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INTERNATIONAL POTATO CENTER

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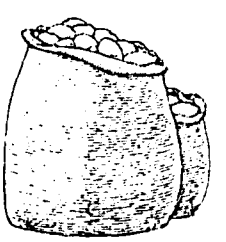

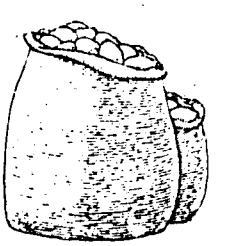

The International Potato Center is an autonomous, nonprofit, scientific institution dedicated to the development and dissemination of knowledge for greater use of the potato and other tuber and root crops as basic foods in the developing world. CIP was established in 1972 by agreement with the government of Peru and is supported by the Consultative Group on International Agricultural Research (CGIAR), whose members provide funding for international agricultural development. The CGIAR sponsors thirteen international agricultural research centers:

- *CIAT* • *International Center for Tropical Agriculture - Colombia*
- *CIMMYT* • *International Maize and Wheat Improvement Center - Mexico*
- *CIP* • *International Potato Center - Peru*
- *IBPGR* • *International Board for Plant Genetic Resources - Italy*
- *ICARDA* • *International Center for Agricultural Research in the Dry Areas - Syria*
- *ICRISAT* • *International Crops Research Institute for the Semi-Arid Tropics - India*
- *IFPRI* • *International Food Policy Research Institute - USA*
- *IITA* • *International Institute of Tropical Agriculture - Nigeria*
- *ILCA* • *International Livestock Centre for Africa - Ethiopia*
- *ILRAD* • *International Laboratory for Research on Animal Diseases - Kenya*
- *IRRI* • *International Rice Research Institute - Philippines*
- *ISNAR* • *International Service for National Agricultural Research - Netherlands*
- *WARDA* • *West Africa Rice Development Association - Ivory Coast*

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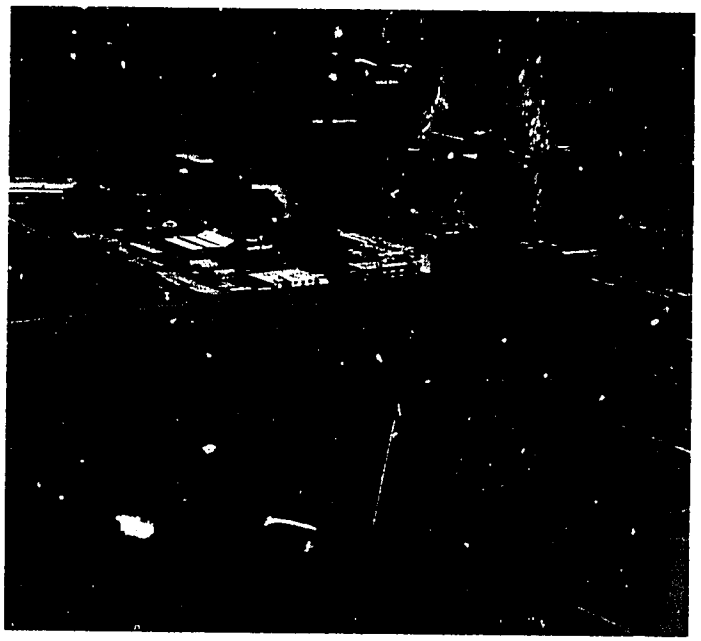
INTERNATIONAL POTATO CENTER

Apartado 5969 - Lima, Perú



In the late 1960's, the world's attention was drawn to the problems of population growth, inadequacy of food production, and limited availability of arable land. This growing concern was accompanied by the efforts of forward-looking scientists and agricultural policy makers to help in making high-quality food with improved production potential available to humankind, especially in areas of pronounced need. Potato was among the crops whose importance as a staple food in the developed world had been amply demonstrated. But it was the recognition of its tremendous potential in developing countries that led Richard L. Sawyer to initiate efforts to establish, in this crop's area of origin, a center of expertise for research on the potato. In 1971, an official decree was issued by the Peruvian government providing for the creation of an international scientific institution dedicated to research with potato and other tuber and root crops: the Centro Internacional de la Papa, or International Potato Center (CIP).

In 1972, CIP was invited to join the group of centers sponsored by the Consultative Group on International Agricultural Research (CGIAR), an informal consortium of more than 45 countries, international and regional organizations, and private foundations. The CGIAR was established in 1971 under the joint auspices of the International Bank for Reconstruction and Development (World Bank), the United Nations Development Program (UNDP), and the United Nations Food and Agriculture Organization (FAO). Its members pool their resources to support efforts aimed at improving the quantity and quality of food production in the developing world.

Through the CGIAR, close to 30 foundations, foreign aid agencies, international organizations, development banks, and governments contribute financially to CIP's ongoing research program, making it possible for this center to pursue its objective of helping to alleviate hunger and poverty in the world.

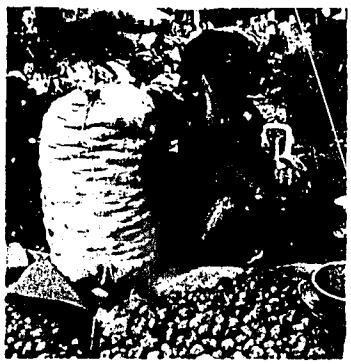
CIP's international staff includes nearly 100 scientists, administrators, and other experts from over twenty countries. In Lima, more than 500 supporting scientists, technicians, administrative personnel, clerical staff, and specialized laborers contribute to the center's operational activity.

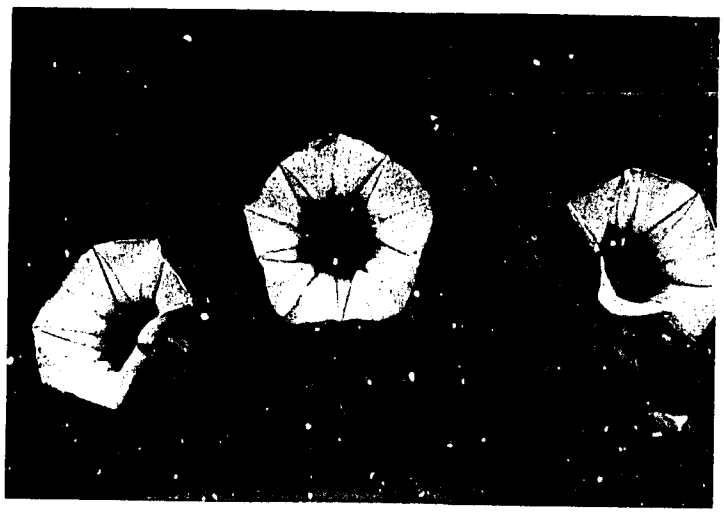
The potato (*Solanum tuberosum*) is one of mankind's most valuable foods. It produces more energy and protein per cultivated area and per unit of time than most other major crops, is fat-free, and contains substantial amounts of vitamins - especially B and C - and minerals.

This important vegetable originated in South America in the highlands of the Andes. It was taken to Europe in the sixteenth century by the Spaniards, where, aided by its easy adaptation to the climatological conditions of the temperate zones, it eventually became an important staple food. Technological advances in the developed world contributed to growth in potato production.

However, the potato is not only suitable for cultivation in the temperate climates; it also has great potential for adaptation to the diverse growing conditions of the tropics, where the majority of the developing countries are located. Nearly 3.5 billion people (3/4 of the world's population) inhabit the 95 potato-producing countries of the developing world. And though in recent years cultivation of this crop in the tropics has expanded more rapidly than that of any other food crop, the potato's potential has only begun to be exploited.

Aside from reducing production constraints in traditional potato-producing climates, CIP's research aims at enhancing the potato's performance in warm climates so that the value of this highly nutritious food may be fully appreciated.





CIP has recently included sweet potato (*Ipomoea batatas*) in its research program. In relation to other foods, this root crop has received relatively little attention from agricultural development programs, yet like the potato it has great potential in the developing world. In food systems, potato and sweet potato are complementary. Also, much of CIP's research on potato can be readily adapted for sweet potato.

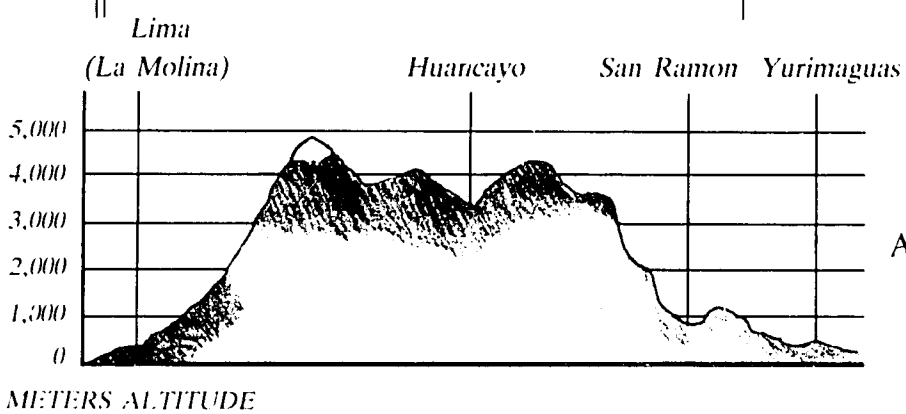
Sweet potato is an ancient crop. It originated in tropical America thousands of years B.C. and is known to have been cultivated by the Mayas and the Incas. Currently, it is grown in more developing countries than any other root crop. The leaders in sweet potato production and consumption are East and Southeast Asia.

Sweet potato's high concentration of carbohydrates and vitamin A and its relatively low water content make it an excellent food source. It grows well under a wide range of farming conditions and has a comparative advantage over many other crops in warm areas subject to drought, numerous pests, and poor or waterlogged soils. Furthermore, it is inexpensive to produce, easy to cultivate, has a short growing period, and gives generally high yields.

In many areas of the world - such as the South Pacific Islands, South Korea, the Philippines, Central Africa, Papua New Guinea, and China - sweet potato's value as a subsistence crop has already been proven. As population in the world increases, more marginal land will be brought into production and there will be a greater number of farmers with scarce resources. Under such conditions, sweet potato has outstanding potential.

As a whole, the developing countries are characterized by wide variations in altitude, temperature, rainfall, soil types, and incidence of pests and diseases. Peru's ecological diversity provides CIP with a distinct advantage in conducting research directed to meet particular needs and circumstances in such areas.

CIP has four experiment stations in Peru, one in each of the major agroecological regions of the country. Headquarters are located in the coastal desert near Lima (240 m altitude). Another station, in the cool Andean highlands near Huancayo (3,260 m), is the home of CIP's World Potato Collection. The two remaining sites are in the Amazon area, one in the mid-elevation jungle of San Ramon on the eastern slopes of the Andes (800 m), and the other in the hot, low jungle of Yurimaguas (180 m). Research at these last two sites is currently focused on the development of the warm-climate potato and on sweet potato research.*



CROSS SECTION OF PERU AND CIP RESEARCH SITES

* CIP's work in Yurimaguas is conducted at the INIAA (Instituto Nacional de Investigación Agropecuaria y Agroindustrial) research station.

CIP's six research departments - Breeding and Genetics, Genetic Resources, Nematology and Entomology, Pathology, Physiology, and Social Sciences - are staffed and headed by international experts from developed and developing countries.

Interdisciplinary research is organized into concentrations called "thrusts" in which specialists from the various departments work together to overcome important constraints to production and consumption. There are presently ten research thrusts:

I. Collection, Maintenance, and Utilization of Unexploited Genetic Resources
II. Production and Distribution of Advanced Breeding Material
III. Control of Bacterial and Fungal Diseases
IV. Control of Virus and Virus-Like Diseases
V. Integrated Pest Management
VI. Warm Climate Potato and Sweet Potato Production
VII. Cool Climate Potato and Sweet Potato Production
VIII. Postharvest Technology
IX. Seed Technology
X. Potato and Sweet Potato in Food Systems

Within each of the thrusts, projects are developed and conducted by CIP staff in close collaboration with scientists from national agricultural research programs worldwide.

The user perspective is included in all stages of research conducted at CIP, from the moment a problem is identified, through experiment station and on-farm testing, until a solution is adapted to meet growers' specific needs and is adopted by them.

CIP's capabilities are enhanced by numerous research and consultancy contracts which allow its scientists to take advantage of the expertise and facilities available at other institutions. Through collaborative research in developed countries, for instance, CIP scientists remain at the forefront of the latest biotechnological advances. Contracts with developing-country institutions allow for the sharing of specialized human and physical resources which can be applied towards priority research areas.

A great variety of primitive cultivars and wild *Solanum* species can be found in the Andean highlands, the potato's ancestral home. CIP has conducted numerous collecting expeditions in this area and has received many accessions from neighboring countries. The CIP World Potato Collection is now the largest bank of potato germplasm in existence. A careful selection process has permitted the original 13,000 specimens to be reduced to 6,500 identified varieties: 1,500 wild species and 5,000 primitive cultivars. The potato genotypes safe guarded in this collection are the resources used by CIP's breeding program to create new varieties.

This reservoir of potato genotypes is maintained in viable condition through yearly planting at CIP's highland station in Huancayo. Due to the risk of disease entry and damage to the planted material in the field, specimens are being transferred to in vitro laboratory storage through advanced tissue culture techniques. To further ensure against loss, duplicates of the in vitro material are maintained at collaborating institutions in West Germany and Ecuador.

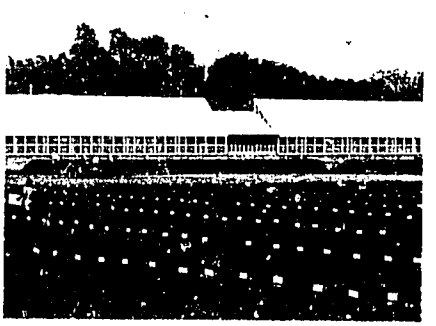
Activities to establish, evaluate, and utilize a similar germplasm bank for sweet potato are under way. The CIP sweet potato collection is already the largest in existence, and new accessions are continually being received. The field collection is maintained at CIP headquarters in La Molina, and this material is also being transferred to in vitro storage. The experience gained through the collection, classification, evaluation, and maintenance of the potato collection greatly facilitates the work with sweet potato germplasm.

Most of the developing countries that cultivate potatoes have had to depend in the past upon varieties imported from Europe and North America and adapted to growing conditions there. CIP's breeding program is oriented to produce materials that will perform well under the varied agroecological conditions and yield constraints of the tropical zones. Despite the potato's adaptability, this is a formidable task, as this crop is vulnerable to climatic stresses, nutrient deficiencies and toxicities in the soil, and over 260 diseases and pests.

CIP uses an innovative breeding approach: traditional pedigree and backcross breeding methods have, in many cases, been substituted by population breeding based on cycles of selection for appropriate attributes. This strategy ensures that the new populations will maintain a wide genetic base, thus giving them stability of performance and increasing the frequency of genes determining desirable traits. Population breeding has been instrumental, for example, in combatting late blight, the cause of the Irish potato famine in the 1840's.

By using advanced techniques such as tissue culture and embryo and endosperm culture, difficult crossability barriers can be broken and desirable characteristics found in distantly related wild and primitive species can be incorporated into cultivars. Genetic engineering techniques continue to be explored, with promising results.

In sweet potato breeding, CIP's current efforts to establish priorities are centered on gathering the information necessary to determine this crop's most important production and utilization constraints.



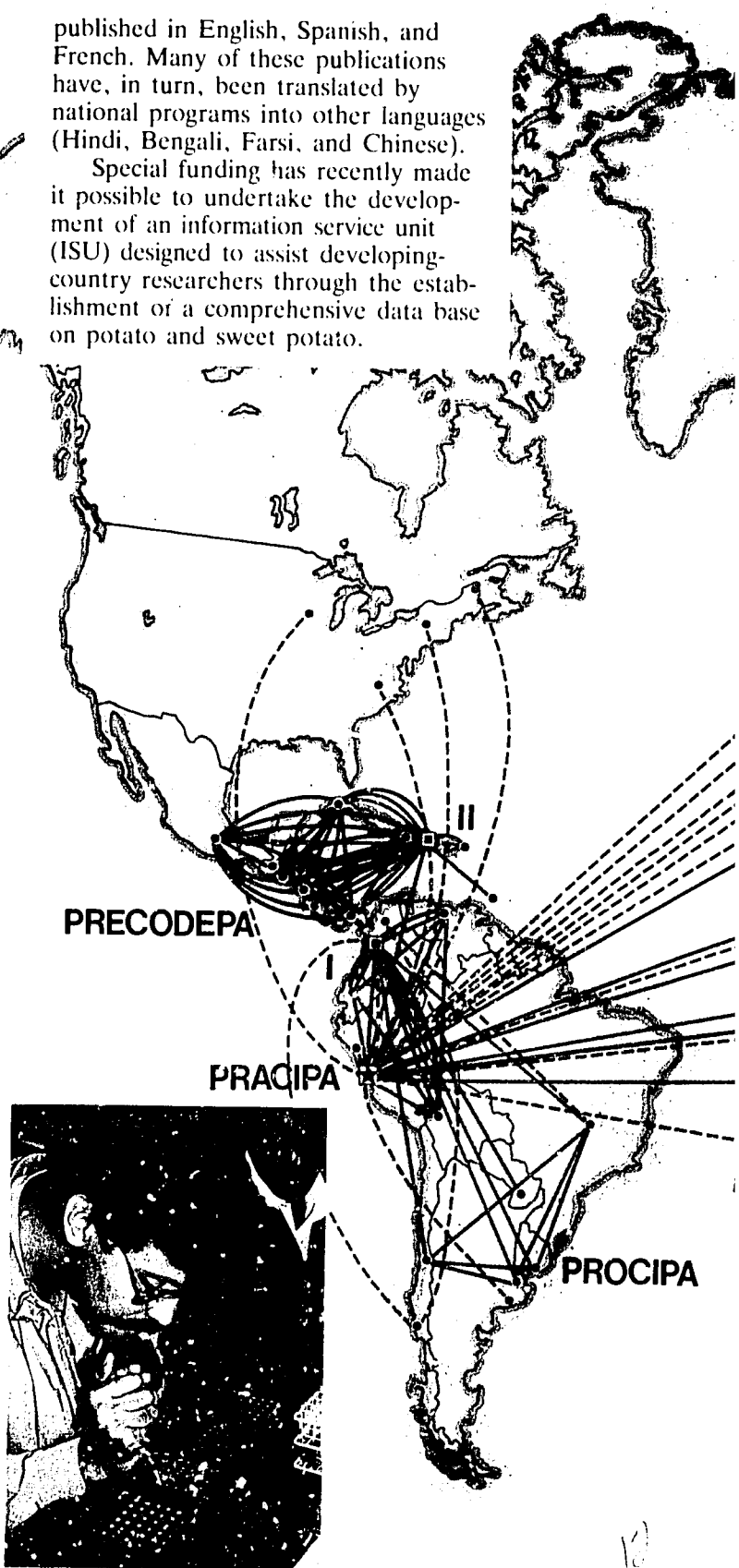
CIP's operational strategy is based on the belief that the effective generation and application of technology for sustained development can be most successfully achieved through a well-articulated global system of national, regional, and international institutions. The agricultural programs of developing countries must be able to conduct their own production-oriented research, apply the results of research conducted elsewhere, and effectively transfer technologies to their producers and to neighboring countries. Thus, one of CIP's primary goals is to contribute - through collaborative research and training - to the emergence of strong national programs with viable capabilities.

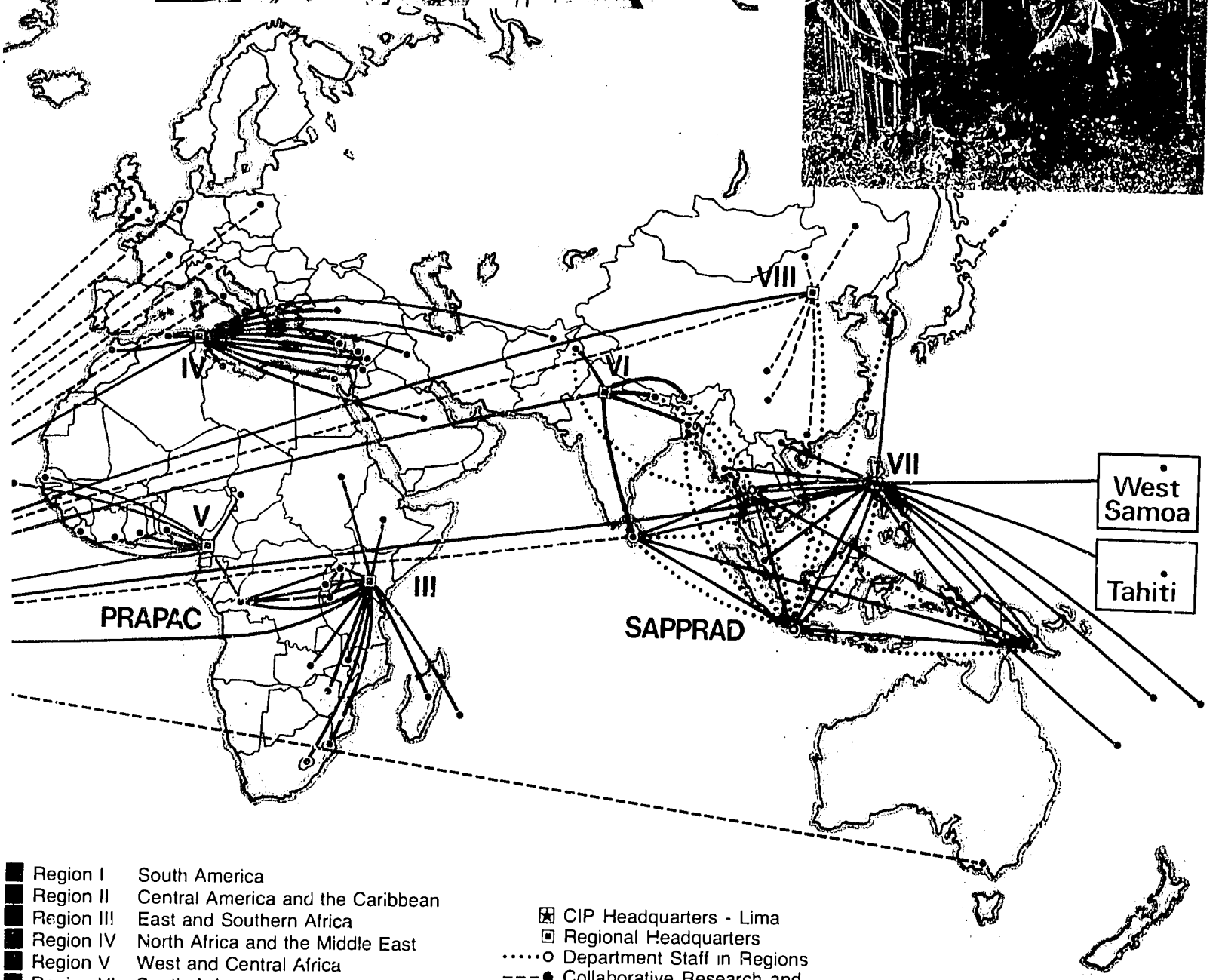
To fulfill this goal, CIP has established a comprehensive regional research program, with eight headquarters located throughout the developing world. Senior scientists appointed to each CIP region work directly with scientists from the agricultural programs in the area, conducting research and on-site testing and adaptation of technologies. Aside from the importance of this type of activity in responding to localized needs, the feedback it generates is fundamental in orienting CIP's priorities.

The regional headquarters also provide bases for CIP training activities, in which many thousands of developing-country researchers and extensionists have participated. Production-oriented training, carried out in collaboration with national programs in the areas where it is to be applied, addresses localized farm-level needs. Specialized training, conducted in the regions and at headquarters in Lima, involves sharing of expertise in those research areas for which CIP is the principal source.

CIP's training activities are complemented and supported by its communication services. Documents relating to research and technology transfer are published in English, Spanish, and French. Many of these publications have, in turn, been translated by national programs into other languages (Hindi, Bengali, Farsi, and Chinese).

Special funding has recently made it possible to undertake the development of an information service unit (ISU) designed to assist developing-country researchers through the establishment of a comprehensive data base on potato and sweet potato.

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III
PRAPAC
SAPPRAD
West Samoa
Tahiti
Region I South America
Region II Central America and the Caribbean
Region III East and Southern Africa
Region IV North Africa and the Middle East
Region V West and Central Africa
Region VI South Asia
Region VII Southeast Asia
Region VIII China
CIP Headquarters - Lima
Regional Headquarters
Department Staff in Regions
Collaborative Research and Contracts
Collaborative Country Research Networks

CIP currently distributes three types of potato genetic material: tubers, in vitro plantlets, and true potato seed. One of the principal concerns in preparing material for export is that it be free of virus and virus-like diseases, since the effective control of pathogens depends primarily upon exclusion rather than cure. For this reason, strict quarantine standards are maintained for all of the material distributed.

Highly sensitive, accurate virus-detection methods have been developed for use at headquarters and in the regions. They include the latex test, a serological method based on the use of antibody-sensitized latex particles that is easy to apply and does not require a microscope; the NASH test (nucleic acid spot hybridization) for detection of potato spindle tuber viroid, one of the most important viroids affecting potato; and the ELISA test (enzyme-linked immunosorbent assay), from which the ELISA kit - a minilaboratory especially designed for use in areas or circumstances where sophisticated facilities are not available - was created. Once detection has been effected, thermotherapy and tissue culture techniques are used to free genetic material from viruses and viroids, preparing it for distribution to national agricultural programs.

The potato germplasm exported by CIP incorporates resistances to the principal bacterial, fungal, and viral diseases affecting this crop worldwide, as well as to prominent insects and pests. These resistances are combined with other desirable characteristics - such as early maturity, cooking quality, and adaptation to warm climates or to frost - according to the circumstances under which each crop is to be cultivated, processed, and marketed.

CIP's regional program provides an excellent vehicle for distribution and evaluation of germplasm. To date, almost 90 CIP-distributed potato cultivars have been released to growers by the national programs of close to 30 developing countries.

Specialized training in the regions strengthens national seed production programs by preparing their scientists to achieve maximum results with the germplasm they receive. Many national programs now routinely apply tissue culture techniques for screening, disease elimination, and rapid multiplication.

The high cost and scarcity of planting materials are major factors limiting potato production in many developing countries. At CIP, a significant amount of research is dedicated to the use of true potato seed (TPS) as an alternative to traditional planting with tubers. True seed is produced in berries on the upper portion of the plant.

There are several advantages to planting with TPS. A handful of true seed replaces two tons of bulky, difficult-to-transport seed tubers, and the cost of the material itself is considerably lower. When TPS is used, tubers normally saved for seed can be consumed, seed storage problems are reduced or eliminated, and seed is made available year-round. Also, few diseases are known to be transmitted by TPS.

Demand for TPS technology is rapidly increasing, especially in warm-climate areas where traditional methods of potato cultivation are not suitable. CIP scientists, in collaboration with national agricultural programs in the regions, are currently improving and enhancing TPS breeding material and exploring methods for true seed utilization under varying agroecological conditions. Close to 40 developing countries are now involved in TPS research, and several of them are already using TPS commercially.

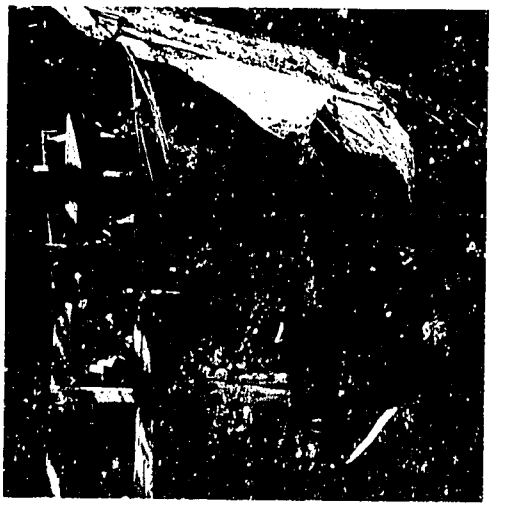
Many of the limitations to agricultural production in the developing world involve complex interrelationships of location-specific agronomic, biological, and cultural factors. CIP scientists and their colleagues in the regions conduct on-farm research to identify localized problems, evaluate techniques, field-test germplasm in the area for which it has been bred, and transfer technologies to producers once necessary adaptations have been made. The important information gathered in the field is processed to aid in ongoing research.

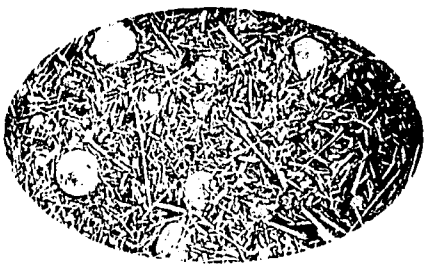
In warm climates, agronomic practices are an important element of field research. Techniques such as intercropping can be used to create desirable growing conditions, allowing potato to be produced in many areas where its cultivation was previously not feasible. Planting strategies can also be instrumental in blocking disease entry and maximizing yield.

In the cool climates, where potato cultivation is well established, field testing is carried out to select populations that mature early under long-day conditions and are resistant to frost. Early harvesting reduces the threat of damage to crops due to low temperatures and thus allows for more efficient production in traditional potato-growing areas.

Research aimed at controlling harmful pests that attack crops in the field has demonstrated that the performance of resistant genotypes can be greatly improved when appropriate planting techniques are used in combination with control agents, such as fungi and insects that are parasitic to the pests, sex pheromones that interfere with their mating processes, and biological and chemical control agents. The integrated use of such methods has been effective in combating numerous major insect pests, among them root-knot nematode, potato cyst nematode, potato tuber moth, and leafminer fly.

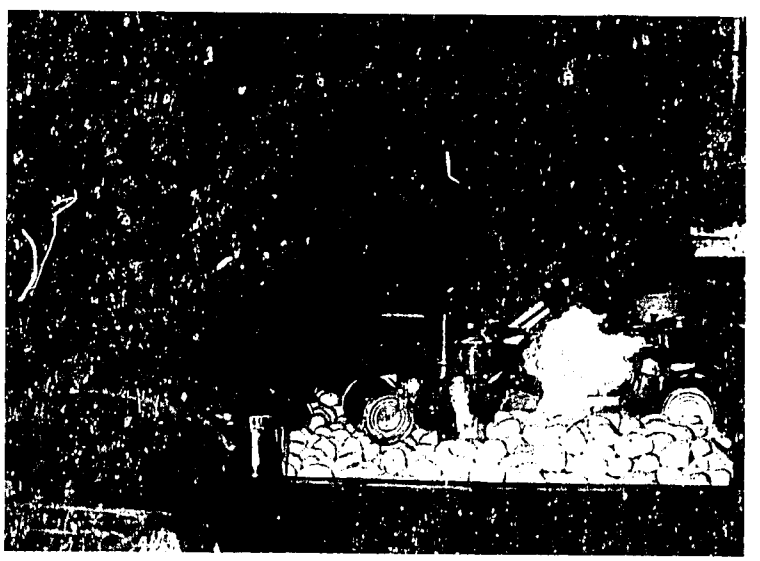
On-farm research and field selection for sweet potato will commence in warm, tropical climates where this crop has an adaptive advantage over potato.





Once a crop has been harvested, two major areas of concern remain: storage, and processing.

Traditional refrigerated potato storage is costly and thus is not feasible in



many developing-country farming systems, especially in tropical climates. CIP scientists have developed an alternative, low-cost postharvest technology based on the use of diffused light in storage. When seed potatoes are stored in diffused light, sprouting is reduced and yields are increased due to improved seed vigor. Diffused-light technology can be easily applied to typical rustic storage systems. It is now being used by farmers in numerous countries in Asia, Africa, and America.

Biological and chemical agents used to inhibit sprouting and spread of disease in stores are examined in the light of their interrelationships with factors such as earliness or lateness of harvesting, and their effect on tuber quality. Alternative storage practices, such as the layering of insect-repellent plants over potatoes to prevent pest entry, are also studied within CIP's postharvest thrust.

In processing research, nutritional value and consumer acceptability have been guiding criteria for the elaboration of low-cost, dried potato mixes. These mixes provide inexpensive, practical supplements to nutritionally deficient diets. They are produced through simple, village-level processing at both the family and the small-factory level. Variations of the basic mix tested in Peru are being developed for other countries, using locally available crops. This consumer-oriented approach will provide the model for sweet potato processing research.

The fast-food industry is rapidly growing in importance in developing-country food systems; research on dehydrated french fries and potato chips is now being conducted at CIP, to provide quality products to meet with this industry's needs.

CIP has helped to develop five unique collaborative research networks. In these networks, several countries in a geographical area pool their resources to solve common production problems. Once priorities have been assessed, each country undertakes the projects for which it has a comparative advantage, sharing its results with the others. CIP participates in the networks as an equal partner, providing technical assistance in its areas of expertise as well as administrative guidance. The distribution of efforts allows CIP and the member countries to utilize their resources efficiently.

This system of shared responsibility and active interchange differs fundamentally from other agricultural networks, designed primarily to aid in germplasm distribution. The members benefit from a wide range of research results, and at the same time their interests are consolidated and their self-reliance is strengthened.

PRACIPA
Programa Andino Cooperativo de Investigación en Papa
Bolivia, Colombia, Ecuador, Peru, Venezuela

PRAPAC
Programme Régional d'Améloriation de la Culture de Pomme de Terre en Afrique Centrale
Burundi, Rwanda, Uganda, Zaire

PRECODEPA
Programa Regional Cooperativo de Papa
Costa Rica, Cuba, Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, Panama

PROCIPA
Programa Cooperativo de Investigaciones en Papa
Argentina, Brazil, Chile, Uruguay, Paraguay

SAPPRAD
Southeast Asian Program for Potato Research and Development
Indonesia, Papua New Guinea, Philippines, Sri Lanka, Thailand, Malaysia

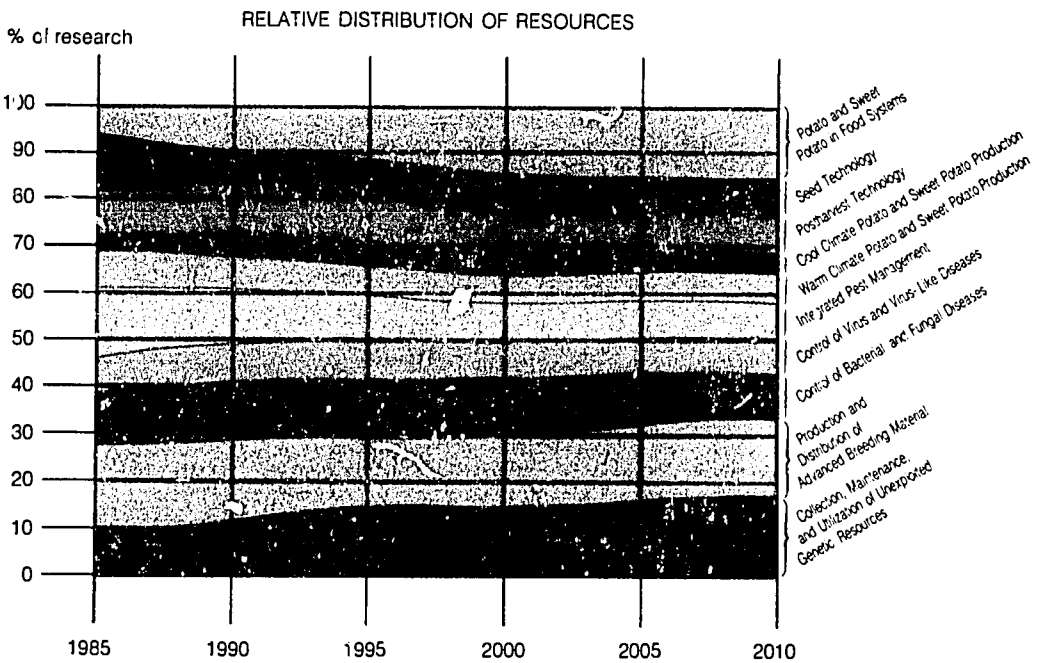
CIP has established several strategies to provide effective periodic external and internal review of the research program and to aid in adjusting planning to meet changing circumstances.

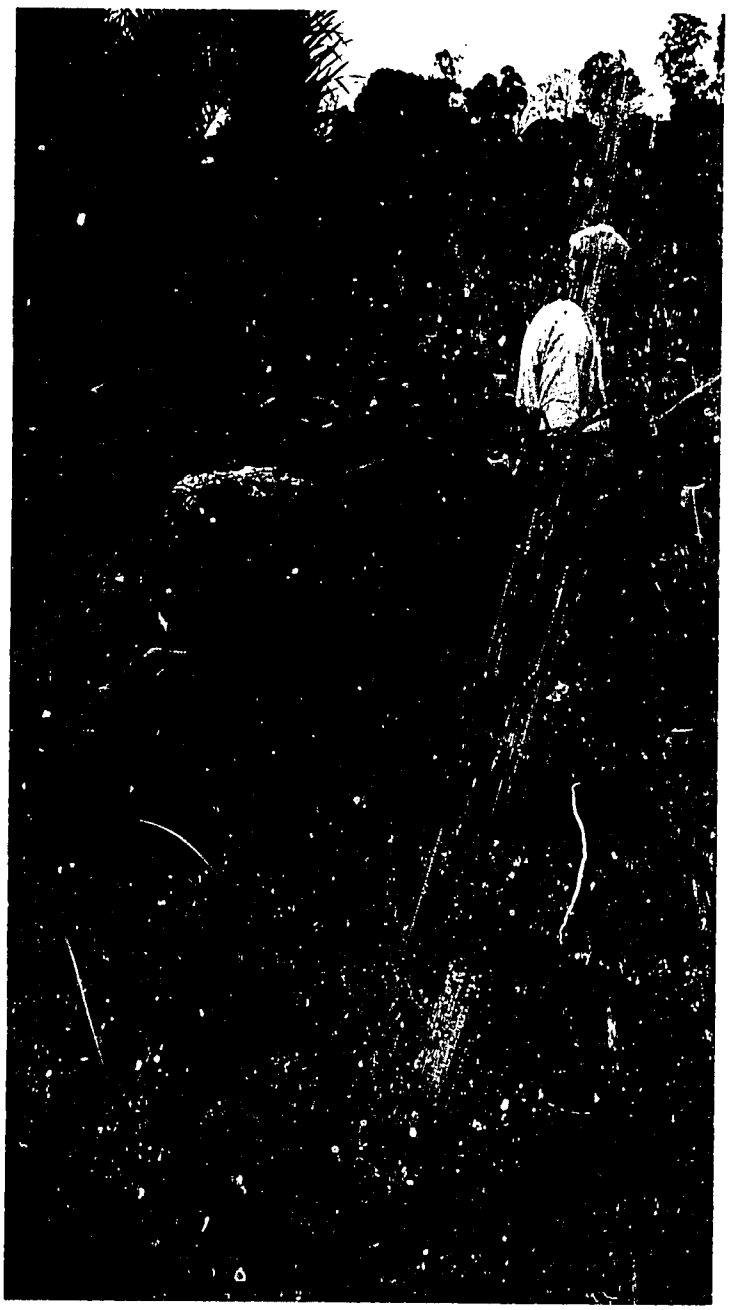
At the annual program review held at CIP-Lima, headquarters and regional staff gather to present highlights of the year's research results. National-program scientists and representatives from the agricultural research and donor organizations collaborating with CIP also attend. The open discussions held during this week-long meeting provide important input for decision making and program planning.

CIP's Board of Trustees, comprised of ten internationally known scientists and research managers, actively participates in determining the center's strategies and programs. The entire board often attends the annual review, following which the members of the program committee prepare a report with their observations and suggestions. Throughout the year, individual board members participate directly in CIP activities within their areas of specialization.

Planning conferences, held for each major research area at three-to-five-year intervals, open another channel for interchange with scientists from collaborating institutions. At these meetings, CIP's ongoing research program is evaluated by invited experts. Their observations and recommendations are useful for establishing guidelines and reorienting priorities.

The CIP *Profile* was created in 1979. This long-term plan outlines progress and assesses changes in the center's distribution of efforts, thereby allowing funding and staffing to keep in step with the research program and its needs. Updated periodically, the *Profile* is now in its fourth edition, with planning through the year 2010.



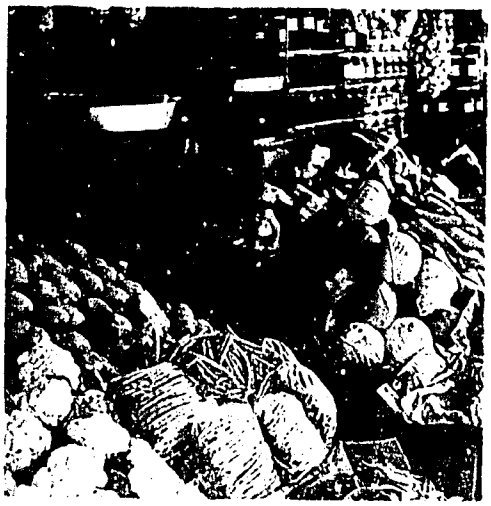


Agricultural research must extend beyond the breeding and transfer of improved germplasm if its full impact is to be felt by those in urgent need of solutions to their nutritional problems. Germplasm and technologies must be developed and evaluated in the context of the total food chain, from seed procurement and planting, through cultivation and storage, to processing, marketing, and consumption. This implies in-depth analysis of a wide range of agroecological, economic, and cultural conditions throughout the world.

At CIP, a team of social scientists - including anthropologists, economists, and sociologists - explores the complex systems within which tuber and root crops are produced and utilized, placing special emphasis on cultural aspects, such as the role of women in agriculture. Their research, integrated with the work of the biological scientists, serves three broad aims: it helps to identify problems that merit priority attention, it aids in the effective development and testing of new technologies, and it provides assessments of the results of research and transfer conducted by CIP and by national programs.

In addition to addressing farm-level problems, food systems research is concerned with the development of agricultural policies and institutional technologies that can contribute to increased production.

The function of the food systems approach can be summarized as placing agricultural research within its broadest context so as to ensure that CIP's efforts to alleviate hunger and contribute to development may achieve maximum effectiveness.



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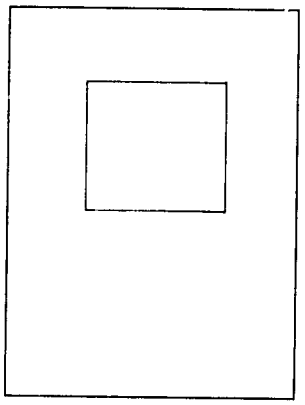

Micropropagation of potatoes through tissue culture, a technique now used in many developing-country programs to aid in rapid multiplication of pathogen-free material.

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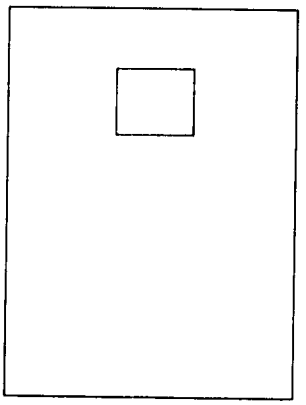

Aerial view of CIP headquarters, Lima-La Molina, Peru. Facilities include laboratories, greenhouses, refrigerated and diffused-light stores, growth chambers, experiment fields, and general research, administrative, and office areas.

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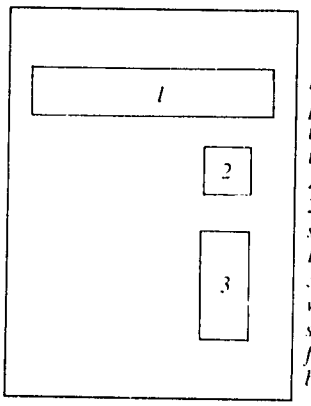

1. Some of the many varieties of potatoes grown in this crop's home, the Andes of South America.
2. Potatoes being sold in a market in Indonesia.
3. Two chinese girls with potato plant, showing tubers, foliage, and TPS berries.

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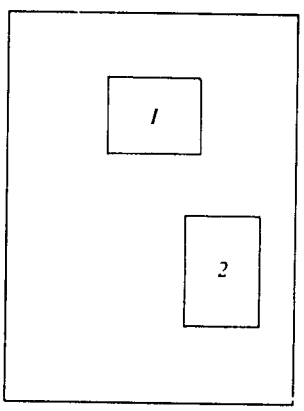
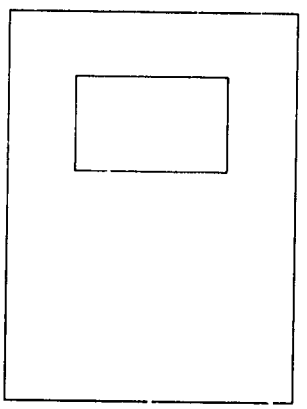


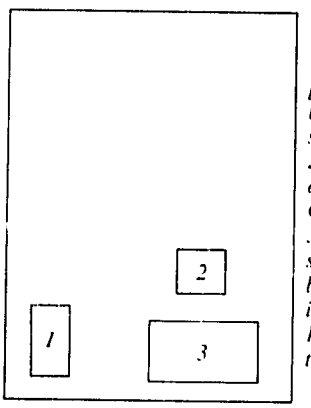
1. Sweet potato flower being pollinated by bees.
2. Sweet potatoes for sale at a New Guinea market.

PAGE 8



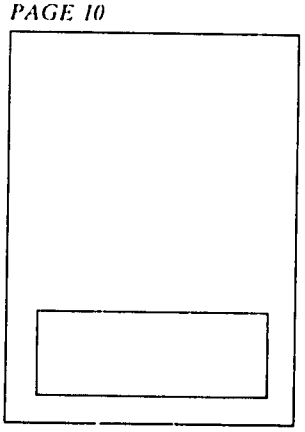
Postharvest selection in Marcapata (Cuzco, Peru), where potatoes are an important component of the local diet.

PAGE 9



1. Testing for the presence of viruses, using nucleic acid spot hybridization.
2. Hand-pollination of potato flowers, CIP-Huancayo.
3. CIP staff member studying specimen box with farmers in Ollantaytambo, Peru, for identification of local pests.

PAGE 10



In vitro sweet potato plantlets.

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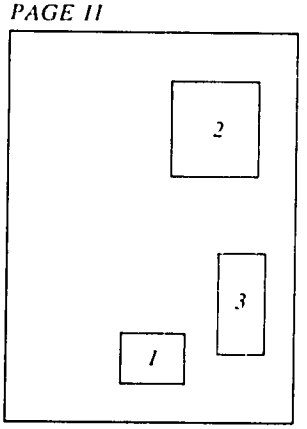

1. Sweet potato collection, La Molina.
2. CIP scientists selecting potato cultivars.
3. Transfer of cutting to jiffy pot for rapid multiplication.

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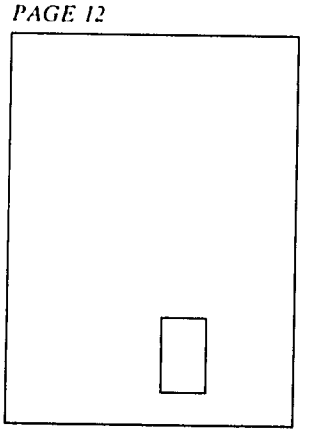
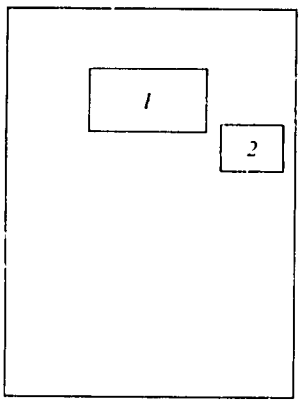


Trainee applying LATEX virus-detection methods.

PAGE 13



1. CIP scientist conducting training in rapid multiplication, Vietnam.
2. On-farm trials raising TPS seedling tubers, nursery in Rwanda.

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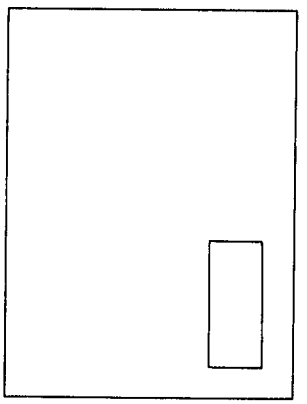
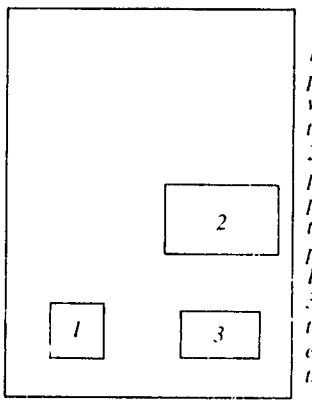


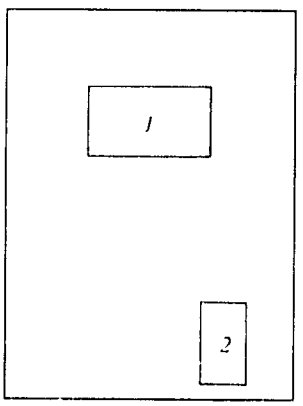
Removal of apical portions of potato plants which will undergo thermotherapy for virus-free reproduction.

PAGE 15



1. Berries of the potato plant from which TPS is extracted.
2. TPS seedling plantlets in jiffy pots, ready to be transferred to field plots in San Ramon, Peru.
3. Hand-emasculation of potato flowers for TPS production, Chile.

PAGE 16



1. In Bangladesh, CIP scientist and local farmers selecting and sorting tubers from potato tuber moth trials.
2. CIP trainees recording results of on-farm testing in Saigon.

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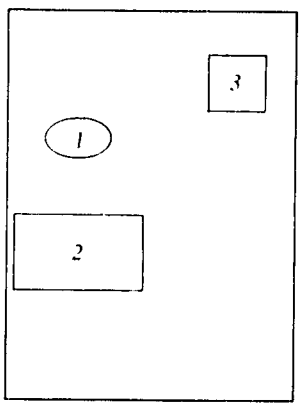

1. Potatoes layered with insect-repellent plants to prevent pest entry in storage.
2. Rural processing plant, India.
3. Diffused-light store, Mantaro Valley, Peru.

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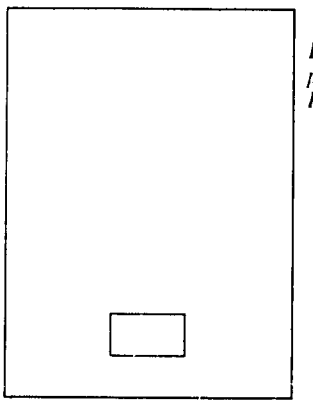
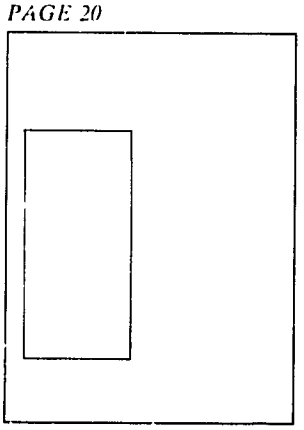


Preparing fields for planting in Costa Rica.

PAGE 20



Harvesting of potatoes intercropped with corn, Cameroon.

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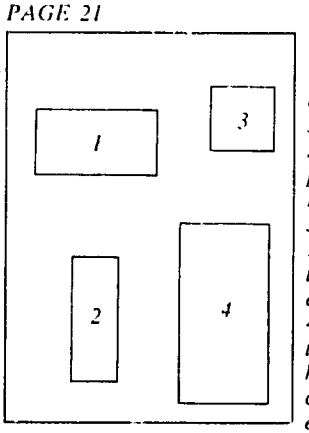
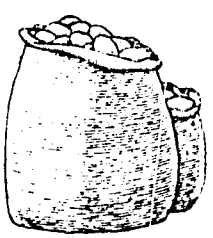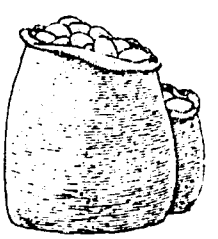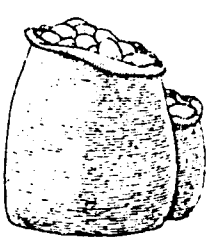
1. Desprouting of potatoes after storage, Turkey.
2. Transporting potatoes to market, China.
3. In Baguio, the Philippines, potatoes for sale as an expensive vegetable.
4. TPS on-farm trial: evaluation of hybrid progenies as compared to farmer's variety, Gilgit, Kashmir.