scientists entered in this type of training program with CIP in 1973.

C. Post-Doctorate Training.

There were seven newly trained Ph. D. scientists on post-doctoral appointments at CIP in 1973. CIP is using some post-doctoral positions to look at future young staff members, and to train scientists for possible regional assignments as the Outreach program is expanded.

The function of the socio-economic program is to provide information of a socio-economic nature in order to facilitate the successful operation of the various programs of the Center.

Working closely with the Outreach Staff, we are analyzing data on price levels and price fluctuations, market-ing and storage, nutritional levels, and farm management practices to determine the relative needs in the various countries of a CIP Outreach program of technical assistance, as well as the possibilities of achieving significant production improvement in those countries within a given period. The accumulation of knowledge concerning the needs in terms of scientific discoveries, as well as the possible economic and social benefits of these biological innovations will enable the economist to support the Director General of CIP and his Director of Research in their own determination of the research priorities in the Center.

The economics program, which only recently began operations in November of 1973, has tentatively defined two major areas for analytical work:

1) Outreach Support. - Analysis of consumption and price data, as well as FAO Food Balance Tables, to derive a picture of actual and potential importance of potato production in countries which may be recipients of Outreach Program. This is being supplemented by personal visits to the countries, and discussions with governmental, private enterprise, and academic personnel on these issues.

2) CIP Program Priorities.- Involves obtaining a thorough knowledge of the projects of the various departments, their costs and possible payoffs, and relating these to receipient country needs.

CONTRACT PROJECTS - 1973

CIP depends upon Contract Projects with Institutions where facilities and capabilities already exist to help solve priority potato improvement problems in developing countries. CIP had four Contract Projects in 1973, three of which were initiated prior to 1973 and one commenced in July 1973. Six additional Contract Projects were negotiated in 1973 to commence in 1974.

1. North Carolina State University - "Breeding and Adaptation of Cultivated Diploid Potato Species". F. L. Haynes, F. De la Puente.

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

3. University of Wisconsin - "Increasing Yield and Adaptation of Cultivated Tetraploid Potatoes". S. J. Peloquin.

   "The Development of Potato Clones with Resistance to Bacterial Wilt (*Pseudomonas solanacearum*)" L. Sequeira.

4. The Swedish Seed Association, Svalov, Sweden - "To Assist the International Potato Center in the Background Work Required for the Development of Late Blight Resistance in the National Potato Breeding Programs of the Developing Countries" - V. R. Umaerus, M. Umaerus.

NEW CONTRACT PROJECTS - 1974

The following Contract Projects were signed during 1973 to be initiated in 1974.

Netherlands: "Resistance Breeding Against the Potato Eel Worm, Heterodera rostochiensis" - C.A. Huijsman, Foundation for Agricultural Plant Breeding, Wageningen.

"A Breeding Program to Utilize the Wild Diploid Solananum Species of Mexico" - J.G. Th. Hermsen, l. v. P., Agricultural University, Wageningen.

"Potato Improvement in the Middle East and North Africa". H.P. Beukema, International Agricultural Center (I.A.C.), Wageningen.

Denmark: "Mapping the Location of Cultivated Potato Accessions in the Andean Region" - P. Hjerting, Botanical Gardens, Copenhagen.

Peru: "Environmental Physiology of the Potato" - U. Moreno, Universidad Nacional Agraria, Lima.

Mexico: "Breeding, testing and maintenance of haploid, diploid and tetraploid clones of Solanum species for resistance to Phytophthora infestans" - G. Pérez U., Centro de Investigaciones Agropecuarias . "Santa Elena", Toluca.

LIBRARY

April 1973 marked the beginning of CIP's library as a functioning part of the International Potato Center. The initial months were dedicated to deciding basic policies and ordering space-saving furniture.

In the initial stages of the International Potato Center, CIP committed itself in an agreement with the Government of Peru to establish a specialized potato library within its headquarters. The aims are to maintain a small current specialized potato library for the scientific staff and in the future to broaden the spectrum so as to serve as a documentation center for potato information.

Part of the task of a new library is that of establishing agreements and contacts to obtain and disseminate information as soon as possible. These contacts were made with the two local agricultural libraries: The National Agricultural Library which operates within the grounds of the National Agricultural University and the Experiment Station Library, both adjacent to CIP. These two libraries will compliment CIP's library by coordinating periodical and book acquisition. The Experiment Station Library primarily serves as a source for historical data and bulletins dating to the beginning of this century and for the retrieval of information concerning potato research in Peru. The National Agricultural library is the source of general current information and also storage of CIP library material that ceases to be current in a two-year period. CIP has been allotted a wing in the fourth floor of the National Agricultural Library for this purpose. It includes storage space and four medium size reading rooms for the staff. This wing will be furnished out of CIP funds and will operate as part of the Center's library. The National Agricultural Library will also aid in cataloguing CIP library material.

Initial contacts have also been made with several international institutions and sister Centers. Publication material has been exchanged and cooperating mechanisms have also been established.

Two bibliographies were compiled and distributed to regional institutions and several foreign ones which had expressed their interest in the progress of CIP's potato library.

By the latter part of 1973, CIP's library had 30 journals regularly received on a subscription basis and directly related to the Center's interest in potato research as well as 100 other periodicals of a general agricultural nature and that are not regular CIP subscriptions. A reprint file system was initiated and includes over 200 reprints directly related to potato information. Reprints have proven to be an effective way of maintaining and exchanging current information in a small library dedicated to the dissemination of potato information.

"AÑO DEL SESQUICENTENARIO DE LAS BATALLAS DE JUNIN Y AYACUCHO"

Price Waterhouse Peat & Co.

Las Begonias 441 - San Isidro
Lima - Perú
Correspondencia: Apartado 1434

April 25, 1974.

To the Board of Directors,
Centro Internacional de la Papa.

We have examined the balance sheet of Centro Internacional de la Papa as of December 31, 1973 and the related statement of resources and expenditures, budget performance and accumulated resources for the year as drawn up in Peruvian soles. Our examination of these statements 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. It was impracticable to extend the examination of donations received beyond accounting for amounts so recorded. In our opinion, such Peruvian sol statements (not submitted herewith) present fairly the financial position of Centro Internacional de la Papa at December 31, 1973 and the resources and expenditures for the year, in conformity with accounting practices generally accepted for non-profit organizations, applied on a basis consistent with that of the preceding year.

We have also examined the accompanying financial statements expressed in U.S. dollars. In our opinion, they present a fair and proper translation of the aforementioned local currency statements on the bases described in Note 1.

Price Waterhouse Peat & Co.

Countersigned by

E. Noriega
-----------------------------(partner)
Enrique Noriega del Valle
Peruvian Public Accountant
Registration No. 1142

CENTRO INTERNACIONAL DE LA PAPA

BALANCE SHEET (Note 1)

ASSETS

	At December 31 1973 US$	1972 US$
CURRENT ASSETS		
Cash	243,793	111,258
Accounts receivable from donors (Note 3)	2,175	50,000
Other receivables		
Advances to third parties for research work	4,057	6,784
Staff advances	11,075	2,255
Institute of International Education	-	13,823
Other	6,389	2,400
	21,521	25,262
Prepaid expenses	3,426	6,255
Total current assets	270,915	192,775
PROPERTY AND EQUIPMENT (Notes 2 and 4)	396,326	140,155
	667,241	332,930

LIABILITIES AND EQUITY

	At December 31 1973 US$	1972 US$
CURRENT LIABILITIES		
Accounts payable	74,486	26,283
Bank overdrafts	-	12,288
Institute of International Education, balance of remunerations payable to scientists and others	20,805	-
Accrued expenses	11,093	1,185
Total current liabilities	106,384	39,756
DEFERRED LIABILITIES		
Reserve for severance pay	11,642	3,344
GRANT RECEIVED IN ADVANCE (Note 3)	70,000	150,000
EQUITY (Note 4)		
Grants used for acquisition of property and equipment	396,326	140,155
Excess (shortage) of accumulated resources over expenditures	82,889	(325)
	479,215	139,830
	667,241	332,930

CENTRO INTERNACIONAL DE LA PAPA

STATEMENT OF RESOURCES AND EXPENDITURES, BUDGET PERFORMANCE AND ACCUMULATED RESOURCES (Note 1)

	For the year ended December 31,			
	1973			1972
	Actual	Budget	Over (under)	Actual
		(unaudited)	(unaudited)	
	US$	US$	US$	US$
RESOURCES				
Grants received (Note 3)	1,362,669			492,000
Other	1,129			-
	1,363,798	1,374,396	(10,598)	492,000
EXPENDITURES				
For operations				
Potato research program				
Pathology	200,100	182,322	17,778	79,179
Genetic and breeding	171,754	141,649	30,105	63,476
Nematology	23,339	50,335	(27,046)	10,049
Taxonomy	25,478	45,897	(20,419)	18,787
Physiology	29,920	51,154	(21,234)	-
Training and fellowships	289,196	321,257	(32,061)	63,244
Library, documentation and information	9,697	10,556	(859)	5,653
Service operation	93,604	107,595	(13,991)	14,717
Administration expenses	150,839	145,681	5,158	69,197
General operating expenses	30,486	28,600	1,886	27,868
	1,024,413	1,085,096	(60,683)	352,170
Grants used to acquire property and equipment (Note 2)	256,171	289,300	(33,129)	140,155
	1,280,584	1,374,396	(93,812)	492,325
Excess (shortage) of resources over expenditures	83,214	-	83,214	(325)
Excess (shortage) of accumulated resources over expenditures				
At January 1,	(325)			-
At December 31,	82,889			(325)

CENTRO INTERNACIONAL DE LA PAPA

NOTES TO THE FINANCIAL STATEMENTS

DECEMBER 31, 1973

NOTE 1 - ACTIVITIES AND ACCOUNTING POLICIES

The Centro Internacional de la Papa (CIP) was constituted in 1972, in accordance with an Agreement for Scientific Cooperation between the Government of Peru and the North Carolina State University, United States of America signed in 1971.

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

In accordance with existing legal dispositions and the terms of the Agreement described above, the CIP is exonerated from income tax and other taxes.

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

The principal accounting policies are as follows:

a) Resources and expenditures are accounted for on an accrual basis. In particular, operating grants are accounted for in the period indicated by the donor and, when grants are used abroad, the expenditure is accounted for on the basis of advices received.

b) Bases of translation

The books and accounts of the CIP are maintained in Peruvian soles. Because the draft exchange rate has been maintained constant since the inception of the CIP's operations in 1972, the financial statements have been translated into United States dollars at the draft exchange rate of S/43.38 to US$1.

c) Property and equipment are valued at cost and are not depreciated.

d) Severance pay is accrued in full

NOTE 2 - PROPERTY AND EQUIPMENT

The movement during 1973 of property and equipment is as follows:

	Balance at January 1	Acquisitions of the year	Balance at December 31
	US$	US$	US$
Constructions and buildings	46,395	24,704	71,099
Site development and installations	18,126	37,381	55,507
Research equipment	17,816	71,788	89,604
Field equipment	-	19,408	19,408
Furniture, fixture and office equipment	10,414	21,687	32,101
Vehicles	35,092	54,152	89,244
Other	12,312	27,051	39,363
	140,155	256,171	396,326

During October 1973, the CIP signed a contract with a construction firm to build an Operating Station in Huancayo, Peru. The building, which is expected to be completed by the end of 1974, is estimated to cost US$147,000.

NOTE 3 - GRANTS

The grants corresponding to 1973, are as follows:

	US$
Donors	
a) Received and administrated by the CIP	
Danish Internationl Development Agency (DANIDA)	225,000
Swiss Government	65,000
United States Agency for International Development (USAID)	340,000
Netherlands Government	180,000
Canadian International Development Agency (CIDA)	200,200
United Kingdom Overseas Development Administration (UKODA)	50,877
Swedish Government, received in 1972	150,000
	1,211,077
b) Received and administrated by other institutions for the development of potato programs	
Granted by the Rockefeller Foundation to:	
Centro Internacional de Mejoramiento de Maíz y Trigo de México (CIMMYT), including US$2,175 to be received in 1974	57,800
Doctor John Niederhauser in respect of salaries, travelling expenses and allowances corresponding to the period from January to June 30, 1973	23,991
	81,791
Amount spent through September 30, 1973 (as per statement of account) by Deutsche Forderungsgesellschaft fur Entwicklunslander (GAWI) of the funds granted by the German Government	69,801
	151,592
	1,362,669

The total of the grants indicated under b) have been applied to programs on accounts which are summarized as follows, and are shown forming part of the respective headings in the financial statements:

	CIMMYT US$	GAWI US$	Total US$
Pathology	24,063	40,627	64,690
Training and fellowships	55,552	-	55,552
	79,615	40,627	120,242
Acquisitions of property and equipment	-	29,175	29,175
	79,615	69,802	149,417
Add: Balance receivable at December 31, 1973	2,175	-	2,175
Total grants	81,790	69,802	151,592

During December 1973 an additional donation of US$70,000 was granted by the Swiss Government, to be utilized by the CIP during the year 1974.

NOTE 4 - EQUITY

The institution's equity at December 31, 1973 is represented by:

	US$	US$
a) Grants utilized in the acquisition of property and equipment		396,326
The movement for the year 1973 is summarized as follows:		
Balance at January 1	140,155	
Add: acquisitions	256,171	
Balance at December 31	396,326	
b) Excess of resources over expenditures		82,889
These funds are earmarked by the CIP in order to finance, during 1974, certain expenses budgeted but not paid in 1973.		
		479,215

THE INTERNATIONAL POTATO CENTER
Schedule 1: Funds Provided and Cost of Individual

Grants for the Year Ended December 31, 1973
(US Dollar)

	Received Grants	EXPENSES CHARGED Direct	Support Costs	General Operating	Total Expenses	Carry-over Unexpended Balance
Core Operations - Multi-purpose						
Sweden	91,292	64,239	25,160	1,893	91,292	
Switzerland	65,000	46,150	16,900	1,950	65,000	
Total	156,292	110,389	42,060	3,843	156,292	-
Core Operations - Unrestricted						
UKODA	50,877	36,123	13,228	1,526	50,877	
U.S. AID	340,000	229,260	96,334	14,406	340,000	
CIDA	200,200	142,142	52,052	6,006	200,200	
	591,077	407,525	161,614	21,938	591,077	-
Core Operations - Restricted						
Rockefeller Foundation	81,791	79,616			79,616	2,175
Germany	40,627	40,627			40,627	
Netherland	180,000	111,328	40,768	4,704	156,800	23,200
	302,418	231,571	40,768	4,704	277,043	25,375
Total Core	1'049,787	749,485	244,442	30,485	1'024,412	25,375
Capital Grants 1)						
Sweden	58,708	58,708			58,708	
DANIDA	225,000	168,289			168,289	56,711
Germany	29,174	29,174			29,174	
Total Capital	312,882	256,171			256,171	56,711
Total Grants and Expenses	1'362,669	1'005,656	244,442	30,485	1'280,583	82,086

1) The Danish/IDA and the Sweden grants were multi-purpose grants. The grant of the Danish and of the one of Sweden have been arbitrarily reclassified as capital grant to cover these funding requirements.

Schedule 2: Detailed Schedule of Earned Income for the year ended December 31, 1973

(US Dollar)

	Approved Budget	Actual
Source of Earned Income		
Insurance premiums & discounts		918
Contract fines		191
Exchange differences on accommodation		19
	-	1,128
Application of Earned Income		
Applied to Deficit prior year		325
Transferred to Retained Earnings		803
	-	1,128

THE INTERNATIONAL POTATO CENTER

Schedule 3: Comparative Statement of Actual

Expenses and Approved Budget for the Year Ended December 31, 1973 *

(US Dollar)

	Core Multi-purpose		Core Unrestricted		Core Restricted		Capital	
Programs	Approved Budget	Actual Expenses	Approved Budget	Actual Expenses	Approved Budget	Actual Expenses	Approved Budget	Actual Expenses
Research								
Potato		63,933		259,248		127,410		
Conference & Fellowship		45,282		141,322		102,593		
Library Documentation & Inf. Services		1,174		6,955		1,568		
Support Operations		42,060		161,614		40,768		
General Operation		3,843		21,938		4,704		
Total	156,292	156,292	591,077	591,077	302,418	277,043	-	-
Capital								
Farm Operating Equipment								19,408
Research Equipment								71,788
Furniture, Fixture & Office Equipment								21,687
Vehicles								54,153
Constructions & Buildings								24,704
Site Development & Installations								37,381
Other fixed Assets								27,050
	156,292	156,292	591,077	591,077	302,418	277,043	312,882	256,171
Analysis of Variances								
Budget Surpluses:								
Carried-over to 1974						25,375		56,711
Total	156,292	156,292	591,077	591,077	302,418	302,418	312,882	312,882

---

* Includes only amount received from donors toward CIP - 1973 approved budget.