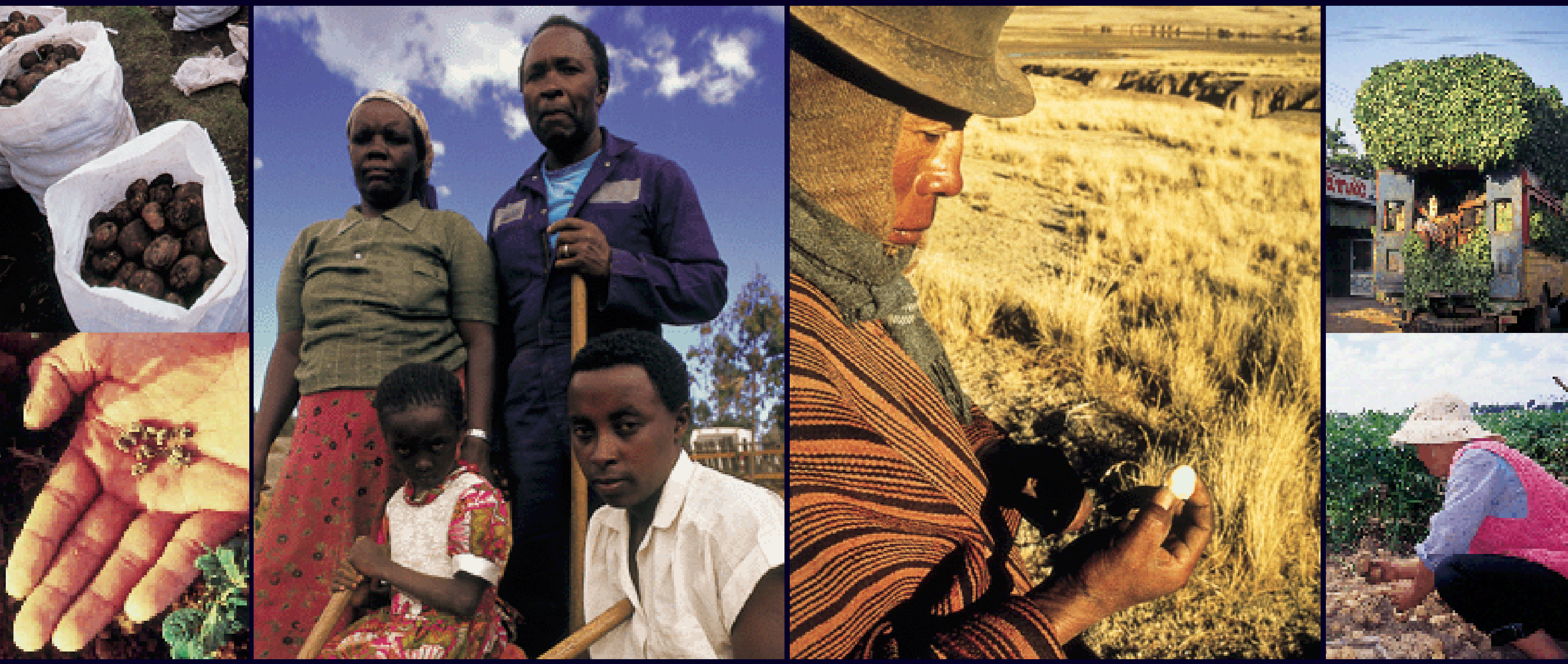
BROADENING BOUNDARIES IN AGRICULTURE

BROADENING BOUNDARIES IN AGRICULTURE: IMPACT ON HEALTH, HABITAT AND HUNGER



INTERNATIONAL POTATO CENTER • ANNUAL REPORT 2001

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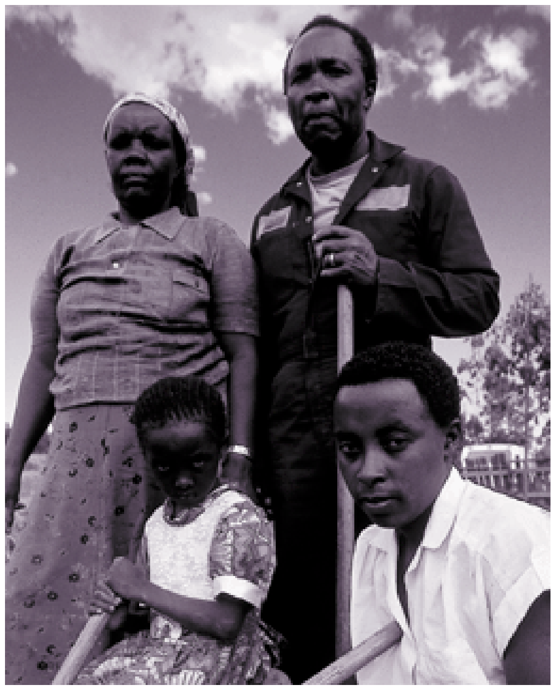



INTERNATIONAL POTATO CENTER • ANNUAL REPORT 2001

Contents

From the Director General

Rising to the challenge Challenge is a word that looms large in my mind as I look back on 2001. During the year, as we celebrated CIP's 30th anniversary, we were faced with challenges far beyond those envisaged in our founding charter.

CIP and the other Future Harvest Centers of the Consultative Group on International Agricultural Research (CGIAR) were being asked to increase our relevance as agents of sustainable development by significantly expanding our impact on poverty and the environment. At the same time, we were experiencing shortfalls that reflected a tilt away from agricultural research in the development funding balance.

Yet we were determined to rise to the challenge. In the words of our Chairman, Ian Johnson, "Put simply, sustainable development is . . . not just a moral imperative. . . Rather, it has become a global strategic priority for the survival of our planet."

At the system level, we began to forge new, high-impact research programs targeting complex issues of global and regional importance. Appropriately named Challenge Programs, these are founded on innovative partnerships linking the Future Harvest Centers among themselves, as well as with numerous other actors. CIP has taken the lead in formulating two of these programs, while actively seeking ways to contribute to others in areas where we have relevant expertise.

Meanwhile, CIP staff and management were assessing our achievements over three decades to extract the lessons on which we would base our institutional strategy for moving forward. This Annual Report presents several illustrative examples from work under way in 2001. *Insects feel the heat* (page 45), for example, illustrates how CIP's strong linkages and our expertise in integrated pest management, steadily developed over the years through research on intensive potato and sweetpotato production systems, are allowing us to nurture new systemwide efforts to deal with climate change.

Waste not, want not (page 37) shows how our research on root and tuber products and processing, firmly grounded in participatory processes, and our collaboration with other Future Harvest Centers on issues ranging from water management to waste disposal, are coming together to make a difference in the lives of urban dwellers and farmers.

In *Heading for the Summit* (page 27), we see how support to new institutional approaches in the Andes and alliances with diverse partners to unravel the complexities of mountain ecosystems have made us the CGIAR's center of choice to convene the Global Mountain Program. And *Pesticide poisoning* (page 17) shows how the powerful data gathering and analysis tools designed to support decision making in complex mountain environments not only are helping to curb serious damage to farmers' well-being, environments and incomes; they also have wide potential for application across the world's fragile—and vital—mountain ecosystems.

Tapping into biodiversity (page 55) demonstrates how CIP's germplasm collections, at the heart of our research, continue to be a key source of impact. CIP-generated potato varieties have spread throughout China answering urgent food and income needs for hundreds of thousands of people (*Cooperation pays*, page 65). And our experience with crop conservation and improvement have helped us to turn the hardy, yet often disparaged, sweetpotato from a last-choice subsistence crop into a vital weapon in the battle to end micronutrient deficiency in Sub-Saharan Africa (*Nutritious and delicious*, page 9).

As we evaluate these achievements we are confident, but not complacent.

Experience has shown us that the challenge of sustainable development will not be met with a simple sum of accomplishments, no matter how impressive these are. If we are to respond effectively to the "global strategic priority" described by Ian Johnson—generating concerted impact on the interrelated issues of poverty, hunger, health and environment—we need to use formulas that will greatly increase the power of our successes to produce change.

Two crucial questions continue to emerge: How are we to produce this wide impact with ever-narrowing resources and in a more tightly focused research environment? How are we, with our mission to conduct agricultural research of excellence, to broaden our boundaries without stepping out of our bounds?

We have found our answer in convergence.

Our future actions–much like our achievements in the past–must be solidly founded on partnerships that will allow us to take our research further, broaden its scope or complete its cycle. In this way, we can have an impact in areas that are otherwise beyond our reach and we can close the gaps that would allow our technologies to fall through the cracks somewhere along the food or policy chain.

By cultivating innovative alliances we can ensure not only more food, but more purchasing power through value-adding activities, less dependence on external inputs and greater local competence. By building on complementarities and avoiding redundancy, we can translate increases in soil productivity and curbs on degradation into more secure habitats with healthier, more productive people, capable of making the decisions that will bring them out of subsistence into self-reliance.

The challenge may, at times, seem daunting. But through partnership we hope to turn sustainable development from an admirable concept into an attainable goal.

Hubert Zandstra
Director General

HEALTH

Healthier people, more productive people The world is now producing more food than ever. But satisfying human nutrition and health needs depends on much more than quantity. In the midst of plenty, people the world over will continue to live and develop far below their full capacity if issues of food quality and safety are not addressed.

In this section we examine two health-related concerns at the root of key research at CIP. The first is micronutrient deficiency. CIP is spearheading a drive to fight vitamin A deficiency in Sub-Saharan Africa, where it is a leading cause of early childhood death and a major risk factor for pregnant and lactating women. The VITAA Partnership, as this effort is known, brings together agriculturists, health experts and nutritionists, all of whom work through the strong community and women's groups existing in the region. The second is pesticide poisoning. As Center scientists search for ways of countering this peril in the Andes, they bring into play years of experience in integrated pest management. By combining their acquired expertise in this field with new participatory approaches and powerful information tools, our researchers are finding that they can make critical contributions to farmers' health, as well as to their productivity.

In both cases, collaboration with a broadening circle of partners, spanning sectoral as well as disciplinary divides, is the key to impact far more profound than we could achieve by going it alone. For the direct beneficiaries of this research, and for countless others as well, the boon of health will bring more gains in its train. Healthier people are more efficient at working and spend less money on medical care. This means a healthier economy with diminished poverty and hunger. The wheel comes full circle.

Nutritious and delicious: Orange-fleshed sweetpotato fits the bill for African consumers

Using a simple, crop-based approach, an innovative coalition is tackling a problem affecting millions of children and mothers in Sub-Saharan Africa

A sweetpotato a day

"My children love it," says Florence Kiwendo. "At first I wasn't too keen, because it's not what I was brought up on. But now I'm getting to like it too. The nutritional advisor at our clinic says it will add a sparkle to my eyes!"

Kiwendo is referring to Ejumula, a variety of sweetpotato with deep-orange flesh. A farmer and a mother of six in crowded central Uganda, Kiwendo is no stranger to sweetpotato. She has long grown this vital food staple on her small plot of land. But until recently, the only varieties she knew were the white-fleshed ones that are traditional in her area and across most of Sub-Saharan Africa. Kiwendo was introduced to Ejumula when she began participating in local on-farm trials.

High in beta-carotene, the precursor to vitamin A, orange-fleshed varieties like Ejumula are an answer to one of Africa's greatest scourges: vitamin A deficiency. Vitamin A is essential for children's normal mental and physical development and for keeping pregnant and lactating mothers healthy and strong. Its lack can be a death sentence, in some cases directly but more often via a weakened immune system, which lays victims open to diseases such as measles, malaria and HIV-AIDS. Vitamin A deficiency also takes its toll on eyesight and often leads to blindness.

According to a study by CIP economists (see page 16), the countries of Sub-Saharan Africa are home to an estimated 50 million children under the age of six who are at risk from vitamin A deficiency. For them, eating just half a cup of orange-fleshed sweetpotato each day could solve the problem.

Strength in partnership

The institutions conducting the trials in Uganda — the Child Health Development Centre (CHDC) of Makerere University and the National Agricultural Research Organization (NARO) — are part of what is thought to be the world's first large-scale crop-based initiative to eradicate vitamin A deficiency. Known as Vitamin A for Africa or VITAA, the partnership spans disciplinary barriers, marshalling the resources of experts in agriculture, nutrition and health in a broad-based alliance designed to achieve wide coverage and lasting solutions.

Until recently, attempts to overcome vitamin A deficiency have been centered on two main approaches. The first is supplementation — handing out vitamin pills. This approach, managed largely through public-sector healthcare programs, can be effective if it is widely applied. But it has to be implemented every six months, making it expensive and difficult to sustain, especially in countries with poor roads and a rudimentary health system. The second approach is fortification of selected foods, such as sugar and salt. This too can be effective, but only for the people who can buy the foods in question. Those most at risk, especially the poor in rural areas, tend to get left out.

"VITAA reflects a groundswell of interest in switching over to a crop-based approach," says Regina Kapinga, the partnership's Africa-based coordinator. That interest culminated in a meeting held in May 2001 to formally launch the partnership. Attending were representatives from the first five African countries to participate: Ethiopia, Kenya, South Africa, Tanzania and Uganda. Each has now prepared a plan of action and formed a national committee to oversee implementation.

The experience that sowed the seeds of VITAA came in the mid-1990s, when the Kenya Agricultural Research Institute (KARI), the International Center for Research on Women (ICRW), CARE International and CIP came together in a pilot project to test whether orange-fleshed sweetpotato would appeal to African consumers. Until then it had been assumed that few would be willing to switch from the traditional white-fleshed varieties, which are less sweet tasting and are high in starch and dry matter content. "To our delight, the project banished the myth of consumer unacceptability," says CIP's regional representative for Africa, Peter Ewell. "Children especially welcomed the taste and texture."

Ewell sees many advantages in using sweetpotato to counter vitamin A deficiency in Africa. "Farmers are already familiar with the crop," he says, "so we are tweaking an existing system, not introducing something new. It's grown by many of the very people we need to reach — the poorest and most at risk from malnutrition." For children, sweetpotatoes are a more appealing source of vitamin A than green vegetables, which in any case allow less easy absorption by the body. And from the perspective of the family's provider, this hardy root crop is cheaper to buy or produce than other sources of vitamin A, especially milk and meat. Varieties of orange-fleshed sweetpotato that fit the bill for African consumers have already been identified. "They are ready now and need only to be locally adapted and deployed," says Ewell. "There is no need for an expensive and protracted investment in research."

Golden opportunity

The VITAA partners are capitalizing on this golden opportunity. In Kenya and Uganda, where activities are furthest advanced, KARI and NARO scientists are screening about 20 orange-fleshed varieties for their suitability to local environments while non-governmental organizations (NGOs) and women's groups conduct on-farm trials.

"Our initial results have confirmed the findings of the pilot study," says Kapinga. "Children love the taste, texture and color of Ejumula, while adults prefer the lighter orange Kakamega variety, which is less sweet." Farmers also are finding that

Orange-fleshed sweetpotato adds flavor to products like chapatis and infant food and puts a smile on mothers' faces.

Continued on page 13

Kenyan women and children value orange-fleshed sweetpotatoes

The women of Siaya

Women are quick to recognize the value of orange-fleshed sweetpotatoes, at home and in the market place. Mary Anyango Oyunga-Ogubi, a food scientist with KARI, recorded some of the reactions of women during PRAPACE training sessions in the Siaya district of western Kenya:

Jane Akoth: "You know, we could make a lot of money from this variety because it sells very well at the market."

Ida Akongo: "We used to call this *olombo*, meaning something that makes the baby stop crying. The bright color is so captivating for children. I did not know it had these values you are talking about. It disappeared and now it is back, looking even brighter. This means healthier babies and no more crying baby!"

Florence Owiti: "This variety cooks so fast—just about 20 minutes and with very little water. If I use the energy-saving stove I will need only one piece of firewood to feed the whole family. This is really exciting!"

Margaret Odendo: "I use less oil and less sugar — and my products are a lot softer and more appealing. I am sure that they will sell well."

Alice Owiti: "Men were not buying any of my products. But since I started making *chapatis* and *mandazis* (fried dough balls) with this sweetpotato they think I have added eggs, so they buy more for their families."

Elizabeth Wesonga: "I will never use food coloring again. This natural color in the sweetpotato is enough."

the new sweetpotatoes grow well, producing acceptable yields even when stressed by drought and insect pests.

The next generation of improved varieties will give farmers even greater options. "We're keen to offer families more choices and it's important we do so," says CIP's Lima-based sweetpotato plant breeder, Dapeng Zhang, whose team developed the new materials by crossing parents chosen from the germplasm collection held in trust by CIP. "Decisions on what to grow on the farms' larger fields are usually made by men, who favor high dry-matter and starch content. But women grow the backyard crops — and they want the varieties that are best for the family's nutrition, especially the children." The new sweetpotatoes offer growers the best of both worlds, relatively high beta-carotene levels with good starch and dry matter content.

About 40 new lines of sweetpotato are now ready for dispatch to Nairobi. After clearing quarantine, they will be multiplied and distributed through the expanding network of VITAA collaborators in Eastern and Southern Africa. As in the pilot study, the partners will work through the strong community and women's groups existing in the region, which offer the best chances of changing the eating habits of rural families. These groups also support the development of much needed micro-enterprises that promote processing of orange-fleshed sweetpotato into products for urban consumers, many of whom are also deficient in vitamin A.

Adding value after harvest

Mary Atieno, an enterprising farmer turned food processor in Teso, western Kenya, is one of a small but growing number of entrepreneurs in Uganda and Kenya who are discovering that processing and marketing the new sweetpotatoes pays. Thanks to Atieno, local schoolchildren are enjoying a delicious yet cheap addition to their diets: chapatis made with flour from orange-fleshed sweetpotatoes.

Atieno used to make chapatis out of wheat flour. She decided to change her recipe after growing the new sweetpotatoes on her farm and trying them out on her own children. Pupils at neighboring village schools have greeted her new chapatis, which sell for only KSh5 apiece (US$.06), with enthusiasm and now regularly buy them at her small kiosk on their way to or from school. Atieno's sales have risen rapidly to around KSh200 (US$2.40) a day, an amount that has enabled her to refurbish her kiosk with a new corrugated iron roof and a cement floor.

"After my experience with the chapatis, I'm keen to learn how to make other products," Atieno says. In October 2001 she had the opportunity to do just that when she attended a workshop for small-scale processors organized by local NGOs. At the workshop, she and other participants were introduced to sweetpotato "crackie", a mashed and fried product popular elsewhere in the region.

In large parts of Eastern and Southern Africa, sweetpotatoes are normally eaten boiled. Consumers are unfamiliar with the diversity of processed products consumed elsewhere in the world and in the few areas, mostly urban, where processing does take place, flour-based products made from white-fleshed varieties still prevail.

Thanks to research by VITAA partners, entrepreneurs like Atieno are learning that there is ample room for sweetpotato-based products on the market and that orange-fleshed varieties can add a welcome touch of sweetness. A classic example of the processing possibilities for the new sweetpotato varieties is the *kabalagala*, a traditional deep-fried pancake made in Uganda from cassava flour and banana pulp. In a survey

GRIST FOR THE MILL

Rueben Kinyua is the owner of a small and unusual milling business in central Nairobi, specializing in health foods. His most popular product is a made-to-order mix of bean and cereal flour that his customers feed to sick and malnourished children and old people. "We're like a pharmacy," Kinyua says. "Only our products are made of food, not chemicals."

Early in 2001, Kinyua began experimenting with orange-fleshed sweetpotato as an ingredient in the mix. He had learned of the nutritional value of the brightly colored roots from CIP scientists. "Now my mixes contain up to 5 percent flour made from these varieties," he says. The lengthening lines of women outside his premises suggest his experiment is paying off.

The business acumen and drive of men like Kinyua will help the benefits of orange-fleshed sweetpotato to spread widely in Africa.

conducted by NARO in the area around Kampala, consumers complained that the local kabalagalas couldn't be relied on to taste good. The reason was the high cost and scarcity of banana, the crucial ingredient for sweetness. Switching from cassava flour to orange-fleshed sweetpotato flour would simultaneously improve quality and cut costs, as it would allow processors to reduce the amount of banana pulp. Around 85-90 percent of processors surveyed thought the switch was a good idea.

Mills and factories are starting to show an interest in making sweetpotato flour and using it in their recipes. For example, the House of Quality Spices, a family business supplying supermarkets in Kampala and exporting its products to Kenya and Congo, recently approached CIP's regional researchers. The owners had seen the flour's potential and wanted to know how to secure a steady supply of it.

Training and public awareness activities are vital in bringing such opportunities to the attention of small-scale producers and processors. In western Kenya, CIP works with the Regional Potato and Sweetpotato Improvement Program for East and Central Africa (PRAPACE) to introduce processing techniques and products to women's groups. The workshop attended by Atieno was one of several such events, many more of which will be organized by NGOs and other institutions as knowledge of the value of orange-fleshed sweetpotatoes spreads.

The signs are that orange-fleshed sweetpotato will rapidly gain a place in the affections of African consumers. Children are already developing a healthy fancy for a food that is not only good for them but actually tastes good too. Adults, though more cautious, are also warming to the new item in their diets. They are learning that it is, indeed, a lifesaver.

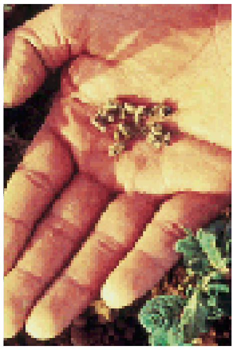
VITAL POTENTIAL

VITAA's potential to combat vitamin A deficiency using orange-fleshed sweetpotatoes was confirmed by a recent ex-ante impact study. Although sweetpotato is widely perceived to be a secondary, seasonally-produced crop in Sub-Saharan Africa, scientists have found that there is enough sweetpotato grown to contribute to a food-based approach to solving chronic vitamin A deficiency there. This finding is key because VITAA's potential medium-term impact depends on new varieties being released into areas that are already under production.

Preliminary results of the study were based on calculations carried out for Burundi, Ethiopia, Kenya, Rwanda, South Africa, Tanzania and Uganda. Across all seven countries about one-third of the population at risk could receive a benefit equivalent to 40 percent of the recommended daily allowance of vitamin A. Another third would benefit to a lesser extent. Only one in three would not be reached by the positive impact of the switch to orange-fleshed varieties. Though the effects were expected to be less evident in Ethiopia, Kenya, South Africa and Tanzania, scientists found that production density in Burundi, Rwanda and Uganda is sufficient to make a large dent in vitamin A deficiency if orange-fleshed varieties are substituted for white-fleshed.

Another finding showed that if sweetpotato were available for more months of the year, this availability would be more effective in improving people's nutritional well-being than augmenting the pro-vitamin A content of orange-fleshed varieties. Indeed, orange-fleshed materials don't have to be that orange to make practical impact.

In the longer run, scientists believe that sweetpotatoes — particularly orange-fleshed varieties — are likely to expand into substantially larger areas of Sub-Saharan Africa. That is partly because the crop is not only widely adaptable to altitudes ranging from 200 to 2200 meters above sea level, it also yields well under marginal soil conditions.



Pesticide poisoning: Tradeoff analysis forges new consensus on the need for change

New research tools and approaches are helping CIP to broaden its impact. The use of models for tradeoff analysis in Ecuador's El Carchi Province is a case in point

A persuasive tool

Developed during the 1990s by researchers in the USA, Canada, the Netherlands and the Andes, tradeoff analysis can be defined as the science of helping people to make difficult decisions in their management of natural resources, balancing diverse and sometimes conflicting objectives.

"Essentially, it's a modeling exercise wrapped up in a participatory research process," says CIP economist Charles Crissman, a member of the team that conceived the idea. The process begins with an invitation to stakeholders — typically a mix of farmers, scientists and policy makers — to identify the priority issues affecting development and the resource base in their area. This leads to a definition of indicators that can throw light on the potential effects of resource management and economic and policy options. The stakeholders formulate hypotheses as to the nature of the tradeoffs involved in each of the options and how these might change if a different course of action were followed. Scientists then design and conduct research to verify the hypotheses. They determine the modeling and data requirements, assemble the necessary disciplinary expertise, collect and analyze the data and then plot the results to form the tool that is the centerpiece of the process: a graph comparing the key indicators. This typically consists of two curves, one showing the current situation and the other the likely outcome of the action taken.

"With its clear graphics, based on empirical data, the tradeoff model can be a highly persuasive tool," says Crissman. "But it has to be derived as part of a participatory process. Only then will its users feel ownership of it." The final and most important step in the process is to present the results of the analysis for consideration and discussion by a larger set of stakeholders, including local people and national leaders. The aim is to broaden and deepen awareness as a basis for improved decision making.

Tradeoff analysis was first developed and applied in Ecuador's El Carchi Province, where it has made a valuable contribution to the search for solutions to the serious human health problem of pesticide poisoning.

El Carchi: Healthy solutions

Overexposure to pesticides is rampant in the intensive production systems of the El Carchi hills, where farmers grow potato and other crops to satisfy demanding national and export markets. Potatoes may be sprayed up to 12 times in a single season, as farmers follow the advice given by chemical company salesmen to apply products regularly, "just in case" pests should appear. Two of these products, methamidophos and carbofuran, are so toxic that their use is restricted in the developed world.

In the late 1980s, observers began to detect

Raising farmers' awareness—be they adults or children—about integrated

growing ill health among El Carchi's farmers, who suffered a range of symptoms known to be pesticide-linked, including headaches and nausea, breathing difficulties and eye and skin problems. Other suspicious symptoms were neurological and motor disorders, although these were thought to be limited to a few cases after prolonged exposure.

Researchers responded by adapting integrated pest management (IPM) schemes to meet El Carchi conditions and needs. IPM components such as improved potato varieties with resistance to late blight and simple traps to kill the Andean potato weevil were combined with better agronomic practices and weekly scouting to detect emerging pest or disease problems. Their use wouldn't eliminate pesticides altogether, but it would allow farmers to reduce the number of applications, particularly of the two most toxic products. Trials in farmers' fields showed that with the IPM interventions, growers could maintain or even increase production while reducing costs, thereby boosting profitability considerably.

Despite these findings, moving from the trials to widespread adoption proved difficult. Farmers still felt that cutting back on pesticides was a risk they couldn't afford to take. They saw the chemicals as a safety precaution without which they might lose their whole crop and hence the bulk of their year's income. Another reason for non-adoption was the fact that the apparent disadvantages of applying pesticides — a headache or a feeling of nausea — seemed short-term and bearable in comparison to the risk of loss of livelihood. "If you are strong, you can tolerate the poison," as one farmer put it.

So what could be done to persuade the farmers? CIP and its partners adopted a threefold strategy. They introduced farmer field schools to help extend IPM in the farming community, they mounted a broad-based campaign of public education and they undertook new initiatives to create a more conducive policy environment.

pest management will help them escape the tragedy of pesticide poisoning. Farmer field schools offer an excellent forum for sharing this knowledge.

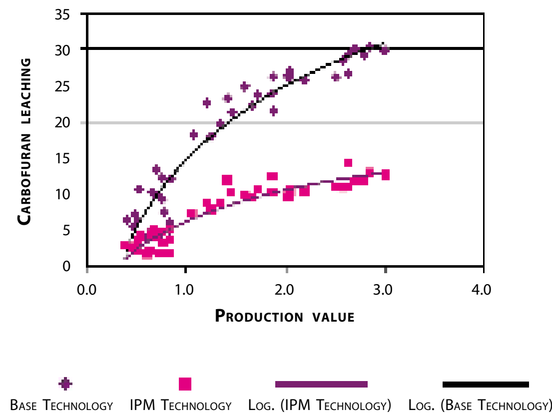
New evidence, new consensus

To obtain empirical data on the health impact of pesticides, Donald Cole, a human health epidemiologist from Canada's University of Toronto, was invited to conduct a detailed study in El Carchi, working with local health organizations.

The results of the study were shocking. Pesticide poisoning was shown to be far more widespread and severe than had previously been

PESTICIDE LEACHING VERSUS PRODUCTION VALUE

THESE "TRADEOFF CURVES" INDICATE THAT FARMERS USING HEAVY CHEMICAL INPUT (BASE) CAN REDUCE PESTICIDE LEACHING WHILE PROTECTING THEIR PROFITS BY SWITCHING TO IPM



suspected. We now know that in El Carchi the presence of pesticides is so pervasive that most of the rural population is affected. Although it is the men of the household who tend to do the spraying, they typically store pesticides in or near the family home, mix them in open drums and apply them using faulty equipment and without wearing protective clothing, often failing to wash properly afterwards. Their wives and children, therefore, are contaminated in numerous ways in and around the home.

Standard tests of the kind used by the World Health Organization suggest that about 60 percent of the at-risk population has already suffered significant damage, including disrupted motor skills and psychological effects such as depression, listlessness and impaired decision making. "If this were to happen in a developed country, compensation would be on the agenda," says Cole.

But if the study was shocking, it also revealed that the potential economic benefits of reducing pesticide poisoning were even greater than had been thought. As expected, there is an immediate gain as farmers save money by cutting back on the pesticides they buy. But in addition, the low productivity found on farms where pesticides have long been in use suggests a second benefit, one that will accrue more gradually. "Farmers who are ill make poor management decisions and don't have the energy to work well," says Cole. "If pesticide exposure declines and the health of the farming population recovers, so too should its productivity and efficiency."

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To terrace or not to terrace

In the Cajamarca region of Peru as in much of the Andes, erosion is a serious threat to the future of agriculture. Terracing can offer an effective means of combating erosion, but only if it is introduced on slopes where it is really needed, and by communities willing to maintain the structures once they are in place. Tradeoff analysis is helping to engage local communities in decision making about terracing.

The government agency responsible for conservation in Cajamarca, PRONAMACHS (Programa Nacional de Manejo de Cuencas Hidrográficas y Conservación de Suelos), hopes to be able to allocate its scarce resources more effectively and to improve participation by using tradeoff analysis. Working with CIP and farmers, they are collecting data on rates of erosion across different degrees of slope and under varying forms of land use. The results will be used to derive tradeoff curves for soil erosion and value of production with and without terracing.

A well tooled strategy

The strategy for tackling El Carchi's pesticide problems is based on the use of key tools and approaches.

Farmer field schools (FFS) are allowing IPM knowledge and practices to take root in farming communities. (See also page 73.) Their greatest advocates are the FFS graduates who have confirmed the effectiveness of the measures in their own fields. FFS participants have reduced their pesticide applications from 12 to 7, and the amount of active ingredients of carbofuran and methamidophos they apply have declined by 75 and 40 percent, respectively. Less use of pesticides has driven down the cost of production by about 20 percent, from US$104 to US$80 per ton, and farmers are reporting further savings in what they spend for medical care. Twenty-seven farmers have been trained as FFS facilitators and are running additional schools. A manual on IPM practices has been published for their use.

Another effective tool traces pesticide contamination. Fluorescent tracers in three communities revealed the numerous "pathways" of pesticide contamination. These range from direct inhalation during preparation and application through contamination from contact with hands and clothing. During community meetings, the evidence of tracers on operators' hands and faces, on the clothing and skin of their children and wives, and on simple domestic objects such as the kitchen table, have been met with a stunned silence. Video footage of the tracer studies has also had media coverage, bringing this serious problem to the attention of the whole country.

When children like these girls in Chimborazo, Ecuador participate, FFS are especially beneficial

Whether this second benefit will be felt by the current farming generation or the next remains uncertain, because little is known about whether or not the effects of poisoning can be reversed. Long-term users may well have crossed a threshold beyond which a full return to health becomes impossible.

Despite this uncertainty, the study revealed a genuine win-win scenario. The higher yields made possible through better decision making and more productive labor can more than make up for any losses that might be caused by the reduced use of pesticides. The study fully vindicated the El Carchi team's efforts to promote IPM in the farming community, suggesting that more resources should be devoted to these activities. And it revealed the scope for policy interventions to reduce farmers' incentives to use the most toxic products, which are currently the cheapest on the market.

It is in this last area that tradeoff analysis has delivered its most striking results in El Carchi. The data from the health study were fed into the tradeoff model, creating a convincing tool for promoting policy initiatives. In 1999, the El Carchi team presented the results of its analysis at a provincial stakeholders meeting attended by 105 people from government, the chemical industry, NGOs and local communities. The group formulated what has since become known as the El Carchi Declaration, a statement of the principles that should apply to pesticide use in Ecuador. "Tradeoff analysis helped build the consensus that led to the declaration," says Crissman.

Since the meeting, the government has set up a national committee to oversee implementation of these principles. Building on the El Carchi Declaration, the committee has drafted a national plan covering tax and pricing policies, options for reducing and eliminating the most toxic chemicals, promotion of IPM packages and education of the next farming generation.

Pesticides have brought benefits to El Carchi's farmers, but they have also exacted a terrible price in human health. Tradeoff analysis is proving a powerful weapon in the fight to reverse this tragedy.

The El Carchi declaration

The El Carchi Declaration calls for:

- greater control over pesticide formulations and sales
- higher taxes, and eventually a ban, on the most toxic products
- the inclusion of pesticide impact information in basic education curricula
- the inclusion of IPM in agricultural degree courses
- more resources for research and training in IPM
- the promotion of awareness-raising activities
- direct support from the agrochemicals industry in implementing these initiatives

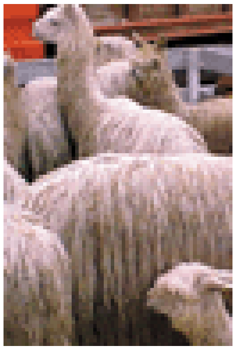


HABITAT

Better environments, better lives Since the mid-1980s, CIP has steadily strengthened the coverage of environmental issues in its research. By focusing on areas directly related to our core mandate, building on accumulated expertise and developing solid partnerships, we have managed to do so without overextending or venturing outside its areas of comparative advantage. In this section we provide three examples of CIP's work to ensure that agricultural research goes beyond improved crops to provide better, more secure habitats.

In the high Andes, home to CIP's mandate crops, support to new institutional approaches is triggering sustainable development. Center scientists are also developing powerful tools to study fragile highland production systems, thereby contributing to a wider and more informed vision of the many factors that impinge on development in these areas. In Vietnam, densely populated Hanoi is home to another emerging global concern: the environmental and human health issues associated with urban agriculture. CIP is contributing to the creation of viable options through research on recycling wastes from tuber processing and pig production. Research in a valley in Peru is highlighting a theme so new that the international research community has barely begun thinking about it: the implications of global warming for integrated pest management. CIP scientists are contributing information and analyses that will shed light on the complex interactions involved.

In all of these efforts, partnership holds the key to improving people's lives while protecting their environments.



Heading for the summit: Prospects brighten for the world's mountain ecosystems

Thanks to new ways of working together, people in the Andes are on their way to environmental and economic recovery after centuries of decline

Made in the Andes

"We've come a long way in a short time," says Roberto Valdivia. To prove the point, he shows his latest, full-color sales catalog featuring attractive young men and women wearing a North American fashion icon — alpaca sweaters. The catalog is tangible evidence that poor rural people can compete in international markets.

Valdivia is a director of the Centro de Investigación en Recursos Naturales y Medio Ambiente (CIRNMA), an NGO based at Puno on the shores of Lake Titicaca in southern Peru. The idea of CIRNMA arose from an earlier research project, the Proyecto de Investigación en Sistemas Agropecuarios Andinos (PISA), which explored opportunities for rural households to raise their incomes while protecting the natural resource base.

One of those opportunities involved improving production of fiber from alpaca, a camelid traditionally kept in large herds that graze the region's natural pastures. The project had attempted to introduce more productive pastures and animals, but these improvements hadn't caught on. "People weren't being offered a premium for quality," explains Roberto Quiroz, leader of CIP's Department of Production Systems and Natural Resource Management

Small businesses make life better for farmers, weavers and herders, providing new markets for their quinoa and wool.

Research. "Animals grow the same amount of hair whether they are hungry or well fed. So it always seemed better for producers to raise two thin alpaca per hectare than one fat one. However, the quality of the hair of badly nourished alpaca is very poor." Until they could realize the benefits of getting higher quality from improved pasture land or grazing fewer animals, the herders wouldn't be convinced of the need for change. The PISA team identified two ways out of this predicament: adding value to the alpaca fiber by processing it; and marketing alpaca meat alongside the fiber. CIRNMA was formed in 1992 to pursue these objectives.

Alpaca fiber is light, soft and warm, making it a pleasure to wear and an ideal protector against winter weather. Since it absorbs atmospheric moisture and is not very resilient, however, it is best combined with sheep's wool to give a more practical and durable garment. CIRNMA's first challenge was to develop the knowhow and install the equipment to make this higher-value mixed wool and alpaca product. Once this was done the aim was to break into the emerging international market for alpaca sweaters. The organization would guarantee quality and supplies while strengthening producers' bargaining power.

Ten years later, CIRNMA has become a flourishing small business. The main alpaca fiber producers are women who work in their own homes in around 40 local communities. Wool is knitted into sweaters at a new central processing plant near Puno, from which CIRNMA markets its products to both domestic and export outlets. "The export market is growing rapidly, especially for mixed wool and alpaca sweaters," says Valdivia. "This is great, because people keep mixed flocks, so we are adding value to both species." Now up to 7,000 sweaters are sold annually to buyers from North America and Europe.

Widening the view

CIRNMA has also gone in for the traditional Andean crop, quinoa. This nutritious grain's protein content boasts high amounts of lysine, an amino acid in which most other cereals are low. Quinoa makes good flour and a tasty flake that can be eaten as a breakfast cereal. There is an expanding market for organically grown quinoa among health-conscious consumers in Europe. But breaking into this market required radically different production and processing methods then those used traditionally.

CIRNMA began by obtaining improved varieties of quinoa from the national agricultural research institute. By using the new seed in combination with organic manure and more effective weeding, the organization's researchers were able to double average yields, to about 1200 kilos per hectare. The surplus is crucial to subsistence farmers who seek to enter the market. Following introduction of the improved production package through participatory research, nearly 900 farmers are now doubling their yields. After harvest, the grain is taken to the processing plant, where it is carefully sieved to remove impurities, and then washed to rid it of saponin, an anti-nutritional compound that can give it an off-taste. The quinoa is then either milled and flaked for export, or sold whole on the local market.

What will this entrepreneurial NGO take on next? Valdivia is keen to expand into meat, demand for which is growing rapidly as incomes rise. He has already begun processing and marketing beef, taking advantage of increased supplies following the introduction of simple innovations to improve calf survival and weight-gain in herds raised around Lake Titicaca. Now he plans to turn his attention to meat from sheep. In the longer term, alpaca meat is also an attractive option, since it contains less cholesterol than other red meat and so could be

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Quinoa: More is better

Quinoa has been an important food crop in the Andes for thousands of years. Now, this relatively unknown millet-size grain is attracting interest elsewhere in the world. And with due reason. Quinoa is not only rich in high-quality protein, vitamins and minerals, but also grows well in extreme conditions of drought, frost and soil salinity.

"Quinoa was prohibited by the Spanish conquistadores due to its significant religious value among the Incas," explains Sven Jacobsen, plant breeder and quinoa expert. "However, it was maintained by indigenous Andean populations until today, when the main drawback for its consumption is its image as a poor man's crop."

This perception has started to change thanks to interest from the outside world and to recent research. The United Nations Food and Agriculture Organization (FAO) has selected quinoa as one of the crops that will play an important role in ensuring food security in the 21st century. Since 1996, CIP has worked to improve quinoa, develop new uses and products, and increase its market demand.

The beneficiaries of this research are many. Small-scale Andean farmers have received improved seed and advice on optimizing agronomic practices. Micro-enterprises are benefiting from new varieties. And consumers have more and better quality foods to choose from. Collaboration has also enriched national research institutions' capacity, which could translate into further benefits in the long term.

The new quinoa-based food products include milk, bread, soft drinks, sprouts, protein concentrates and colorants. Research has also helped identify plants with especially high resistance to salt, drought and frost. (See page 85.) The availability of hardier quinoa varieties is expected to enhance nutrition and food security and to increase farmers' incomes. But, because current supplies are unable to satisfy the increasing demand for this grain from national and international markets, researchers are working to increase production and productivity. Over the past five years, quinoa production in the Andean region has grown by 50 percent.

Much work still remains to be done if this crop's full potential — as highlighted by FAO — is to be realized. In Ecuador, the World Food Programme (WFP) will contribute to promoting the crop by including quinoa in school breakfast programs, replacing imported commodities. To meet WFP's demand, the quinoa-producing area in Ecuador will need to be more than doubled. CIP and its partners in Ecuador are establishing a program (ECUAQUINUA) to help achieve this goal.

a healthy alternative to beef. The only drawback is the slow gestation of alpacas, a problem that needs to be addressed.

The benefits from CIRNMA's two most successful enterprises to date — wool and quinoa — flow directly to poor rural people who have few other options for earning income. The impact on their livelihoods is substantial: a woman trained to produce sweaters on the plant's new machinery can add up to US$400 yearly to family farm income, nearly doubling it; for families involved in both enterprises, the gain is even greater.

Replicating success

CIRNMA's success shows what can be achieved by linking poor producers to expanding global markets. (See related story page 55.) It also shows how new ways of working can enhance impact.

"When this research around Puno began in the late 1980s," says Quiroz, "CIP was deeply involved in all activities and had two professional scientists living in the area. Today, we support CIRNMA's research from Lima, mainly by telephone and e-mail."

To help replicate institutional innovations of this kind, CIP and its partners founded the Consortium for Sustainable Development of the Andean Ecoregion (CONDESAN) in 1992. CONDESAN is an umbrella association of public- and private-sector partners who work together on the full range of issues affecting rural livelihoods and environments in the Andes. The idea is to integrate research with development in just the way that CIRNMA does, but on a larger scale.

"Our aim is cooperative thinking for mountain ecosystems," says Elias Mujica, CONDESAN's deputy coordinator. "Projects such as PISA showed us that component research is necessary for development, but is not enough by itself." A more holistic approach, linking production with processing, is vital.

The holistic approach applies in other ways too. "Focusing on agriculture alone will not bring sustainable development in the Andes," says Hugo Li Pun, CIP's Deputy Director General for Finance and Administration. "We have to include other sectors. This means not just the obvious 'next-door' sectors such as forestry and fisheries but also those further afield, such as ecotourism and mining. Links with ecotourism are particularly important because this sector increases the demand for products such as handicrafts and processed foods." A broad alliance such as CONDESAN can solve previously intractable

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Spreading success

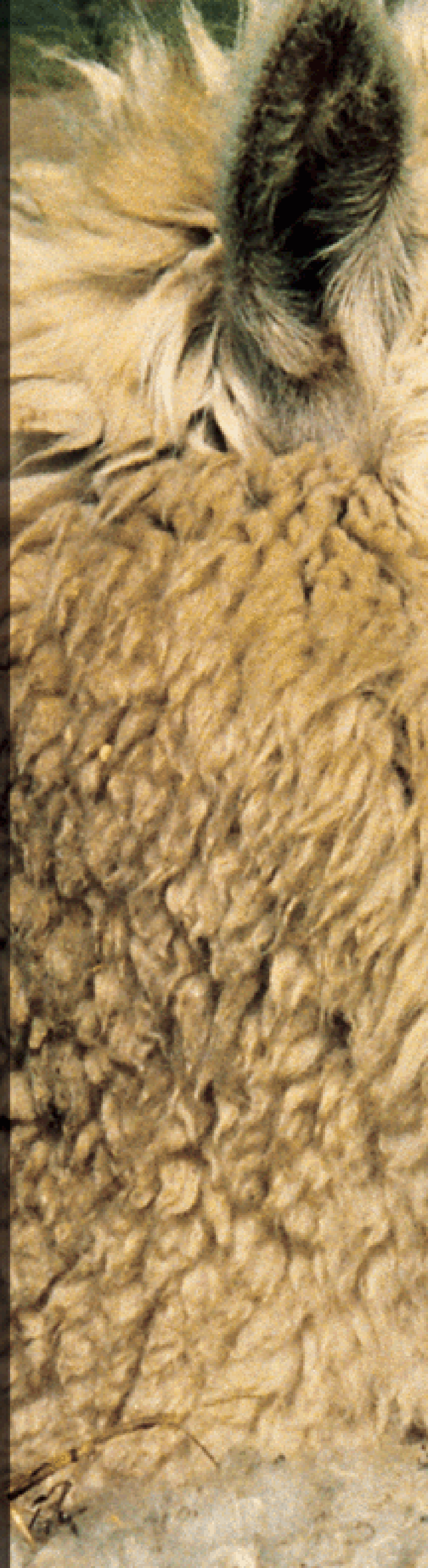
Several CONDESAN projects have successfully replicated the Puno experience by linking producers with more lucrative markets. For example, in Colombia's Rio Ovejas watershed, maize farmers who have switched to growing avocado for a fruit company stand to increase their incomes fivefold.

Meanwhile, researchers continue to find new uses for the Andes' lesser known crops, helping to conserve the region's rich genetic heritage. In Cochabamba, Bolivia, demand for olluco, a vitamin-rich tuber with poor storage qualities, has risen following the development of a method for drying olluco that allows the crop to be marketed year-round.

Interventions geared to raise farmers' incomes while protecting the environment have also proven highly successful. These include the construction of terraces together with the development of seed enterprises and tree nurseries in Cajamarca, Peru, and the introduction of saltbush as a forage species on land degraded by salinization near La Paz, Bolivia.

A new university campus in La Miel, Colombia, a community organization in La Paz, and a multi-institutional water forum in Cochabamba testify to the high success rates of institution building. Another institutional innovation, the *mesa de concertación* or round table, has proved effective in defusing contentious issues such as the sharing of water resources. This approach was first developed in Cajamarca, Peru, and is now spreading to other areas.

InfoAndina, the information arm of CONDESAN, has enabled thousands of people to join the region's debate on development issues. Electronic conferences, using low-cost e-mail, are especially popular, with 13 events held in the past 5 years. Traveling workshops are raising awareness of the opportunities afforded by the Internet against a background of rising connectivity in the region. "These initiatives are allowing the voices of poor, previously marginalized people to be heard for the first time," said InfoAndina's coordinator, Ana Maria Ponce. Since 1997, InfoAndina has acted as the Andean node of the global Mountain Forum, further broadening the circle of participants.



Alpacas, like llamas and vicuñas, are camelids native to the Andes

problems by tapping expertise across sectoral boundaries. One of the consortium's most valuable roles is to help resolve conflicts over the sharing of natural resources. This work is conducted using an integrated watershed approach in which stakeholders are encouraged to think about the effects of their actions on others.

CONDESAN is also a vehicle for tackling the difficult challenge of extending the benefits of research on a larger scale. This is perhaps the biggest barrier to impact in diverse mountain ecosystems, where every valley has different problems needing different solutions. There is scope for technology transfer, but usually not over large contiguous areas. Appropriate analytical tools and communication links are needed to spot opportunities for transfer, pinpoint needs for adaptation and encourage it all to happen. With CIP's support, many of these tools have been put in place and are enabling the consortium's partners to enhance and accelerate progress through better and more inclusive decision-making.

The key to impact in all CONDESAN's work is to unleash the creative energies of local people, enabling them to find their own solutions to the problems they recognize as priorities. Participation and empowerment have become clichés in the development lexicon, but the consortium's experience has shown just how important they are.

CONDESAN's impact is still limited. "We can't reverse the degradation of five centuries in just 10 years," says Mujica. But the consortium's many achievements, and the diverse sectors they span, testify to its effectiveness in marshalling resources to get things done — and get them done well. CONDESAN is now widely recognized as a highly effective model for integrated rural research and development — one that could prove useful elsewhere in the developing world.

Going global

The 1992 Earth Summit in Rio de Janeiro brought world leaders together to sign Agenda 21, an impressive declaration that committed them to better stewardship of the world's natural resources. Chapter 13 of the declaration, on mountain development, highlighted the fragility of mountain ecosystems and the poverty of the people who live in them. In 2001, as the world prepared for a second summit and the United Nations made plans to commemorate the International Year of Mountains 2002, it was normal to ask: "What has been achieved in the meantime?" The short answer is "not nearly enough".

Far too many mountain dwellers still face a deteriorating natural resource base accompanied by shrinking opportunities to earn a living. Yet there are exceptions — pockets of the Andes and other mountain regions where people have begun changing their lives for the better. A drive is needed to share these positive experiences far more widely.

A global dialog on sustainable mountain development is already under way. In 1997, the CGIAR responded to the needs set out in Chapter 13 of Agenda 21 by launching the Global Mountain Program (GMP), with CIP as its convener. The program links the partners in the Andes with similar multi-institutional approaches in the Hindu Kush region of Asia and the highlands of East Africa. Efforts in these two areas are coordinated by the International Center for Integrated Mountain Development (ICIMOD) and the African Highlands Initiative (AHI), respectively. The Mountain Forum, an electronic network that promotes the exchange of information among its 2500 individual and 150 institutional members, complements the GMP.

The Global Mountain Program has launched activities around the two main themes outlined in Chapter 13: knowledge about mountain ecosystems and their development; and integrated watershed development and alternative livelihood opportunities. In pursuit of the first theme, the GMP has concentrated initially on developing or adapting tools and methods, especially geographical information systems (GIS), and on training local professionals in their use. Already, over 200 people have received short-term training; a further 20 are completing degree studies.

With regard to the second theme, the program has selected nine "model" watersheds in the Andes and the Himalayas and produced a series of CD-ROMs describing each watershed and the options for its development. These CD-ROMs are proving popular with practitioners worldwide.

Despite these promising beginnings, the Global Mountain Program needs strengthening if it is to prove equal to its task. That's why CIP is proposing that the program become one of the new Challenge Programs being established by the CGIAR. This status would better reflect the vital contribution of mountain ecosystems to lives and livelihoods worldwide — and should, as a result, attract greater financial support.

Healthy competition

"Somos todos ganadores, we are all winners," was the verdict of one of the farmers participating in a novel project of the Peruvian Ministry of Agriculture in collaboration with the Global Mountain Program.

Launched in 1997, the project works in three mountainous areas of Peru where development stopped when Sendero Luminoso, the country's notorious guerrilla movement, became active in the 1980s. "The key issue we addressed is how to engage people, how to persuade them to change their minds about the way they manage resources," says project member Roberto Quiroz. To do so, the researchers hit upon two novel approaches.

The first was to engage communities in a competition for a cash prize. The project's leaders asked groups of seven to ten communities in several small watersheds to draw maps of their community, showing how it was in the past, how it is today, and how they would like it to be in the future. They then asked the communities to devise a plan for reaching the desired future state, offering US$1,000 for the best plan.

Second, each community was asked to name an individual known for his or her skills in a particular aspect of natural resource management. The project then funded that individual to train others in the community.

"The results have been astounding," says Quiroz. Innovations have mushroomed, covering a plethora of activities from collecting the seeds of threatened plant species, through promoting irrigation and reforesting eroded slopes, to introducing improved stoves and running cooking contests. The spirit of competition is catching on, with everyone trying to outdo his or her neighbor and villages spying on one another for good ideas.

The project is so successful that it will be doubled in size to include around 800 communities over a seven-year period. In addition, the Global Mountain Program is hoping to transfer the project design to the Hindu Kush.

Waste not, want not: Recycling wastewater helps poor urban households raise incomes

Starch processors in Hanoi can clean up their act without harming their livelihoods, affirm researchers working in SIUPA, the CGIAR's Systemwide Initiative on Urban and Peri-urban Agriculture

There's more to the muck than meets the eye

It's an ugly sight that gives off an even uglier smell: a drainage ditch full of a foul blackish liquid with lumps of solid waste runs through the middle of the village. At intervals along its banks, households add their effluent to swell the flow. At the lower end of the village, the current slows as the ditch turns a corner and runs into a pond covered by an evil-looking brown crust. Here some of the contaminants in the water settle before the sluggish stream flows on, banked by fields, until it reaches the next village.

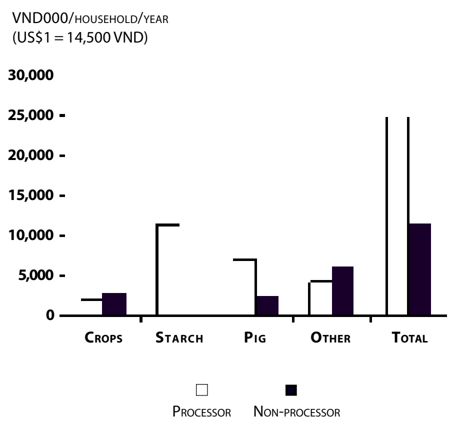
The noxious cocktail carried by the ditch is a classic example of what economists call "negative externalities". Behind the euphemism lies a form of pollution that is a serious health hazard and a source of considerable resentment. "It's a running sore between communities and neighbors that can erupt at any time," says CIP anthropologist and SIUPA Coordinator Gordon Prain.

What's in the cocktail? The wastewater is generated largely by an important source of employment and incomes in Greater Hanoi: processing of starch from cassava or canna. The starch is destined for a variety of products, including noodles, maltose and medicines.

Starch processing is a complex multi-tiered industry through which thousands of poor peri-

Benefits of starch processing

A comparison of average incomes in processing versus non-processing villages shows that processing allows families to double their incomes



urban households supplement their meager farm earnings. They supply crude starch to wealthier enterprises that refine it or turn it into finished starch-based products. The industry has also spawned a multitude of support services, such as the manufacture of starch-making equipment, the supply of enzymes needed to break down starch into maltose, and transport and fuel supply.

Large amounts of water are used to process starch, producing a runoff that carries a high proportion of suspended solids. CIP surveys in three villages found that a single season's processing generated some 1.45 million cubic meters of wastewater containing physio-chemical and microbiological contaminants in addition to nutrients such as nitrogen and phosphorus. But these processing by-products are not the effluent's only ingredients. Most of the households engaged in processing also raise pigs, the source of a slurry that is rich in nitrogen but also contains the bacterium *Escherichia coli* and a high count of worm eggs, both dangerous to human health. Human excrement and household wastes make the mixture even more potent. To make matters worse, most processing is carried out in the dry season, so the effluent is little diluted with rainwater.

Starch making also produces solid wastes. Those from cassava — peel, fibrous residue and low-quality "black" starch — are fed to pigs, but canna residues, which do not have a high feed value, tend to be unceremoniously dumped into streams or ponds where they add to the pollution of wastewater, or, worse still, on roadsides outside people's homes.

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Runoff from starch processing can pose serious health hazards

New choices, new risks

Migrant urban producers face conditions utterly different to those they may have known in the countryside from which they came. "Their overriding need is to make money fast," Prain notes. "In large part this reflects the struggle to get a foot on the ladder out of poverty in the new, highly competitive environment of the city, where nothing comes for free. But it also reflects the insecure land tenure and other risks they face." The land cultivated by peri-urban growers may be owned by speculators, who could drive them off it at any time; or it may be derelict land where soil and water resources have been poisoned by industry; or land left empty by other migrants because it is too close to a river and therefore subject to flash floods. Growers are often forced to cultivate roadsides, where passersby may steal the crop just as it reaches maturity.

The commodities produced, and the management practices used, reflect these risks. The poorest, who face the most insecure conditions, choose crops that demand a low initial investment and that reach maturity quickly. One example is Chinese spinach, which can be harvested within 25 days of sowing.

Because goats breed rapidly and can graze urban rubbish dumps and very poor pastures, they are the poorest's preferred livestock species. In contrast, more settled and secure households, where animals can be locked in at night, tend to graduate to sheep or crossbred cows. They may also invest a little in their enterprises, as the starch processors of Hanoi do.

Management practices often show great ingenuity in adversity, while also incurring high risks. For instance, a frequent sight in some cities is the blocking or diversion of sewerage pipes or channels in order to irrigate vegetables — a practice that endangers the health of both producers and consumers.

Working with Do Duc Ngai, of Vietnam's Institute of Ecology and Biological Resources and CIP scientist Dai Peters, Prain began investigating the effluent problem in 2000. Ngai and Peters selected four neighboring villages in Greater Hanoi — Cat Que, Duong Lieu, Minh Khai and Son Duong — three of which are centers for starch processing while the fourth, which lies further downstream, was the main recipient of the industry's negative externalities.

The project began by conducting a survey on attitudes to starch processing. "Everyone, even in the processing villages, said that the solid waste looked and smelled bad," says Peters. "Virtually all the non-processors thought that it also harmed their health. And even 84 percent of the processors admitted as much." Most people in the processing villages had had solid waste dumped outside their houses, causing arguments with neighbors. As regards the liquid waste, residents in the downstream, non-processing village frequently complained about the pollution and nasty smells arriving via the drainage ditch, which sometimes overflowed, flooding their homes. "They are clamoring for a solution," says Peters.

"But whatever the problems created by starch processing, we must not forget the importance of this activity to poor households," Peters continues. "Processing more than doubles their incomes." The extra cash earned directly from the starch, plus the value added to pig production using the by-products as feed, more than offsets the reduction in income caused by diverting labor away from crop production and other activities. "Interventions aimed at cleaning up the environment for the benefit of the public at large must do so without prejudicing the economic interests of the individual processor," says Peters.

Turning a problem into an opportunity

The project's main activity has thus been to look for ways of cleaning the wastewater and using it productively. The best potential use appeared to be as nutrient-rich irrigation water for dry-season crops. If the nitrogen and other nutrients in the water could replace some or all of the purchased chemical fertilizers and manure that farmers apply to these crops, the costs of production would fall, boosting profitability.

The challenge was to achieve this without increasing the risks to human health. "This involves a subtle tradeoff," notes Prain. "Processes that clean the water will also reduce its nutrient content. The safer the water, the less it will raise crop yields."

To investigate the tradeoffs, Ngai and Peters conducted two sets of experiments. The first was carried out using potted plants in the garden of a village school. Concentrations form 0 to 100 percent of wastewater were applied to the potted plants to determine how well the crops would perform and what would happen to the soil. In the second experiment, the researchers tested the effects of the timing and frequency of wastewater applications in farmers' fields. They were interested in seeing whether it was better to apply the wastewater to young plants during the first part of the growing season or to more mature plants later in the season, and whether weekly or fortnightly applications were better.

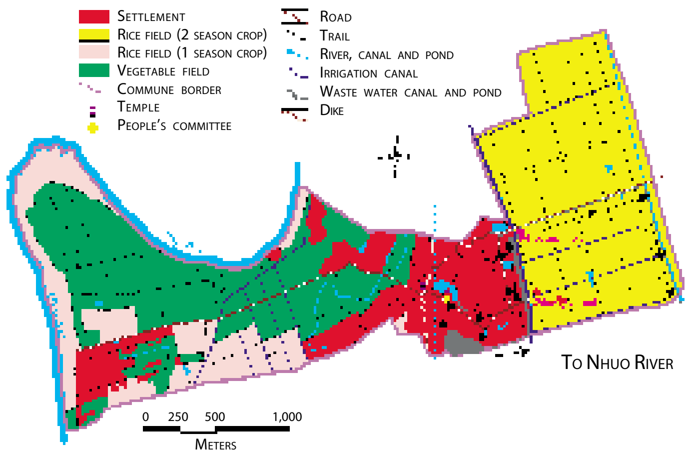
A further important aim was to find out the effect of settling on the quality and nutritive value of the water. To gauge this, the water was passed from one field to another over successive weeks. In the pot trial, the results were uniform across all the crops tested: the plants irrigated with 80-100 percent wastewater had the highest yields. The soil's organic matter content increased, suggesting that these yields could be sustained or raised still further over time. Soil salinity also increased, but not to a degree that would threaten crop productivity, at least in the short term.

The results of the field trial showed that in terms of plant growth, wastewater was most

Marketing canna roots and making starch and noodles are urban occupations in Hanoi, where captured wastewater can help farmers to grow better crops.

Duong Lieu Commune

This map shows the Duong Lieu Commune and the wastewater canal, running past settlements, settling ponds, treatment plants and experimental fields



effective when it was applied once a week during the early part of the growing season. This trial also shed light on best — and safest — practices in use of wastewater for growing human food crops. Researchers found that the window of opportunity comes after one week of settling, when the amount of *E. coli* bacteria and worm eggs is greatly reduced, but a sufficiently high nutrient content remains to make a difference in yields. After two weeks of settling, the microbiological contaminants have all but disappeared but the wastewater has also lost much of its nutritive edge over ordinary irrigation water.

Two crops used mainly to feed pigs, kangkung (*Ipomea aquatica)* and water taro *(Colocasia esculenta)*, responded particularly well to the trials. In the case of kangkung, yields rose to an astounding 130 tons per hectare — more than four times the yield achieved without wastewater. Water taro showed similar, though less spectacular, gains. These yield increases could lower the cost of feeding pigs, which seem to be immune to *E. coli.* But they also suggest another promising way forward: the safest and most productive use of wastewater could be achieved by passing it through a bed of kangkung or water taro for a week, on its way to a rice plot. "This way you clean the water in a way that adds no risk to human health, while providing the rice with water that is still fairly rich in nutrients," says Peters.

Research on the best irrigation practices for different crops continues. But whatever its outcome, only a certain proportion of village wastewater can be recycled in this way. The rest still needs to be cleaned before it passes on to other villages further downstream. The best opportunity for doing this occurs at the downstream end of the processing villages, where ponds or tanks slow the flow of the current. A "water accounting" exercise conducted by the International Water Management Institute, another partner in this project, found that some natural cleaning takes place as the water moves through these areas. This process could be improved by expanding the ponds or, more easily, by raising the level of the outflow at the bottom end of the pond, thus slowing the rate of flow still further. The next task will be to design and discuss interventions of this kind with villagers, and then to introduce them for testing.

Filling the gap

Problems of the kind researchers are investigating in Hanoi had received only sporadic attention from the Future Harvest research centers until the birth of the Systemwide Initiative on Urban and Peri-urban Agriculture in 1999.

"SIUPA is timely," says Prain, who coordinates the initiative. "The past 30 years have seen an explosion in urban populations and urban poverty. Peri-urban agriculture provides one of the few opportunities open to new migrants to cities for earning cash income," (see page 39). An estimated 800 million people already earn their living in this way, a number that will continue to rise rapidly through the first half of the twenty-first century.

SIUPA began its work by holding two stakeholder meetings, one in Asia and the other in Sub-Saharan Africa. The Asian meeting selected Hanoi, where CIP and other international research centers already had activities, as the pilot city. In Africa, Yaounde, Kampala and Nairobi all emerged as possible candidates, with Yaounde becoming the first to implement activities, under the leadership of the International Institute of Tropical Agriculture. In both regions, SIUPA conducts its work through partnerships involving national and municipal research and development groups, alongside international centers and organizations.

Peri-urban agriculture raises critical health and environmental issues that must be tackled if we are to meet the challenges posed by the broadening agenda of natural resources research. "It's a far cry from yield trials on new potato varieties," says Prain. "But the stronger partnerships made possible by SIUPA will enable us to make the most of our resources to tackle these issues."

Award for Partnership

The Sweetpotato Homegarden and Enterprise Development Project in Baguio City, Philippines, was granted the 2001 Pagasa Award for outstanding interagency collaboration in agricultural research and development. The public service award is given annually by the Philippines' National Civil Service Commission.

Led by the Northern Philippines Rootcrops Research and Training Center, the award-winning research project supports the development of sweetpotato-based homegardens and snackfood enterprises among poor urban and peri-urban households. Beginning as a small urban homegardens project in 1991, it has evolved to include a wide range of partners from health, education and nutrition agencies in supporting the national food security program.

The project is one of the participatory research efforts of Users' Perspectives With Agricultural Research and Development (UPWARD), a network developed by CIP and national research program partners in 1990, UPWARD is based in Los Baños, Philippines, and currently supports activities in several countries in South, Southeast and East Asia.

Insects feel the heat: Pest management expertise contributes to research on global climate change

Findings from Peru suggest that global warming is already affecting the distribution of crop insect pests. CIP and its partners are analyzing the implications

The heat is on

Global warming is with us, say scientists. Records show that average temperatures worldwide rose by 0.6ºC between 1900 and 1990. The latest models predict a further rise of between 1.4 and 5.8ºC by the year 2100. Along with hotter climates, we will have to contend with rising sea levels and more extreme weather events.

These trends have momentous implications for agriculture. There will be a dual shift in crop and livestock production: away from the equator to more temperate latitudes; and into the hills to escape heat or floods. Farmers will face new threats to their livelihoods and, as always when disasters strike, the poor will be hardest hit.

The international community is just beginning to come to grips with the challenges posed by global warming. The CGIAR system's first response was to form the Intercenter Working Group on Climate Change to coordinate activities and identify priority areas for future research. Recently the group proposed the theme "Beating the Heat: Climate Change and Rural Prosperity" as one of the system's new Challenge Programs. This proposal is being considered for implementation because of its high priority on the international research agenda.

CIP is contributing with its expertise in integrated pest management (IPM). Predictions in this field, as in all others affected by global warming, are fraught with uncertainty, but scientists agree that the current balance of insect populations is almost certain to be upset. For instance, some insects react strongly to relatively small changes in temperature and rainfall. Their altered distribution could be one of the first indicators that global warming is taking hold.

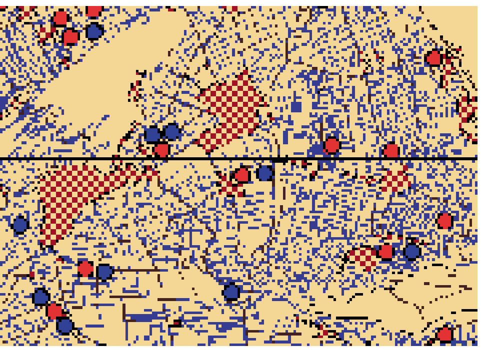
"Expect the unexpected," says CIP entomologist Aziz Lagnaoui. "Climate change will favor invaders over native species. Some insect pests will become more important while others will decline, but the net effect will be to increase the pressure of pests on crop yields and therefore on farmers' incomes." Lagnaoui's ideas may have seemed mere speculation until dramatic evidence emerged from a valley in southern Peru.

Farmers in Cañete Valley have learned that managing pest populations is a constantly evolving science. IPM is helping them to keep on top of changes

The Cañete Valley laboratory

Around 150 kilometers south of Lima, Cañete Valley is one of the powerhouses of Peruvian agriculture. For two-thirds of its length, the river that gives its name to the valley tumbles through steep gorges, carving its way through the western flanks of the Andes. But as it approaches the Pacific Ocean the current slows and deepens, entering a broader plain. Here, on the flat valley floor, farmers grow cotton, potato, sweetpotato and other crops in an intensive production system. Much of the harvest is destined for urban markets, especially Lima, or for export.

Cañete farmers face the usual array of insect pests that typically plague such systems, including the ubiquitous whitefly *(Bemisia tabaci* and related species*)*. When whiteflies are few in number, their feeding on crops does little damage. But if sprayed, they soon develop resistance and multiply, especially in systems where cropping is year-round. At high population densities, whiteflies can devastate whole crop stands, giving them a characteristic "silver-leaf" or burned appearance. Whiteflies are also vectors of some serious viral diseases, particularly mosaic and mottle viruses.



and to safeguard their crops, their environment and their profits.

The *Bemisia* genus is highly diverse, with many different biotypes and species occurring around the world. Until recently, only biotype A of *B. tabaci* — which is common throughout the tropics and usually causes only moderate yield loss — was found in Cañete Valley. In 2001, however, a more aggressive whitefly, biotype B, was identified. According to farmers, it arrived during an El Niño year when the climate in this part of Peru was hotter and drier than usual. But instead of disappearing when the weather reverted to normal, the pest apparently adapted to its new environment, where it is now inflicting severe damage on yields and farmers' incomes.

Biotype B was detected during routine surveys by Peru's national entomology service, whose scientists alerted Lagnaoui and his colleagues at CIP. The two institutions decided to make the valley the subject of a more detailed study, which would form part of the Whitefly IPM Project of the CGIAR Systemwide Program on Integrated Pest Management. Working with Pamela Anderson, an entomologist based at the Centro Internacional de Agricultura Tropical (CIAT) in Cali, Colombia, Lagnaoui and Peruvian colleagues carried out extensive fieldwork in Cañete Valley.

What they found was cause for serious concern. The presence of *B. tabaci* biotype B was bad enough, but it was not wholly unexpected because this insect has been found elsewhere in Latin America. Research revealed, however, that another whitefly, *B. afer*, had also arrived. This species, which is even more aggressive than biotype B of *B. tabaci,* is normally restricted to the hotter, drier climates of Africa and had never been reported before in the Americas.

"*B. afer* is now widespread in the valley and is causing serious damage to crops there," says Lagnaoui. "On sweetpotato it is even out-competing biotype B of *B. tabaci*." Particularly worrying is the fact that farmers are increasing

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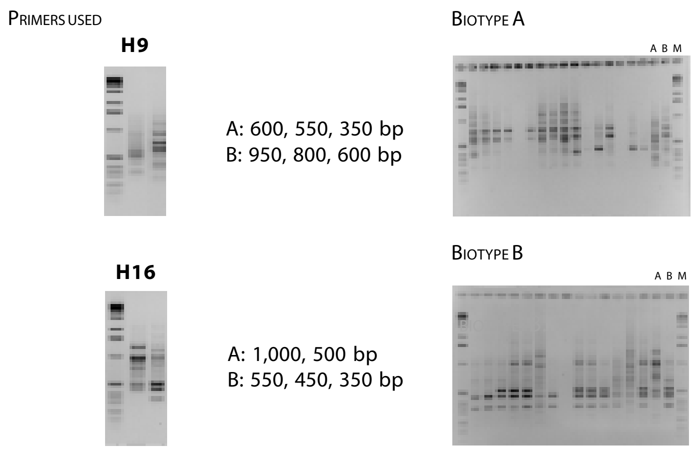
Climate change and insects: Some key questions

The complex interactions between global climate change and crop insect pests raise some major questions:

- How will changes in temperature and rainfall affect pest populations and distributions? Pests vulnerable to high temperatures may decline in numbers or move to higher latitudes or altitudes. There could be population explosions in species that respond to higher rainfall or drought by increasing their feeding and/or breeding behavior. New biotypes and species could evolve.
- How will the increased atmospheric carbon associated with global warming affect plants and insects? It could stimulate plant growth, increasing the amount of feed available, although this effect may be offset by drought stress. More carbon could reduce the nutritive value of plants, causing some insect species to decline but others to multiply as they step up their feeding behavior.
- How will relationships between insect pests and their natural enemies change? Some natural control mechanisms could "decouple" as the populations of pests and predators react differently to changes in rainfall and temperature.
- How will crop resistance or tolerance to insects be affected? Some cultivars could prove more vulnerable to pests as a result of stress caused by higher temperatures or other climate changes.
- How will changes in the pressures from insect pests interact with those from diseases and weeds? The host plants available to insect pests could vary if warming favors some weeds over others. Changes in the populations of insect vectors of plant viral diseases may alter disease incidence. Climate could also induce changes in the incidence of fungal diseases.

Electrophoretic patterns in whitefly samples from Cañete Valley

New biotechnology tools, such as RAPDS (randomly amplified polymorphic DNA), help to evidence differences between biotypes of the *B. tabaci* species



their pesticide applications to control the newcomers. The result could be rising levels of resistance, eventually leading to crashes in yields and incomes, as has been the case elsewhere in the developing world.

While Lagnaoui and his colleagues collect data on pest distributions, other CIP scientists are analyzing climate data for the valley to find out how its weather has changed over the past 50 years. The aim is to match the data on pest populations with information on changes in temperature and rainfall. If patterns are detected, the analysis will be broadened to cover other valleys on the Pacific Seaboard, with a view to obtaining a more comprehensive picture.

"At the moment, we are caught in the typical predicament of scientists who make discoveries of this kind," notes Lagnaoui. "Report too early, and you court accusations of inadequate science coupled with sensationalism in order to attract funding; report too late, and farmers, politicians and the public ask, why didn't you warn us?" Early confirmation of similar findings in other locations will ease that dilemma.

Tracking pest movements

There is good reason to suspect that the new pests have spread beyond Cañete Valley. An insect similar to the whitefly, the leafminer *(Liriomyza huidobrensis),* has, in less than ten years, risen from comparative insignificance as a minor pest on a few vegetables to the status of a serious international problem. Population explosions have been reported globally, with the most serious outbreaks occurring in the intensive production systems of Asia and Latin

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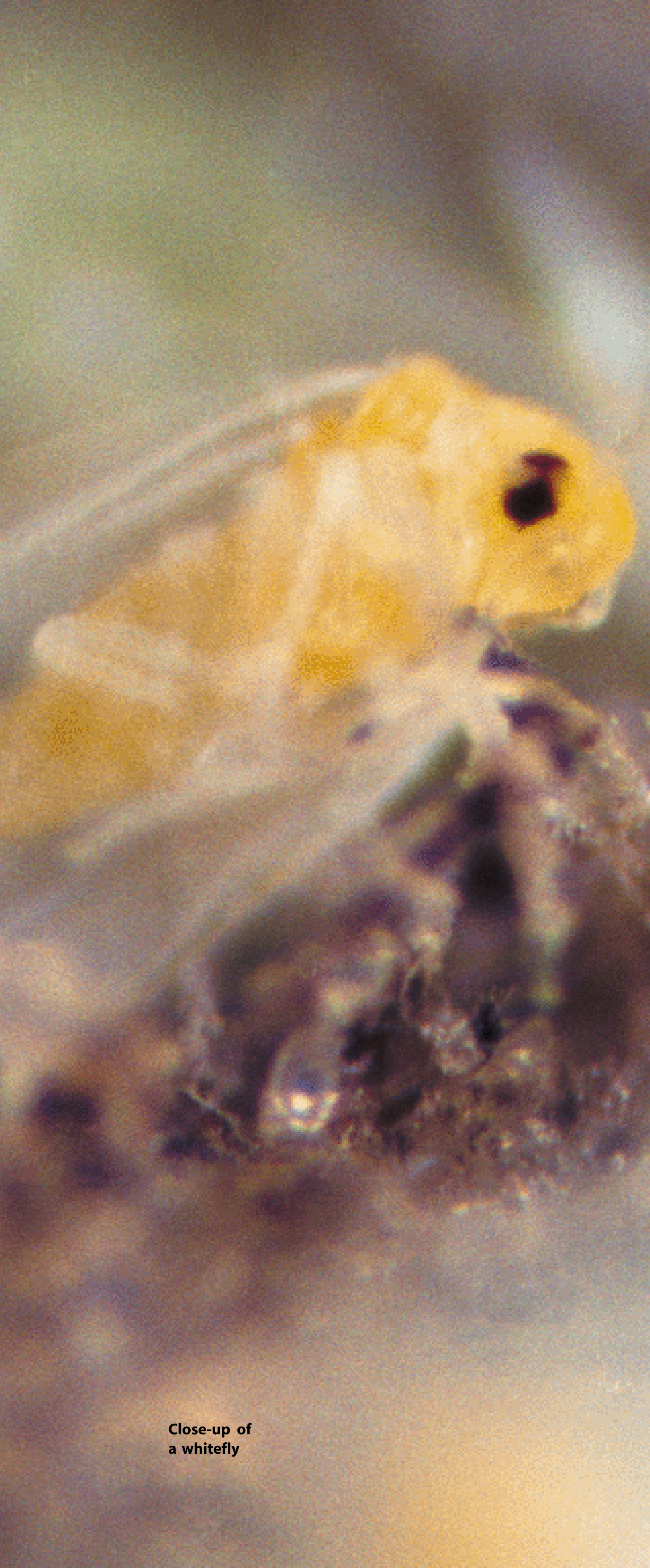


Close-up of a whitefly

Honing the tools

Researchers will need to explore and perfect the use of all the tools they can muster to help us manage the IPM challenges related to climate change.

Satellite imagery, for instance, can be useful for tracking pest movements — at least in theory. Heavy pest densities reduce photosynthesis and crop growth, leading to higher reflectance in the red band of the light spectrum. But such reflectance could be caused by other factors, especially drought or the overgrazing of pastures.

That's why it's vital to combine satellite imagery with climatic data. "Only when high reflectance coincides with high rainfall can we postulate that pests are involved," says Lagnaoui. "And even then, we have to rule out human factors, such as a farmer's decision to harvest early, graze the area with livestock or simply leave the land fallow."

Ground truthing to find out exactly how the land has been used is needed to back up satellite imagery. And it may not be possible to do this until after the pests have moved on, leaving scientists none the wiser as to their identity. These complications mean that the science of using satellite imagery to understand pest distributions is only gradually becoming exact.

America. In Cañete Valley, the pest has long been reported on peas and beans but has recently begun to feed on other crops as well. More polyphagus tastes on the part of a pest are commonly the prelude to a steep rise in its numbers.

In these cases of rising population levels, it is difficult to single out the causes. Climate is one of a complex set of inter-related factors that could be causing the changes. Other are associated, for instance, with intensification of production. In leafminers as in whiteflies, pesticides seem to have been a large part of the problem, fostering resistant strains and killing off the pests' natural enemies. In Cañete Valley, resistance appears to have developed in leafminers when the pest was restricted to peas and beans. The spread to other crops probably has occurred since the most recent El Niño event raised temperatures in the valley.

Modern science is contributing to the analysis by providing tools that can help us to understand just how pests spread. At the request of Lagnaoui and his colleagues, for instance, a scientist in the USA is conducting detailed DNA analysis of different biotypes of leafminer, with a view to tracking their movements worldwide over the past decade. The tools of molecular biology will provide a clearer answer than human eyes can, because the different species of leafminer, like those of whitefly, are difficult to distinguish by appearance alone. "So far, the analysis suggests that the most widespread biotypes are Latin American in origin," says Lagnaoui.

Managing change

In the face of global climate change, IPM strategies and technologies may need a radical overhaul.

Increasingly, plant breeders will need to combine pest resistance with tolerance to factors such as heat and drought when they develop new varieties. The search for such tolerance has made good progress in a few dryland cereals, such as pearl millet, sorghum and durum wheat, but has been less successful — or hardly attempted at all — in most other crops. Flexible global arrangements will be needed to facilitate the speedy exchange of germplasm with the necessary resistance characteristics.

The shift away from chemical pesticides towards bio-insecticides will doubtless continue as an IPM strategy. Some bio-insecticides, however, are highly susceptible to rises in temperature and ultra-violet radiation. For example, the half-life of commercial preparations based on the granulosis virus — widely applied as a dust to stored potatoes to destroy the potato tuber moth and other pests — falls by 60 percent when temperatures rise from 25ºC to 30ºC. Storage temperatures in North Africa frequently reach 31ºC and stand to go higher as global warming takes hold. Already, these preparations can rarely be applied in the field under tropical conditions, because — unless they are mixed with a UV-protectant — they become ineffective within a few hours.

"We must be alert and ready to respond quickly to changing conditions," says Lagnaoui. That implies a need to improve capabilities for detection of early signs of changes in pest pressure, strengthen links between all relevant partners and increase investment in farmer field schools and other participatory approaches that can help educate farmers to keep a close watch on their crops and deal effectively with problems as they arise. And these farm-level approaches will need to be linked to stronger public-sector advisory services at regional and national levels.

In short, the international community has its work cut out if it is to meet the challenges of global warming. CIP's IPM experts are poised and ready to help.

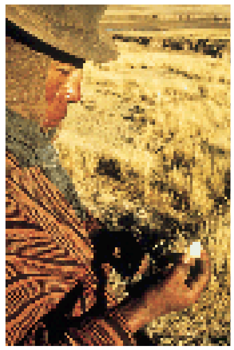


HUNGER

Less poverty, less hunger During the 1980s it became clear that putting an end to hunger involved much more than guaranteeing food production; economic access to food was just as important.

An estimated 1.3 billion people, nearly a third of the population of the developing world, lives on less than US$1 a day. Improving this condition has been described as the greatest single moral challenge facing humankind. In response to this challenge, the CGIAR's mandate, and with it that of CIP, was broadened to embrace the closely intertwined goals of providing a way out of poverty while putting and end to hunger. The articles in this section give an idea of how this can work.

At the core of CIP's efforts to improve the lives of the poor is crop germplasm, the raw material on which agricultural scientists depend to combat hunger and poverty. The first article in this section looks at efforts to save some rare Andean crops from extinction while turning them into cash-earners for the region's resource-poor farmers. Our second story shows how China has achieved massive reductions in the number of its poor and hungry over the past 20 years, largely thanks to the creation of a conducive policy environment. Potatoes, of which the country is one of the world's largest producers, and cooperation with partners such as CIP have been part of the formula. Another key to improving the link between livelihoods and food security is a tight focus on the needs of farmers. Today, they have a far greater say in research planning and implementation than they did 20 years ago. Our third article explores the evolution of the farmer field school, a useful vehicle for involving resource-poor farmers in the research process and for extending its results.



Tapping into biodiversity: Research on neglected Andean crops set to pay dividends

A little public-sector investment goes a long way towards saving the threatened genetic heritage of the Andes—especially if it helps develop new markets

Kitchen table research yields a prize-winner

"Mmm, that's nice!" says Felipe, licking his lips. Felipe is a 6-year-old boy whose taste for natural sugars has triggered new thinking in ongoing research at CIP.

Earlier that evening, Felipe's father, CIP scientist Michael Hermann, had brought home some strange-looking, blackish-skinned roots, which he had first chopped then put through a juicer in the family's kitchen. Reduction by boiling had resulted in a small amount of thick, dark syrup, which Hermann had offered to Felipe and his older sister, Barbara, as a before bedtime treat.

The source of the syrup was a traditional Andean root crop, yacon *(Smallanthus sonchifolius)*, domesticated centuries ago. Until recently, yacon remained little known outside its original habitat, modern-day Peru, Bolivia and Ecuador. Now, scientists believe, it is about to become a household word in many other countries, thanks to its remarkable health-promoting properties.

Juicy yacon roots are rich in oligofructose, a carbohydrate that, although sweet, carries no calorie penalty because it is not absorbed by the body. In addition, as it passes through the colon oligofructose is fermented by beneficial bacteria in a process that lowers pH, leading to improved intestinal health. Oligofructose also lowers the blood's triglyceride content, increases the body's uptake of calcium and improves vitamin B synthesis.

Because of these properties, consumed either fresh or processed, yacon can help prevent such conditions as constipation, cancer of the colon and osteoporosis. Yacon is, furthermore, a hardy crop and can be grown without chemical fertilizers and pesticides, making it an ideal candidate for the organic as well as the health food market.

CIP got to know yacon in the early 1990s, when it implemented a collaborative research project on nine Andean roots and tubers that had been largely overlooked by researchers. The project involved studies of the crops' distribution and diversity, as well as germplasm collection. This prepared the way for later research on processing and marketing. The idea was to save the region's threatened biodiversity while creating new income-earning opportunities for farmers.

It was during this project that Hermann first became interested in processing yacon. One day he crushed samples of the tubers and tried to make jam from them in the laboratory, but the results, obtained without removing the fiber or adding lemon juice to prevent browning, were disappointing. "All I got was a kind of primeval green slime," he says.

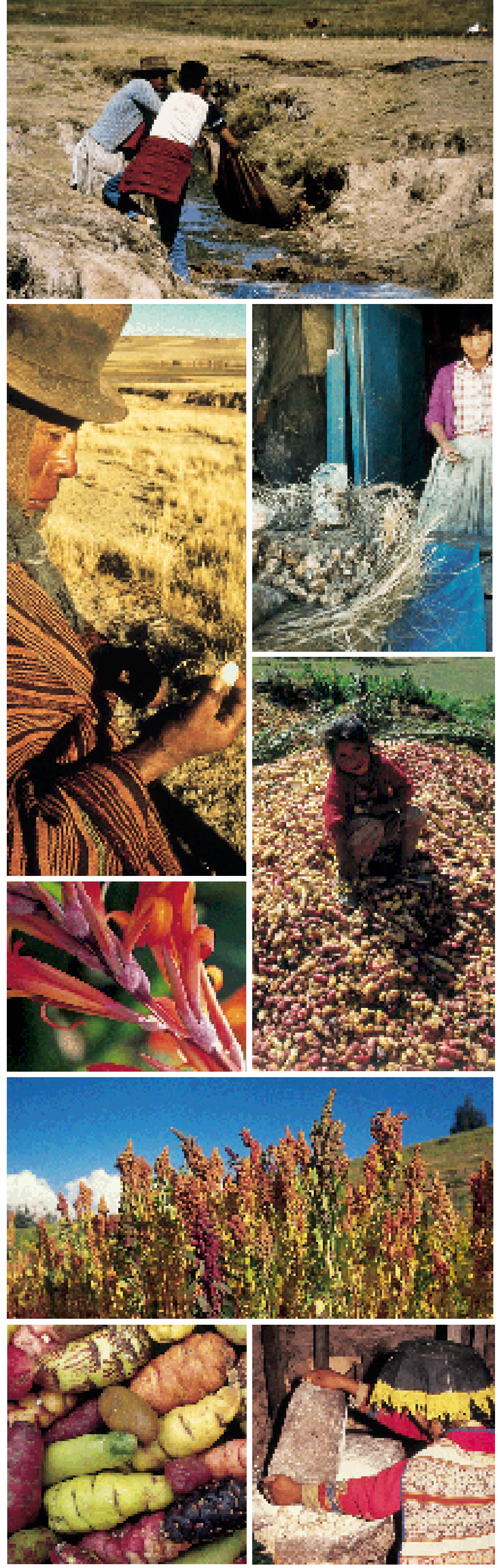
Three years later, Hermann's interest was rekindled when he was appointed head of CIP's postharvest project. "We were on the lookout for new products that farmers could make easily in their own homes," he says, "so I decided to have another go." The family kitchen seemed the ideal place to start.

After successfully pilot testing the syrup on his children, Hermann transferred work on the new product back to CIP laboratories, where he and his assistant Ivan Manrique began by following procedures that are well charted for many fruits. They experimented with using variables like adding lemon juice and other antioxidants, peeling roots and filtering the syrup. They also got hold of a special evaporator adapted for use over a wood-burning stove that was originally developed in Canada for making maple syrup.

But the most important variable was the roots themselves. CIP scientists contacted colleagues at the university of Oxapampa in central Peru, where the crop had long been grown. Together they made contact with a group of farmers, who were immediately interested in finding a new market for their crop. The farmers began to work with the researchers to identify plant types that had large, succulent roots with a high oligofructose content. Hermann and his colleagues, in turn, agreed to help the farmers organize a yacon growers' association and build a pilot plant to process the syrup.

In late 2000, Hermann and Manrique decided to enter the newly perfected syrup in Peru's Innovación Tecnológica Agro-Industrial, an annual competition offering prizes for new products with potential to increase the incomes of poor rural people. "I didn't think we had a chance of winning," says Hermann. But to the scientists' delight, the product earned first prize, which carried a cash award of US$8,000. The sum was just enough to fund the projected processing plant.

The prize also brought a surge of publicity and commercial interest in yacon, encouraging Hermann and his colleagues to conduct research on marketing. They are now developing a brand name and label, and are conducting surveys on consumer acceptability. If their research continues to be successful, Andean farmers will soon have a new source of income to help them protect — and promote — a long neglected crop.



The Andes are home to unique root and tuber crops and high-protein grains like quinoa.

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Developing diversity

The ancient inhabitants of the Andes domesticated many species of edible roots and tubers. Among these, only the potato has taken on international importance. CIP's research to make the most of under-utilized Andean genetic diversity focuses on:

- three little known tuber crops: mashua, oca, and ulluco; and
- six promising root crops: achira, maca, arracacha, ahipa, mauka and yacon
- the more than 3800 known native Andean potatoes (*Solanum* spp)

The Center and its partners adopt a two-track approach: ensuring that germplasm is conserved — both in genebanks and in farmers' fields — and characterized; and identifying and developing new products and markets.

Not only are both tracks equally necessary — they are mutually supportive. As farmers begin to experience the benefits that these species can bring to their own and their communities' livelihoods, they are more likely to conserve them. Likewise, genebanks help to safeguard the materials that will be needed by tomorrow's plant breeders to develop new and better products.

Colorful chips made from native Andean potatoes

Spuds go up-market

Some resemble butterfly's wings; others have concentric circles, like agate; one bears the outline of a bicycle wheel, another of a starfish. With their delicate designs in orange, red and purple, these patterned potato chips look like miniature works of art (see previous page). But the patterns are natural, of course, each representing a unique cross-section of the multifaceted potato tuber's diversity.

"The chips are made from just a few of the more than 3800 varieties of native Andean potatoes," explains CIP's marketing expert Thomas Bernet, who works closely with Hermann. These varieties are a source of pride to the region's resource-poor farming communities, who often greet visitors with *papa regalo*, a gift of potatoes reflecting local diversity. Farmers typically grow up to 40 types of native potato in the same field. But many of these varieties are found only in the areas where they have evolved over centuries, and few make it as far, even, as the Lima market.

That the chips exist in prototype owes everything to the vision and commitment of CIP plant breeder Merideth Bonierbale and her research associate, Walter Amoros. The two began to explore possibilities with the chips unofficially, at a time when such work fell outside the scope of CIP's research agenda. "We were considered truant when we first announced our results," says Bonierbale. "But we have since found a legitimate home in CIP's new project on postharvest utilization, launched when the Center revised its mandate to include this kind of work." Product champions like Bonierbale and Amoros can be essential in focusing attention on the potential of minor crops, which are often left off the research agenda.

Under Bonierbale's guidance, Amoros spent three years screening 400 varieties for their processing aptitude while keeping up with his other duties in the breeding for resistance area. This exercise led to a short-list of about 50 varieties with exceptional processing qualities, from which seven were selected for inclusion in chipping tests.

Throughout the process, the scientists have kept in close touch with farming communities that grow these varieties, involving them in on-farm conservation and participatory evaluation. The farmers view the colored chips with enthusiasm and are keen to get the product into the market.

"For the purposes of processing, these varieties beat conventional potatoes hands down," says

Bonierbale. The tubers have a higher dry matter content, so they absorb less oil when frying. They are also tolerant to cold, making them less likely to darken. Everyone who has seen the patterned chips agrees that they would make a unique gourmet item. And the coloring denotes the presence of antioxidants, adding a plus on the health side. Best of all, the chips are very tasty, with a full flavor quite unlike the blandness of most modern varieties.

In the era of globalization, characteristics such as these can make the difference between a species' extinction and its survival. As borders open and economies liberalize, developing economies will find it hard to compete in the already saturated market for conventional food products. Instead, argues Bernet, they should act fast to enter the emerging markets for gourmet, organic and fair-trade foods.

"Small-scale farmers in the Andes have a competitive advantage in these niche markets," says Bernet. "Their produce comes from an environment high above the pollution of the lowlands. The possibility of helping to lessen their poverty gives an added appeal on equity grounds. And their land is renowned for its beauty, giving plenty of scope for attractive packaging."

Ancient delicacies

Bernet and his colleagues will share the responsibility for marketing the chips with Papa Andina, a project established to promote Andean potato species by developing new products and markets. The project works with national partners in Bolivia, Ecuador and Peru.

One native species, *Solanum phureja*, is already gaining ground. It produces small, deep-yellow tubers that, like the colored chips, are as tasty to eat as they are attractive to look at. "The image of these potatoes is a far cry from the working-class spud," says André Devaux, Papa Andina's project leader. "They are begging to be served at tables in city restaurants." Only two countries, Colombia and Ecuador, export this delicacy at present. Devaux is investigating the potential for expanding the market, particularly in the organic-foods sector.

Another product that could soon be consumed more widely is *chuño blanco* or *tunta*, made from bitter-tasting potatoes that can be toxic if eaten fresh. In this case, an ancient processing system adds to the product's interest. Tolerant of frost and insects, the bitter varieties are grown at high altitudes on the *altiplano* (high plains) of Bolivia and Peru, where most other varieties perform poorly.

Farmers harvest the crop from May to July, leaving the tubers out at night in temperatures that sink below zero. Once the frost has broken down the tubers' tissue, their water is expelled by treading on them. This is usually done by women who take their shoes off in order to experience the right "feel" for the work and so bring just the right amount of pressure to bear: the aim is to gently squeeze, but not crush, the tubers.

Once trodden, the potatoes are left to dry during several hot highland days before being soaked in water to totally rid them of their toxic compounds, then redried. Besides making bitter potatoes edible, chuño can be stored for long periods with no refrigeration. To use the tubers, cooks simply rehydrate them.

At present, the market for chuño blanco is almost entirely local, but there are indications that other markets could develop. Peruvian and Bolivian immigrants in cities such as Buenes Aires often ask their relatives to bring the precious freeze-dried tubers when they visit, and small surpluses occasionally find their way to urban fruit and vegetable stalls. Papa Andina is investigating the possibility of broadening chuño's appeal by improving its quality and presentation.

Strategies for small-scale producers

While new products undoubtedly offer tempting opportunities, small-scale farmers need to look carefully before they leap, warns Devaux. CIP can play a critical role by analyzing the pros and cons of entering the market.

The Center has developed a set of criteria for this purpose. "The first thing we ask is whether the product requires labor or capital," Devaux says. "Labor is something the resource-poor farmer can provide, whereas large amounts of capital are not." The yellow potato is a case in point: the small tubers are planted at high densities, ruling out the use of machinery for harvesting and so rendering the crop unsuitable for large-scale farmers.

Quality requirements are a second criterion: unlike tuber size, which can be assessed relatively easily by digging up a plant, processing characteristics such as chemical content must be measured in a laboratory, putting the resource-poor farmer at a disadvantage.

A third, closely related criterion is riskiness. "A small-scale farmer cannot wait until next year if his or her produce fails to meet market specifications," says Devaux. "A certain amount of risk is inevitable, but it should be kept to a minimum."

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New weapons in the war on late blight

Modern biotechnology is helping CIP and its partners add value to biodiversity by unlocking the secrets of crop genomes. An example is CIP's work on late blight, the most serious disease of potato worldwide. (See also pages 76, 79 and 83.)

CIP's conventional breeding program has been successful in developing varieties with partial resistance to late blight. However, conventional screening for resistance genes takes up a great deal of time and space. Biotechnology is contributing by enabling these genes to be identified and tracked through successive generations of plants quickly and accurately, while offering tools that can also help combine or "pyramid" resistance genes.

CIP's scientists began by using genetic markers to identify a "core" collection of varieties with distinct sources of resistance. The markers allowed them to efficiently detect duplications and misclassifications at the genetic level, thereby reducing the time and costs of subsequent work.

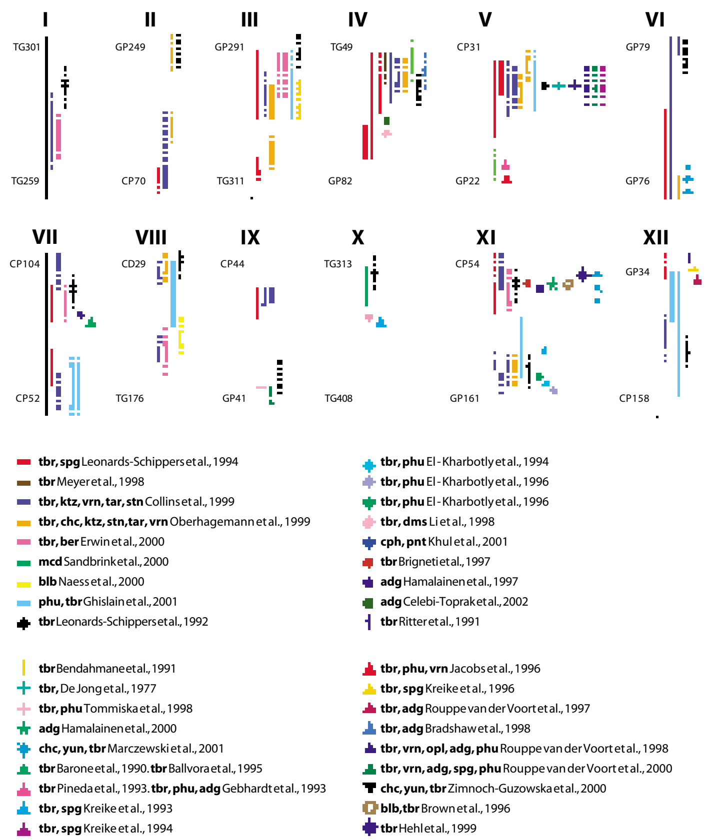
Next, the scientists crossed a native Andean potato species, *Solanum phureja*, with a potato plant known to be susceptible to late blight. By studying the inheritance of resistance in offspring they were able to make a genetic map showing the chromosomal regions or quantitative trait loci (QTLs) that contain resistance genes (see next page). This exercise gave rise to a number of markers thought to indicate resistance. The scientists are now field testing 100 lines of *S. phureja,* correlating their resistance with the presence or absence of these markers.

Two different strategies are being followed to zoom in on the genes themselves. The first involves the use of "candidate genes", which are likely to be implicated in resistance to late blight because they have already been found to play a role in disease resistance in other plant species. The sequences of candidate genes are downloaded from the Internet or obtained from the literature and matched against those present in a given QTL. The mere presence of a candidate gene at a QTL, however, doesn't prove that it is responsible for resistance. This could be a coincidence, with the gene that is really responsible lurking close by. Hence the second strategy, which consists of trying to detect differences in the behavior of genes in response to infection. To do this, the scientists will use a highly sensitive, high-throughput technology known as micro-arrays to tell them which genes are "switched on" or off.

Once the resistance genes in each QTL have been identified, they can be transferred to susceptible but more productive varieties using either marker-assisted selection or genetic modification. Either way, the end result will be a product of immense value to farmers: potato varieties with more stable resistance to a disease that currently devastates their yields and hence their incomes.

Resistance gene consensus map for potato

Compiling information from genetic maps of several *Solanum* species helps breeders to identify potential sources of unique resistance and corresponding genome regions for incorporation into new varieties



Farmers also need help in developing the terms on which they will do business and in finding reputable companies that will accept those terms and stick to them. "As a public-sector institute, our job is to take the part of the small producer," says Devaux. "Resource-poor farmers are often inexperienced in dealing with buyers and their bargaining power tends to be weak." They need to form collectives to protect their interests, as well as to organize production and delivery or to carry out processing at the village level — another area in which CIP can provide advice.

The benefits from this type of backing are multiple. They include increased income flows for farmers; more jobs in processing, packaging and marketing; new high-value products for consumers; and a safer future for some unique crops. This is a remarkable pay-off for a small initial injection of public money.

Carlos Ochoa wins William L. Brown Award

Reputed Peruvian scientist Carlos Ochoa, who has devoted most of his life to exploring remote territory to rescue ancient potato species from extinction, added a new honor to his already long list of achievements in 2001. The American scientific journal *Diversity* named him the first winner of the William L. Brown Award for Excellence in Genetic Resources Conservation.

"We are proud to honor this man who labored for years in a developing country with limited resources and accomplished so much," said Don Plucknett, Chairman of the Selection Committee, who announced the award in Washington DC in December.

Ochoa, CIP Scientist Emeritus, was chosen for the prize from a list of 30 prominent scientists from all parts of the globe. A prolific author, Ochoa has published over 100 scientific articles and numerous books on potato taxonomy and breeding.

During his long and distinguished career, Ochoa has discovered some 80 wild species of potato (almost one-third of all those known), and has had three species named for him. He has collected and classified more than 12,000 accessions of wild and cultivated potatoes and has developed a dozen potato varieties.

Cooperation pays: CIP supports China's drive to end hunger and poverty

CIP's collaboration with China's potato research programs dates back to the mid-1980s. In the early 1990s, the partners singled out China's south-western provinces as meriting special attention

A rural backwater

Media coverage of China's economy tends to focus on the booming cities of the lowlands and the coast where annual growth tops 10 percent. The country's mountainous rural hinterland, where the pace of development is much slower, attracts less attention. This is, however, where China's estimated 60 million poor and hungry live, most of them in the densely populated southwestern provinces of Chongqing, Guizhou, Sichuan and Yunnan.

Paradoxically, many of this region's hungriest people are farmers. Typically they are solitary women or older married couples, often belonging to minority cultural groups, who raise crops and livestock on tiny farms of less than 0.25 hectare. They supplement their meager incomes from agriculture with remittances from their husbands or children, who have joined the exodus to the cities in search of labor.

Closely associated with rural poverty in China's southwest and therefore central to its eradication is that stalwart of peasant economies, the potato. The crop is grown in three main zones: the plains and valleys, where it is sown in winter to reach nearby urban markets in spring when prices are highest; the steeply sloping low- to mid-hills where it is a mixed

Continued on page 68

For many Chinese households, the potato harvest promises a better life

Chongqing appreciates potato's promise

Chongqing, China's fourth largest province, was established in 1997 when the Three Gorges Dam project separated the area from Sichuan Province. Most of Chongqing's 24,000,000 farmers live in remote areas where poverty is the common denominator.

The province's new authorities quickly recognized potato's potential for helping to solve urgent food and income problems and decided to invest 1 million Yuan (US$120,000) yearly in production of the crop. When CIP scientists visited the province in 1998, a fruitful relationship of collaboration began. CIP has introduced more than 70 late blight resistant potato lines to Chongqing. To help in evaluating and disseminating the new materials within integrated, participatory programs, researchers have set up 31 farmer field schools and conducted numerous training courses and workshops.

Gu Wenyu, Director of the Chongqing Municipal Agricultural Bureau, highlighted the impact the program has achieved through "great technical support, the introduction of promising varieties, and the participatory research approach, [which] is very suitable for the remote mountain region and poor farmers, especially for the potato crop."

subsistence and cash crop, often grown twice a year with sowings in spring and early autumn; and the high plateaus, just below the snows of the peaks, where it is virtually the only crop that can be grown during a brief season in high summer. Whereas the first two zones have filled up with people, the third is extremely remote and has few inhabitants. In many areas, potatoes are strip-cropped with maize — the region's other important food crop — but monocropping is also practiced.

"Southwest China presents us with a classic challenge," says CIP economist Tom Walker. "In this largely rural region, increasing the production of staple food crops such as potato and maize is the way to drive broad-based economic development in which the poor can participate."

Dangerous dependence

Despite potato's importance to these rural populations, when Walker asked farmers in a remote village in Chongqing Province what they had learned from a farmer field school they had recently attended, he got an unexpected reply: "There is more than one kind of potato." It turned out that until then they had known only one East German variety called Mira, introduced back in the 1950s. Mira had become so prevalent that the farmers thought it constituted the entire species.

It isn't difficult to understand why Mira caught on. With its northern European origins, it had proved well adapted to the variable but harsh conditions of the southwestern mountains. Mira is a trustworthy "rustic" potato of the kind that has fueled peasant economies the world over. It yields well year after year, is a staunch ingredient of soups and stews, tastes good and fills stomachs, especially during long winter months when there isn't much else to eat.

But the farmers' ignorance of other varieties was symptomatic of a dangerous dependence. The narrow genetic base of their potato production placed them at risk of crop failure to pests and diseases. Already, Mira's resistance to late blight — which devastated potato fields under similar conditions in Ireland in the 1840s — was breaking down. The farmers complained that when blight struck, their yields fell drastically to 6–7.5 tons per hectare, compared with 18–22 tons per hectare in a normal year. The quality of their seed tubers had also declined under the continuous onslaught of viruses.

It was clear that increasing biodiversity in the region was crucial to protecting farmers' food security. Over the past decade, Chinese researchers have stepped up their efforts to develop and disseminate a wider range of improved varieties, often using materials supplied by CIP. Those efforts are now paying off.

A WIDER BASE

In 1990, CIP sent the seeds of a cross known as S-88 to Wang Jun, a professor at the Root and Tuber Crop Research Institute of Yunnan Normal University, in Kunming. Tested in an experimental plot, S-88 yielded better than all the other selections under evaluation. Its promise was recognized by Ting Fei, a senior plant breeder at the county level, who worked with Wang and other researchers to further evaluate S-88 in Yunnan's government-sponsored provincial trials. In 1995 this work led to the release of a new variety, which the team named Cooperation 88 to reflect the importance of partnership in its development and testing.

As the researchers had expected, Yunnan farmers took to the new variety immediately. By late 2001, less than seven years after its release, Cooperation 88 covered an estimated 20 percent of the area devoted to potato in the province. It had also spilled over into neighboring Sichuan and Chongqing. And its seeds were being traded over China's borders, into Vietnam and Burma.

Cooperation 88 is highly responsive to inputs and delivers a massive yield gain over Mira, producing up to 60 tons per hectare when monocropped. It also has another advantage: with its uniformly large tubers and shallow eyes, it is better for processing. This is an important characteristic in regions emerging from subsistence into market economies, enabling farmers to sell their surpluses not just to local markets but also to a growing number of factories producing chips, starch and other products.

But researchers still feel the need to broaden the genetic base for potato farmers in China. "Cooperation 88 is merely the first in a stream of new materials that will reach farmers' fields," notes Zhang Yongfei, one of the team who worked with Wang and is now a plant breeder himself. He and his colleagues are busy developing the next generation of improved varieties. These will have more stable resistance to late blight disease and will be more suitable for intercropping than Cooperation 88, which tends to compete too aggressively with companion crops and is therefore best monocropped. Other traits receiving attention include resistance to bacterial wilt, as well as early maturity.

Seed dynamos make the difference

The rapid spread of Cooperation 88 owes much to Yunnan's dynamic seed sector. China's southwest enjoys the same advantages for seed production as the Andes in Latin America: strong demand for seed on the plains, where commercial farmers grow the crop for market, coupled with ideal conditions for the production of healthy seed in the mountains, where the cool, dry climate reduces the risk of pests and diseases.

Yunnan has decided to capitalize on these advantages. "The province has the most positive policy environment for the potato seed sector that I have seen in a developing country," says CIP economist Charles Crissman, who visited the region recently to assess the potential for impact. The lead comes from the Provincial Department of Agriculture, which provides financial support for seed program development in designated areas. The department has linked this investment with the introduction of technologies — for tissue culture and virus-free seed production, for instance — to speed up seed multiplication and guarantee its quality. Farmers can obtain small loans from rural banks to buy seed or other inputs, and seed tubers of new varieties are made available at subsidized prices from county agricultural bureaus during the first few years of production.

The seed sector in other provinces is less well organized, according to Crissman. In Sichuan, production sites are widely scattered and there is less formal policy support. Guizhou and Chongqing have generally lower altitudes, offering fewer opportunities for quality seed production. All three provinces, however, can catch up to some extent by following their more progressive neighbor's example.

Even in Yunnan, several constraints still hold back the seed sector, and potato production as a whole. "Many farmers don't yet appreciate the



Whether monocropped or intercropped with maize, potato makes a big contribution to nutrition in rural China.

value of good seed," says Zhang. "As a result, they aren't willing to pay a premium for it, putting quality seed producers at a disadvantage." And when farmers do obtain good seed, they are seldom able to get the most out of it. "Except on larger farms near cities, the use of inputs remains low, so there is a large gap between the yields achieved on research stations and those on farmers' fields. For some farmers, potato is still a 'lazy crop' — one for which they just plant the seed then wait for the harvest," Zhang adds.

Impact ahead

Despite these problems, the prospects for achieving substantial impact in the southwest are good, Crissman argues. Coupled with higher yields, expansion in the area cultivated should allow a quantum leap in production over the next few years, with large surpluses meeting growing demands from Hong Kong and the coast, as well as Malaysia, Singapore and other Southeast Asian and Pacific markets. Already, orders are coming in from as far afield as Shanghai.

Progress with potatoes is running in tandem with another regional success story, that of maize. With the support of the Centro Internacional de Mejoramiento de Maíz y Trigo CIMMYT), provincial researchers have introduced modern hybrids and improved open-pollinated varieties, contributing to a steady rise in yields to over 3 tons per hectare by the late 1990s, nearly double their level in 1970.

"Together, potato and maize are doing much to pull the region out of poverty and hunger," says Walker. Turning farmers' deficits into surpluses has already increased food security and incomes. It is also triggering growth in other sectors, notably the processing industry and livestock production, both of which are valuable sources of additional cash for farmers. The demand for meat, in particular, is growing rapidly as incomes rise.

China does not intend to rest on its achievements in reducing hunger and poverty since its economic reforms of 1978. The government is determined to finish the job it has started and is channelling the necessary additional resources into the southwest. CIP will continue to support these efforts through research, training and information activities. The high probability of success indicates that, once more, cooperation pays.

China's push to eradicate poverty

China is almost alone among developing countries in having consistently applied, over nearly 25 years, a large-scale, nationwide program to eradicate poverty. The government's commitment to this mission — and its focus on the rural, agricultural sector — has undoubtedly contributed to the success of cooperation with CIP.

China launched its anti-poverty program in 1978, along with a package of economic reforms to speed up growth. The first major achievement was agricultural reform: price controls were relaxed and collectives were disbanded, providing small-scale farmers with incentives to increase their productivity. Then, in 1986, the government launched a large-scale drive to eradicate poverty in the more underdeveloped rural areas, specifically targeting the center and west of the country with special funds and favorable policies. A third phase began in 1994, when a seven-year priority poverty alleviation program was launched, focusing again on the problems associated with rural poverty. Throughout the program, development initiatives have been complemented by direct relief in the form of food and clothing for the poorest households and the destitute. Key disadvantaged groups, such as ethnic minorities, the disabled and women, have also been singled out for special initiatives.

The program is remarkable for its sustained, all-round assault on the full range of factors that create and perpetuate poverty. Infrastructure, education, health, farming and basic services have all received attention. Using funds targeted to poor counties, the program has built roads and railways, opened up new areas of farmland and brought drinking water, electricity and telecommunications to villages among the most remote in the world. In agriculture, the government has strengthened the capacity for research and promoted production and processing in the poorest provinces and counties. Farmers are receiving credit for establishing enterprises in aquaculture, poultry and crop production, and many are adopting new technologies as their access to markets improves.

Since 1978, the percentage of people in the rural population considered poor, by Chinese standards, is estimated to have fallen from 30 percent to less than 3 percent.

Full marks for adaptability: Farmers reap multiple benefits from field schools

The farmer field school began as a way of teaching Indonesian rice farmers how to reduce their pesticide applications. As the model has spread, its uses—and its benefits—have diversified

Bottom-up approach to learning

It's eight o'clock on a fine tropical morning. Twenty farmers are stooping, crouching or down on all fours in a field of sweetpotato, their heads and necks craned at awkward angles as they peer at the plants. From time to time someone removes an insect or a damaged leaf and places it in a plastic bag, then makes a quick note on a scrap of paper.

In half an hour or so, the group's facilitator will call the farmers back to the shade of a large tree. Here they will form small groups to compare notes and record their findings on large sheets of paper that will be used to make presentations to the others.

After these presentations, every observation will be aired and sifted in a plenary session before the discussion moves on to the big question: what to do next in the field. Wait another week to see how the insect population develops? Or take action to control pests now?

The farmers will end their debate by making a collective decision. Then they will reassemble to discuss what constitutes good planting material and how it can help combat the pests and diseases that appear in the field. Finally, they will set up their own experiment to test their ideas before returning home to their farms.

That was a day in the life of the farmer field school at Turi, a village in East Java. The farmers met in this way weekly, throughout the cropping cycle. After the harvest, they compared the yields they had achieved in their "learning field" with those of non-participating farmers on adjacent land.

The field school concept was developed in the late 1980s by the Food and Agriculture Organization of the United Nations (FAO) as a way of introducing integrated pest management (IPM) to rice farmers. The idea was to achieve impact in a way that differed radically from top-down extension methods.

"Instead of telling farmers what to do, we design activities that enable them to observe, deduce and decide for themselves," says Elske Van de Fliert, an IPM specialist who worked on field schools with FAO before joining CIP in 1994.

This emphasis on discovery-based learning helps to ensure that farmers will internalize new knowledge and skills, empowering them to make better decisions on how to manage their crops. It also kindles a spirit of enquiry and collective action that lasts after the FFS has finished, helping farmers to meet new challenges as they emerge.

An evolving model

While the basic principles of the farmer field school have remained the same, their application has evolved over the past decade. CIP has been a part of that evolution.

The Center's involvement dates from 1995, when Van de Fliert and other members of CIP's Southeast Asian team began working with Indonesian partners to adapt the FFS model to integrated management of sweetpotato pests. To establish the necessary protocols, the scientists trained small teams of farmer researchers and development workers from NGOs to conduct a participatory assessment of farmers' IPM needs in four Javanese villages. But when the teams entered the villages, they found that the farmers were less concerned with pests and diseases than they were with the problems of marketing their crop. And whereas losses to even the most serious insect pests were generally low, there were huge variations in yields, mainly associated with crop management practices such as the use of fertilizers.

All this suggested a broader agenda than the IPM curriculum of the original project proposal. At community-level workshops in 1996, the partners decided to switch to an integrated crop management (ICM) framework. "The switch was the direct result of farmers' participation," notes Van de Fliert.

The next evolutionary step came when institutions in Vietnam decided to adapt the Indonesian model to their country's needs. In Vietnam, unlike Indonesia, the whole sweetpotato plant — vines and roots — is commonly used as animal feed. In a 1999 planning workshop, researchers, farmers and extension workers endorsed the ICM-FFS approach developed in Indonesia, noting that the broad curriculum and simultaneous emphasis on economics and ecology were particularly attractive.

In the 2001-02 pilot seasons they realized, however, that it would be beneficial to farmers to broaden the FFS curriculum to include utilization and processing aspects in addition to production. CIP and national partners had recently developed a new labor-saving technique for processing vines for pig feed, involving the use of fermentation instead of boiling. The technique was included in the new curriculum, providing a vehicle for its dissemination.

Meanwhile, CIP's Lima-based scientists had begun adapting farmer field schools for potato, starting with four pilot schools launched in collaboration with CARE in the Cajamarca area of Peru. This work was driven by two overlapping interests: to help farmers control late blight disease and to evaluate and disseminate new potatoes with resistance to the disease. To achieve these dual objectives, the scientists included various participatory research (PR) elements, forming a new model known as the PR-FFS.

"The idea was to generate a large data set that would be useful to scientists, and at the same time to try the new materials out with farmers," says Oscar Ortiz, the CIP social scientist who coordinated the project. "In conventional research, the baseline data used to formulate hypotheses are often collected from no more than two sites over a couple of growing seasons. When farmers conduct research in their own fields, in many locations, you get much more information at a lower cost."

The new model successfully met the project's combined research and extension objectives. Multi-locational trials within the PR-FFS showed that a number of new breeding lines performed outstandingly across locations, even under extreme disease pressure. Some of these lines have now been officially released as new varieties and others are spreading spontaneously, giving farmers much earlier access to them than

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A SCHOOL FOR DIFFICULT SUBJECTS

Late blight poses a special challenge for potato farmers and scientists. (See also pages 62 and 83.) It is caused by a fungus (*Phytophthora infestans*) that is invisible to the naked eye, making it difficult for farmers to grasp the nature of the disease. If not dealt with promptly, late blight can be devastating, leading to heavy losses. And because the pathogen evolves rapidly and is highly variable, practices traditionally used to control the disease may no longer work and solutions that apply in one place may not be transferable to others.

All this makes knowledge a precious commodity in dealing with late blight, and the FFS is an ideal vehicle for imparting that knowledge. Farmers need to understand the pathogen, to be familiar with the resistant varieties available, to know how and when to use fungicides, to be aware of the principles of seed health and to know what agronomic practices can help them avoid the disease.

The use of fungicides provides a good example of the way knowledge can help. Many farmers do not know the difference between systemic fungicides, which are absorbed by the plant, and contact fungicides, which protect it superficially. Systemic fungicides are more efficient at protecting the crop in the short term, but may lead to resistance in the fungus if applied too often. By alternating the two types, farmers can slow down the development of resistance by making sure a high proportion of fungal spores are killed. Experiences in Bolivia (see page 79) show how effective this strategy can be.

The central plank of integrated control strategies, however, is resistant crop varieties, which can allow much lower fungicide use. The variability and rapid evolution of the pathogen make it vital to obtain large data sets over multiple locations when developing and testing such varieties. This is especially important in rainfed and mountainous ecosystems, where conditions vary greatly over short distances. Farmers are the best people to evaluate new varieties because they can assess culinary and agronomic qualities alongside resistance to late blight.

"Viva farmer field schools!" proclaim these puppets

if they had been evaluated through the formal research system. And as in Indonesia, broadening the project's initially narrow focus on pests to include other problems raised by farmers resulted in a set of priorities more sharply focused on their needs, as well as stronger farmer ownership of the FFS process.

Success with the four pilot schools in Peru sowed the seeds for a larger project linking six countries in Asia, Africa and Latin America. As in Peru, the aim is to design and disseminate technologies and practices for the control of late blight. But a further aim has been built into the project proposal: to adapt FFS to suit local conditions in each country, in preparation for training farmers and scaling up the approach.

"This time we made adaptation an explicit goal," says Ortiz. "Our previous experience shows that there is no blueprint for a successful FFS and that the agenda needs to be left open, as in participatory research." Hence the different subset of problems being addressed alongside late blight in each country: seed management in Bangladesh, potato tuber moth in Bolivia, bacterial wilt in Uganda, to give but a few examples. All countries, however, are evaluating new resistant breeding lines, thereby laying a foundation for the same rapid dissemination as observed in Peru.

Broadening the agenda increases impact

At each stage of its evolution, the FFS has increased its impact by broadening its scope.

"One of the biggest benefits of the new FFS models is the boost they give to the dissemination of new technologies," says CIP economist Tom Walker. "Piggy-backing technologies on the FFS, such as new crop varieties or improved processing, can accelerate adoption." Experiences in Indonesia, Peru and Vietnam have been borne out by those of the recent six-country project, which has led to varietal releases in nearly every participating country.

Ortiz and his colleagues believe the sharing of skills and resources among institutions with distinct comparative advantages is another key to broadening the impact — and the reach — of the FFS. The six-country project takes its cue from previous CIP experiences, such as that with CARE in Peru, by inviting NGOs and extension services to participate alongside research institutes. In some countries, close relationships have been forged between institutions that had seldom worked together in the past. In Uganda, for example, the NGO Africare has developed a joint workplan with the National Agricultural Research Organization (NARO): Africare supports the fieldwork while NARO provides technical

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BOLIVIAN FARMERS GO TO THE TOP OF THE CLASS

Potato farmers in Cochabamba, Bolivia, have achieved spectacular gains in income through their participation in FFS. The schools have taught them how to increase their yields by making more efficient use of fungicides to control late blight.

Although the farmers described late blight as their main problem, their conventional practices for controlling the disease were not very effective. They made only two to four fungicide applications to the crop, with the first of these made too late and with too long an interval between the others. In addition, they relied almost entirely on systemic fungicides, risking the development of resistance.

During the early 1990s, the Fundación para la Promoción e Investigación de Productos Andinos (PROINPA) developed a strategy for more efficient chemical control, beginning with the use of a systemic fungicide 10 days after the plants had emerged and following this with the alternating use of systemic and contact products at 7- to 14-day intervals, depending on the weather. The foundation then imparted this strategy to farmers, first through talks at field days, then through repeated sessions with fixed groups of farmers, and finally through farmer field schools.

The FFS approach achieved by far the best results. Farmers exposed to the strategy during field days and in group sessions subsequently tended not to make the crucial first application before disease symptoms appear. In contrast, those who had participated in the field schools had a deeper understanding of the nature of the pathogen and so of the need for this early, preventive application. While farmers trained in fixed groups increased their incomes by as much as US$762 per hectare per year, they were far outstripped by the FFS participants, who made gains of up to US$2,415.

Across the world, farmers appreciate the value of learning as they reap the benefits from their participation in field schools.

back-up, and the two are working together to write and test a field guide. In addition, the project builds on the experiences of other institutions in implementing not only FFS but also other forms of participatory research and development, such as village research committees. "The result is a fascinating process of cross-fertilization," says Ortiz. "We hope to combine the strengths of all the models."

Farmer participation in determining the FFS curriculum has also helped to extend its range, as well as its benefits, increasing both the immediate impact and the likelihood that farmers will take ownership of the learning process and so continue it afterwards. An evaluation of the sweetpotato FFS in Indonesia concluded that an FFS focused only on IPM would have had far less impact than the more broadly focused ICM-FFS, which raised farmers' incomes by up to 24 percent. Besides pests and natural enemies, farmers singled out seed health, field sanitation and nutrient management as areas in which they had improved their practices.

In Peru, where farmers also intervened to broaden the agenda, a workshop held after the project showed that farmers were keen to continue their learning process and to extend it even further to cover cereals, legumes and livestock. Participants in the six-country project have reported a similar extension of research activities carried out by farmers' groups, who have gained greatly in strength and confidence through the FFS experience.

This wide buy-in is paying off. "All of the countries involved in the six-country project have refined their methodologies and have published or will publish FFS field guides," reports Ortiz. "What's more, most partners have taken steps to institutionalize the method." There is also a good measure of spontaneous dissemination, which may lead to additional impact at the local level. For example, 68 percent of farmers participating in the pilot sweetpotato ICM-FFS in Indonesia said they had spread information on ICM to nearby non-participating farmers.

Scaling up: The challenge remains

Scaling up is the final challenge in delivering the multiple benefits of the new FFS models to farmers. It is also the hardest.

"As a resource-intensive model, the FFS is faced with the same scaling up problems as other participatory research and development approaches," says Walker. "Coverage is low, with only 20 or so farmers typically included in a group. And you may need two to three seasons with a group before the participants feel confident and knowledgeable enough to teach others. In this respect the very adaptability of the model works against it. The tendency to expand the curriculum to include all farmers' problems slows down the learning process even further."

Scaling up is likely to be even more difficult in diverse rainfed cropping systems than in the more uniform irrigated systems. Facilitators will find that the solutions that work in their own small patch of fields don't necessarily apply beyond the village boundaries. The multiple crops grown in rainfed systems could severely overburden the FFS curriculum. And there is usually only one cropping season a year, so schools cannot follow one another in quick succession as they can in the multiple cropping systems of irrigated areas. These considerations add weight to the argument that FFS should teach experimental skills and the basic principles of ecosystem management rather than specific technologies.

What can be done to speed up dissemination? Ortiz stresses that the foundation for expanded efforts must be more training. The FAO has trained NGO and governmental staff, initially in

Southeast Asia and more recently in Africa and Latin America. In some countries, notably Indonesia and Vietnam, national programs have also played a lead role. For example, the pilot sweetpotato schools in Indonesia encouraged the country's Directorate of National Food Production to design a program to train a further 12,000 farmers. But numbers alone don't tell the whole story. "The quality of training is just as important as the quantity," says Ortiz. "And much depends on how faithful facilitators are to their training once they start implementing FFS independently."

The biggest impact from the FFS is still in the country where it all started, Indonesia. But the impact there isn't solely to do with a longer history of exposure. Other factors have played a part in creating what appears to have become a self-sustaining movement among farmers, in which the FFS is part of a broader agenda. These factors include the creation of a strong and dedicated national program on IPM, a receptive NGO movement and a supportive policy environment. According to Van de Fliert, around 40 percent of the FFS in the country are now organized and led by farmer-trainers, the first of whom participated in a two-week Training of Trainers course hosted by the national program.

As well as launching schools, the farmer-trainers hold seasonal technical meetings and training workshops. These forums have evolved into local, provincial and national farmers' organizations, whose agenda includes policy and institutional issues as well as technology development. Their activities vary from collective enterprises at the village level to nationwide congresses involving thousands of people.

It remains to be seen whether other countries can emulate Indonesia's success. If they can, millions of small-scale farming families across the developing world could soon reap the benefits of the FFS accrued to their food security and incomes, as well as to their health and environment.

In brief

Fighting late blight: Do wild relatives hold the secret?

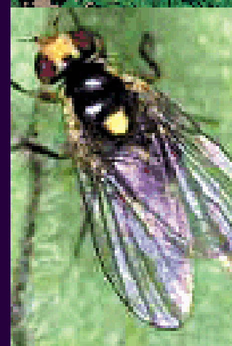
CIP continues to make advances in its effort to combat late blight, the world's most devastating food-crop disease. After evaluating over 50 tuber-bearing wild potato species held in CIP's genebank, scientists discovered evidence of late blight resistance in at least seven species endemic to the South American center of origin of potatoes.

Moreover, researchers were able to identify a number of accessions that presented quantitative, or "horizontal" resistance to late blight. This means that while the late blight fungus is able to infect these potato plants, disease development is so slow that the crop continues to grow and prosper with lower fungicide inputs than would susceptible plants under conditions that would normally be devastating.

That is why breeders have placed greater emphasis on horizontal resistance in comparison to the previously favored qualitative resistance that is concentrated in a single gene. Unlike qualitative resistance—which provides complete protection for a time, but can readily be overcome by changes in the pathogen population—horizontal resistance—which may be comprised of a combination of resistance strategies—is expected to be stable in the field.

During the screening process, scientists gave priority to species that had never been evaluated and to those that have evolved in Andean climates conducive to late blight. Their findings confirm the value of conserving in-trust germplasm collections such as the potato collection held at CIP, which facilitates the systematic use of wild species in improvement programs.

CIP researchers believe that wild species may be key to future potato breeding efforts, helping scientists to broaden the genetic base of resistance to late blight and other serious diseases.



Models for mountains

CIP's natural resource management team contributes to the understanding of complex highland production and ecological systems through the development and use of application models and powerful data-gathering and analysis tools.

These tools help the team and their partners to anticipate the effects of variables such as climate, management choices and policy interventions, thereby contributing to productive and sustainable natural resource management in the mountain areas of developing nations.

A process-based model for interpolating weather data in highland terrains, for example, has been created using data collected over an extended period of time from three weather stations set in the La Encañada watershed near Cajamarca, Peru. Documenting weather data is key to understanding how climate variables affect plant growth and soil-related processes.

Using geographical information system (GIS) capabilities, CIP scientists were also able to create a comprehensive "digital atlas" of the La Encañada area. The atlas, which combines agronomic information with social and economic data, helps to plan and implement development activities and infrastructure improvements in the region.

Similar tools are being developed in other key sites in the Andes, including Bolivia's Altiplano region and Ecuador's highlands. A case in point is the El Carchi Province in Ecuador, where CIP scientists are linking models of soil processes, pasture quality, dairy productivity and crop growth with an economic tradeoffs model that quantifies the costs and benefits of diverse scenarios in terms of environmental impact, health, productivity and profitability. (See also pages 17-24.)

Plant oils may prove "essential" to pest control

CIP scientists made advances in their fight to control the leafminer fly, a pest that has been introduced in many developing countries in recent years and causes devastating losses.

The researchers found that a combination of abamectin, a commonly used biological pesticide, with plant oil not only can help farmers cut their use of chemical pesticides, but could also reduce treatment costs by as much as 60 percent.

Scientists began by testing abamectin for effectiveness in controlling the leafminer fly at different application levels. They then measured the efficiency of an abamectin-plant oil mixture.

Results confirmed that when used at commercially recommended dosages, abamectin is effective against the eggs and larvae of the fly. Lower dosages were less successful. The scientists also found that the combination of plant oil with abamectin increased the potency of the pesticide, resulting in a higher embryo mortality rate.

The oil used in this experiment was a commercial soybean oil commonly found in agricultural supply stores. The oil boosts abamectin's penetration into leaf tissue by dispersing the insecticide while helping it adhere to the plant. It also encapsulates the abamectin, greatly reducing losses caused by hydrolysis, evaporation and photo-degradation.

Because abamectin comes from a biological source, it offers an environmentally-friendly pest management option. The abamectin-plant oil mixture does, however, have one important shortcoming: it is expensive when compared to alternative chemical products.

The fact that by combining these two ingredients, farmers can reduce their pesticide use by as much as three-fourths, may just make this combo a viable choice.

A solution for saline soil

Saline soils adversely affect crop production in many arid regions of the world.

In 1999 CIP's natural resources management program embarked on a project to study salt tolerance in quinoa, a millet-size, highly nutritious grain that thrives in dry, saline soils under cold, highland conditions.

After a series of greenhouse and laboratory experiments, scientists discovered that the Andean grain's salt tolerance—and in some cases its seed yield—are much higher than previously reported. Furthermore, quinoa absorbs salt ions from the soils, storing them in its tissue. This means that farmers could even grow quinoa to help clean salt-contaminated soils.

Aside from helping to identify the best quinoa varieties for saline soils, the experiment allowed scientists to identify salt tolerance mechanisms in quinoa. This information can enhance researchers' understanding of how to improve salt tolerance in other crops. Screening for only a minor reduction in, say, plant height, may allow farmers to benefit from higher yields and hardier crops. Salt-tolerant crops are especially important in

mountainous areas of developing countries, where food production faces serious limits.

New hope from a known lifesaver

Sweetpotato has a long history as a lifesaver, especially in times of crisis. This is particularly important for farmers in rural areas of Latin America, Africa and Asia.

The island nations of East Timor and Cuba are cases in point. When they were battered by violence—one by a civil war and another by a hurricane—sweetpotato became the crop of hope.

The civil strife that surrounded East Timor's struggle for independence from Indonesia left subsistence farmers in dire straits. To help respond to their urgent needs, in 2000 the Australian Centre for International Agricultural Research joined with CIP, four other Future Harvest Centers (CIAT, CIMMYT, ICRISAT and IRRI) and partners such as World Vision International and Catholic Relief Services to launch "Seeds of Life". This three-year, $1.2 million collaborative program was designed to boost yields with well adapted, high-quality lines of cassava, green beans, rice, peanuts and sweetpotato.

"When you come into a post-conflict situation, where there has been a lot of displacement of people, one of the most important things you can do is restore the plant material of staple crops for the farmers," said Patrick Kapukha of World Vision. Seeds of Life is doing just that.

Farmers in East Timor are now producing six times their normal sweetpotato yields using planting material supplied by CIP. The dramatic boost in

production has translated into higher returns and a better life for them and their families. The success of the sweetpotato harvest was such that in Aileu, a mountain town, farmers made off with most of the vine cuttings that had been set aside as planting material for the next season. Kapukha regarded the theft as an endorsement: "When the local people carried off a lot of vines, this was really an indication of their approval of the quality of the produce."

In Cuba, meanwhile, sweetpotato's quality as a survivor was confirmed when Hurricane Michelle battered the island in November of 2001, razing fields of basic food crops—including bananas, plantains, yucca and citrus—along its path. Only one crop survived the destruction: sweetpotato.

Because of its broad versatility and adaptability, sweetpotato has long been a staple food in Cuba. Its production normally covers one-fourth of Cuban agricultural land and runs at about 60,000 hectares a year. Soon after the hurricane subsided, local authorities decided to take advantage of the upcoming growing season, which runs from November to April, with massive planting of sweetpotatoes.

CIP and Cuba's Instituto de Investigación de Viandas Tropicales (INIVIT) had already been working to make more and better sweetpotato varieties available on the island: more than 50 percent of the sweetpotato growing area in Cuba was planted with varieties recommended by INIVIT. The partners had also disseminated integrated pest management principles, helping to reduce the damage produced by weevils from 40 to 10 percent in just five years. The added push from Cuban authorities is expected to increase he island's output by as much as 30 percent.

While scientists around the world continue to refer to the sweetpotato as a "small farmer's crop", its impact on rural farming communities—such as those of Cuba and East Timor—is anything but small.

Farmers come together to solve seed problems

Farmers in Nepal have seized the opportunity to expand the country's potato production industry by participating in informal, farmer-run Seed Producer Groups (SPG) supported by CIP.

This approach—which has proven to be simple, cost effective, result-oriented and viable in small-farm communities—is so successful that the SPG are currently fulfilling close to 20 percent of Nepal's demand for potato seed.

Two years of trials to evaluate the quality of the SPG seed in Nepal's three major potato-producing regions showed it to be far superior to the alternative: seed produced through a contract system that is time consuming, costly and unsustainable. In most cases, yields from the SPG seed doubled those of the non-SPG alternative.

The country's Ministry of Agriculture has officially accepted the SPGs as national models for sustainable seed-potato production. Researchers and field workers hope that farmers will extend their use of the model to other crops.

CIP scientists are certain that the SPGs can be successfully replicated in the potato farming communities of many developing nations where the lack of low-cost, quality seed limits the crop's production.

CIP IN 2001

Board of trustees

Donor contributions

The International Potato Center is grateful for the generous support of all our donors, particularly those who contribute with unrestricted contributions. The funding we receive enables us to carry out high quality research and training designed to contribute to reducing poverty and achieving food security on a sustained basis in the poorest countries of the world. CIP's revenues in 2001 were lower than they were in 2000, reflecting a general trend of decreasing funding to agricultural research. We are actively seeking new partners and additional sources of funding to maintain operations at a sustainable and stable level. This will enable us to make a solid contribution in the years to come to our goals: food security, healthy environments and less poverty through research, training, information and technical assistance on potato, sweetpotato, Andean root and tuber crops, natural resources and mountain ecologies.

Donor (ranked by level of contribution)	**US$000**
Swiss Agency for Development and Cooperation (SDC)	2,868 [a]
United States Agency for International Development (USAID)	2,142 [b]
International Bank for Reconstruction and Development (IBRD/World Bank Group)	1,964
Government of Japan	1,428
European Commission (EC)	1,142 [c]
Department for International Development (DFID), UK	943
Danish International Development Agency (DANIDA)	818 [d]
Government of Netherlands	802
Government of Germany	746
Swedish International Development Cooperation Agency (SIDA)	648
Government of Luxembourg	611
Canadian International Development Agency (CIDA)	598
Government of Austria	515
Government of Peru	500
Australian Centre for International Agricultural Research (ACIAR)	343
International Livestock Research Institute (ILRI)	333
Government of Spain	300
International Fund for Agricultural Development (IFAD)	285
International Development Research Centre (IDRC)	246
Government of Italy	180
The McKnight Foundation	170
Government of Norway	165
Government of China	140
Ford Foundation	105
Government of the Republic of Korea	80
Government of France	68
Government of Belgium	66
National Oceanic and Atmospheric Administration (NOAA)/University of Missouri	52
Government of South Africa	50
International Fertilizer Development Center (IFDC)	48 [e]
Government of the Islamic Republic of Iran	40
Rockefeller Foundation	40
Organization of Petroleum Exporting Countries (OPEC) Fund for International Development	38
Government of India	37
United States Department of Agriculture (USDA)	34
Food and Agriculture Organization of the United Nations (FAO)	30
Government of Brazil	25
Proyecto Nacional de Manejo de Cuencas Hidrográficas y Conservación de Suelos (PRONAMACHS/Asociación Benefica PRISMA), Peru	21
Technova - Toyota	13
International Plant Genetic Resources Institute (IPGRI)	12
Consultative Group on International Agricultural Research (CGIAR) Participatory Research and Gender Analysis Project	11
Wallace Genetic Foundation Inc	10
Servicio Nacional de Sanidad Agraria (SENASA), Peru	8
Government of Mexico	5
Government of Thailand	5
Fondo Regional de Tecnologia Agropecuaria (FONTAGRO/Red Internacional de Metodologia de Investigación de Sistemas de Producción RIMISP)	4
Government of Philippines	3
TOTAL	**18,692**

a Includes US$120,000 for an associate expert
b Includes US$88,000 for university partners in the USA
c Comprises US$802,000 for work on sustainable land use in the Andes and US$340,000 for work on conservation of Andean root and tuber crop diversity
d Includes US$89,000 for an associate expert
e Includes US$47,000 for an associate expert

FINANCIAL REPORT

CIP's total revenues in 2001 were US$19.0 million (18 percent less than the 2000 revenues of US$23.3 million). This revenue comprises US$9.0 million of unrestricted donations and US$10 million of restricted donations. At the end of 2001, US$3.3 million (17 percent of total revenues) had not been received. The allocation of CIP's funds to its research activities is shown below.

Allocation of funds to CIP activities, 2001 and 2000

	2001		2000	
CIP activities	**US$ millions**	**%**	**US$ millions**	**%**
Potato	8.8	46	10.8	46
Sweetpotato	5.8	31	7.2	31
Andean roots and tubers	2.2	12	0.9	4
Natural resource management (including CONDESAN)	1.6	8	1.3	5
Global Mountain Program (GMP)	0.2	1	0.2	1
Global Initiative on Late Blight (GILB)	0.2	1	0.1	1
Urban and peri-urban agriculture (SIUPA)	0.2	1	0.2	1
Financial operating reserve	0	0	2.6	11
	19.0	**100**	**23.3**	**100**

The main reasons for the lower revenues in 2001 were a sharp fall in unrestricted donations and exchange rate losses. CIP's donations are received in US dollars (41 percent), euros (23 percent) and various other currencies (36 percent), making revenues sensitive to exchange rate volatility in international financial markets. During 2001 there was a rise in the value of the US dollar against other international currencies, especially the Japanese yen and the euro, and a consequent fall in these currencies in US dollar terms.

In response to the drop in income, CIP restructured its budget, monitored expenses closely and made a major effort to obtain new donations. Despite these actions, the budget deficit reached US$1 million, and as a result the financial operating reserve was reduced from US$3.1 million to US$2.1 million. At the end of 2001 the cash position stood at US$4.9 million.

Liquidity problems, largely due to delays in the receipt of contributions, have been a challenge during previous years. Prudent liquidity policies, however, have made it possible to operate in an uncertain environment. CIP is currently exploring with multinational banks new options that will allow more flexibility in liquidity management.

The budget review and the prudent financial policies adopted during the year made it possible to reduce the percentage of indirect costs from 16 percent in 2000 to 14 percent in 2001. As a result of new austerity measures to be implemented during 2002, it is expected that indirect costs will continue to decline.

The statement below summarizes CIP's finances in 2001. A copy of the complete audited financial statement may be requested from the office of the Deputy Director General for Corporate Development at CIP headquarters in Lima, Peru.

Statement of financial position
Year ending 31 December 2001 (compared with 2000)

	(US$000)	
	2001	**2000**
Assets		
Current assets		
Cash and cash equivalent	4,850	5,477
Accounts receivable:		
Donors	4,052	3,572
Employees	368	268
Others	244	323
Inventories	667	571
Advances	324	399
Prepaid expenses	136	167
Total current assets	10,641	10,777
Property and equipment, net	3,274	3,355
Total assets	**13,915**	**14,132**
Liabilities and net assets		
Current liabilities		
Accounts payable		
Donors	1,030	689
Others	5,402	4,483
Accruals	1,575	1,781
Total current liabilities	8,007	6,953
Net assets		
Appropriated	3,846	4,109
Unappropriated	2,062	3,070
Total net assets	5,908	7,179
Total liabilities and net assets	**13,915**	**14,132**

The research program

CIP's research program comprises 13 projects (restructured from 17) that address the most pressing constraints to improving livelihoods through potato and sweetpotato production and use, managing natural resources in mountain ecosystems and preserving and exploiting underutilized Andean root and tuber crops. Within the 13 projects are three that formally recognize CIP's increasing success in convening and facilitating research among a large number of partners around global (potato late blight and urban agriculture) and regional (Andean ecoregional) themes.

CIP's research projects and project leaders

	Project	Leader
1	Integrated management of late blight	J Landeo
2	Uptake and utilization of improved potato production technologies	C Crissman
3	True potato seed	E Chujoy
4	Integrated pest management for root and tuber crops	A Lagnaoui
5	Sweetpotato improvement and virus control	DP Zhang
6	Post-harvest quality, nutrition and market impact of root and tuber crops	M Hermann
7	Biodiversity and genetic resources of roots and tuber crops	W Roca
8	Integrated natural resource management in mountain agro-ecosystems	R Quiroz
9	Gene discovery, evaluation and mobilization for crop improvement	M Bonierbale
10	Global commodity analysis and impact assessment of potato and sweetpotato technologies	T Walker
G1	SIUPA (Strategic Initiative on Urban and Peri-Urban Agriculture)	G Prain
G2	GILB (Global Initiative on Late Blight)	G Forbes
R1	CONDESAN (Consortium for the Sustainable Development of the Andean Ecoregion)	J Posner (until July 2001) /E Mujica

Project 1. Integrated management of late blight

Late blight in potato, caused by the oomycete *Phytophthora infestans*, continues to be the most devastating potato disease worldwide and the cause of huge crop losses, particularly in less developed countries. CIP's highest research priority is to develop, adapt and integrate technologies for managing late blight of potato. CIP scientists have already produced (through classical breeding techniques) and deployed improved populations and advanced clones with durable resistance to this disease, for utilization by developing countries in particular. Combined efforts by projects 1 and 9 are being directed towards the development and use of state-of-the-art molecular tools for tapping newer sources of resistance. Components of integrated disease management (IDM) are being developed to complement host resistance in overall IDM strategies. The farmer field school (FFS) farmer participatory approach is being used to integrate components for disease control. Crop and disease models linked to geographic information systems (GIS) are being used to understand the complexities of the disease's epidemiology across diverse agro-ecologies and to develop simple decision-support systems (DSS) for disease management.

Project 2. Uptake and utilization of improved potato production technologies

The aim of this project is to develop and disseminate production technologies that can improve on-farm yields and hence the welfare of farm families. The project is centered thematically and philosophically on seed potatoes, either clonal or true potato seed (TPS), as a delivery mechanism for new technologies. Because seeds transmit pests and diseases, improved production and management of seed potatoes, either in formal programs or in informal farmer systems, is a key factor in improving potato productivity. We focus on the introduction of new genetic materials and on overcoming the constraints caused by potato viruses and bacterial wilt.

Project 3. True potato seed

True potato seed (TPS) enables a crop to be grown in areas where traditional production systems fail, for example where seed tubers are scarce or not available. By facilitating the transfer of improved TPS hybrids in such areas of the tropics and subtropics, CIP aims to expand potato cultivation and increase its efficiency (reduce production costs, increase yields). This project concentrates on breeding parents for hybrid TPS production and improving TPS hybrids for needed specific traits such as late-blight resistance, earliness and seed set. This research is back-stopped by the TPS utilization activities in CIP's Project 2 and by the work of local organizations (private sector, NGOs, NARS) in efforts to commercialize TPS systems and thus underpin developing small industries.

Project 4. Integrated pest management for root and tuber crops

Root and tuber crops are among the world's most important food crops, with a great potential to improve food security, eradicate starvation and alleviate poverty in resource-poor countries. For many farmers, these crops are not only their food staple but also their principal source of cash income. Root and tuber crops are commonly grown in production systems where biotic factors such as weeds, nematodes, pests and diseases limit yields. In the developing world, insect pests pose a serious constraint to potato and sweetpotato production and hence to the capacity of farmers to secure a livelihood; losses in the field and in storage can easily reach 50 percent of total yield. Besides the economic losses, current farmer control practices rely on the use of highly toxic pesticides applied with little or no protective equipment, causing substantial damage to the health of people and the environment. And the use of chemical pesticides is increasing rapidly, particularly where farmers are intensifying production methods in order to sell in urban markets, and where the crops are expanding into agro-ecological regions and planting seasons outside their traditional range. To achieve its goal of increasing farmer income and food security by reducing pest losses, while protecting the health of producers, consumers and the environment, this project adopts a systematic and comprehensive approach to crop protection. More specifically, this implies maintaining pest populations at acceptable levels using combinations of control techniques and practices, and with due consideration of the socio-economic and environmental consequences.

Project 5. Sweetpotato improvement and virus control

This project aims at improving the productivity, nutritional quality and utilization of sweetpotato through the development and adoption of new varieties with enhanced post-harvesting characteristics and of technologies for controlling sweetpotato virus diseases. Current project activities include vitamin A biofortification through development and deployment of beta-carotene-rich sweetpotato in sub-Saharan Africa and southwest Asia, genetic improvement of dry matter and starch yields to facilitate diversified use of sweetpotato in China and Southeast Asia and application of technologies for producing healthy planting material in low-input farming systems.

Project 6. Post-harvest quality, nutrition and market impact of root and tuber crops

This project has two main objectives. The first is to alleviate rural poverty by linking farmers with markets and thus assisting them in income generation through diversified and expanded post-harvest use of roots and tubers; in this context the identification of market opportunities, equitable rural enterprise development and product development are central concerns. Project activities aim at improving processing technologies and farmer access to markets; identifying novel root and tuber products; developing methodologies for successful product and small agro-enterprise development; and increasing awareness of specific health benefits from eating roots and tubers. The second objective is to prevent vitamin A deficiency by promoting the increased use of orange-flesh sweetpotatoes in regions where this nutritional disorder is rampant. Initially concentrating on East Africa, the project has established a partnership, called VITAA (Vitamin A for Africa), which engages the agriculture, health and nutrition communities in an effort to boost the demand for, and use of, orange-flesh sweetpotatoes by those most threatened by vitamin A deficiency.

Project 7. Biodiversity and genetic resources of root and tuber crops

The overall objective of this project is to characterize and secure the long-term conservation of potato, sweetpotato and other Andean root and tuber crop genetic resources through global and regional collaborative research on the management of seed, field and in vitro genebanks. The project also explores technologies to improve cryopreservation methods for the long-term conservation of potato and sweetpotato clones. Project activities include research to improve pathogen elimination and health assurance procedures for worldwide distribution of healthy clones; linking collections with the conservation of biodiversity carried out by farmers (in situ/on farm conservation); rationalization of germplasm collections (coverage, redundancies, clonal identity, core collections); promoting access to, and use of, genebank holdings through the identification and evaluation of new sources of priority traits; and upgrading and improving the quality of databases containing information and documentation of root and tuber crop genetic resources, and linking these databases to georeferenced and genetic information.

Project 8. Integrated natural resource management in mountain agro-ecosystems

Mountain ecosystems are found on every continent and sustain an estimated 10 percent of the world's population. In addition, billions of people living in the lowlands depend on these ecosystems for food and other resources (water, raw materials, energy). Mountain areas are also important sources of plant and animal diversity, both wild and domestic. In the past few decades, environmental changes and rapid increases in population densities in mountain areas have increased problems for planning effective resource management strategies. Despite the global recognition of the importance of these areas following the lead of the United Nations Conference on Environment and Development in 1992, many mountain communities continue to live in poverty. Through integrated natural resource management research, CIP and other Future Harvest centers are working to alleviate poverty, increase food security and protect the environment in mountain areas. The goal of this project is to contribute to more productive and sustainable natural resource management in selected mountain areas. The management practices, methodologies, policy recommendations and analytical tools being developed jointly with NARS, and complemented with appropriate training, will enhance the capability of local and national researchers and authorities to analyze their problems, search for windows of opportunity, and to assess, ex-ante, the tradeoffs of interventions.

Project 9. Gene discovery, evaluation and mobilization for crop improvement

Strategic germplasm evaluation is conducted in collaboration with CIP's biodiversity conservation project (Project 7) to identify and characterize new sources of resistance to late blight, bacterial wilt and viruses; such new resistance sources are needed to develop broad-based potato varieties less dependent on pesticides and other inputs. The project's applied breeding program develops resistance to major potato viruses (PLRV, PVY and PVX) to protect crops from the degenerative diseases that are important in tropical lowland regions where vector pressures are high and capacity for the production of healthy vegetative seed is limited. Molecular tools and information are used to identify and monitor resistance to potato late blight and viruses and to help improve productivity, post-harvest quality and nutritional and market value of sweetpotato and potato through better understanding and more efficient manipulation of carbohydrate gene networks. In addition, novel resistance mechanisms are engineered, and foreign genes are mobilized to confront priority diseases and pests for which conventional breeding does not offer ready solutions. High levels of multiple virus resistance are developed in advanced potato clones and parental lines that also possess the productivity and use characteristics that are needed for variety development in collaboration with national breeding programs.

Project 10. Global commodity analysis and impact assessment for potato and sweetpotato technologies

This project functions as a capstone in CIP's revised project portfolio. Information is generated for scientists, research administrators, policy-makers and donors for decision-making on technology design, resource allocation, policy formulation and investment options related to potato and sweetpotato improvement and utilization. Some of the specific objectives are to: quantify the agronomic, economic, social and environmental effects of improved potato and sweetpotato technologies; document the rate of return and the effect on poverty of CIP's research; assess the level and adequacy of investment in potato and sweetpotato crop improvement in developing countries; assemble and maintain price and production databases for priority setting; evaluate the effects of potato price instability on diverse groups in society; assist in improving domestic potato and sweetpotato marketing and international potato trade benefiting developing countries; and participate in generating the most informative commodity projections with specialized institutions.

Project G1. SIUPA (Strategic Initiative on Urban and Peri-urban Agriculture)

The Strategic Initiative on Urban and Peri-urban Agriculture (SIUPA) was launched by the CGIAR in late 1999 in response to growing urban populations and urban poverty and the increased dependence of city dwellers on farming. CIP is the convening center for the initiative. SIUPA's goals are to contribute to increased food security, improved nutritional status and higher incomes for urban and peri-urban farmers while mitigating negative environmental and health impacts; and to establish the perception of urban and peri-urban agriculture as a positive, productive and essential component of sustainable cities. SIUPA has established a set of research activities in regional sites collectively known as Urban Harvest. CIP is one of several Future Harvest centers implementing research activities with other international and national agencies in such fields as sustainable agroprocessing and livestock enterprises, quality aspects of vegetable production systems, and the contribution of urban agriculture to human nutrition.

Project G2. GILB (Global Initiative on Late Blight)

The Global Initiative on Late Blight (GILB) was convened by CIP in 1996 in response to the escalating agricultural crisis brought about by the evolution of more aggressive and fungicide-resistant forms of the potato late blight pathogen, *Phytophthora infestans*. GILB stimulates collaborative and complementary research and technology transfer among developing and developed countries by improving communications among researchers and institutions. GILB has established regional and thematic linkage groups to encourage people to work together and to identify additional opportunities for collaboration. To assist these groups, GILB has sponsored meetings and developed World Wide Web pages for each group. To facilitate access to information, a Global Late Blight Information System, with numerous resources and links, has been established online at the GILB web address. A newsletter is distributed three times a year to GILB members in 79 countries. GILB sponsored an international conference in 1999 and is planning another for 2002. GILB is managed by a steering committee representing different regions of the world where late blight is important.

Project R1. CONDESAN (Consortium for the Sustainable Development of the Andean Ecoregion)

CONDESAN is an open and dynamic consortium of diverse organizations, each one contributing its knowledge and expertise on research and/or rural development, that works on the interlocking issues of sustainable natural resource management, increasing rural incomes and social equity. The objective is to strengthen local capacity to understand natural resource management and to develop environmentally sound production systems and policies that can enhance life in the Andes. Focusing mainly on poor farmer groups of the highlands, CONDESAN concentrates its fieldwork at seven benchmark sites that broadly represent the major ecological zones. Cross-sectional and common themes, however, are promoted for the entire region. InfoAndina, the electronic information system, is a key component of the Consortium's team-building strategy. Through coordination and facilitation activities by a small coordination unit, the project aims to create effective and strong linkages between research and rural development partners.

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Training highlights

The topics covered by CIP's training curriculum respond directly to the center's main research areas centered on the production and use of CIP's mandate crops and the conservation and management of natural resources. There is a growing demand for training on natural resource management in mountain areas and on conservation of root and tuber genetic material.

CIP leads training sessions and workshops, organizes and sponsors international conferences, and develops training materials. The more than 40 main training events conducted across the world in 2001 were attended by participants from 63 countries. These activities focused on research methodologies, tools and techniques for developing-country scientists, and on capacity building for sustainable production, targeted at NGOs, government organizations and development agencies. At CIP headquarters, individual training was provided for participants from 22 countries. CIP also supported training at distant locations by distributing publications and manuals, as welll as through the use of electronic media, including downloads of manuals, articles and reports from CIP's training website (www.cipotato.org/training), and e-conferences and workshops.

CIP continues to develop its website and interactive CD-ROMs to support training activities organized by CIP headquarters and regional offices, and by CIP-related networks.

Main group training events

Event (number of participants in parentheses)	**External sponsors**	**Participating countries**
Course: Methods for detecting bacterial wilt in potatoes and their application to seed programs (17)	Department of Agriculture (Thailand)	Bangladesh, India, Philippines, Thailand, Vietnam
Workshop: Information systems for genetic resources management (21)		Colombia, Ecuador, India, Peru, Venezuela
Workshop: Planning, implementing, monitoring and evaluating potato integrated pest management programs (39)		Argentina, Bolivia, Colombia, Cuba, Ecuador, Peru, Venezuela
10th International Congress of Andean crops (209)	CONDESAN, FUNDANDES, Universidad Jujuy and Ministerio de la Producción (Argentina)	Argentina, Belgium, Bolivia, Brazil, Canada, Chile, Colombia, Ecuador, France, Mexico, Peru
Course: Application of statistics to agricultural research (24)	Universidad Nacional Daniel Alcides Carrión (Peru)	Peru
Workshop: In situ conservation of root and tuber crops (16)	SDC	Bolivia, Colombia, Ecuador, Peru
Program meeting: Ex situ conservation of Andean root and tuber crops (16)	SDC	Bolivia, Colombia, Ecuador, Italy, Peru,
Workshop: Complementing genetic resistance for late blight in the Andes (23)	GILB, PAPA ANDINA, PROINPA	Bolivia, Colombia, Ecuador, Guatemala, Netherlands, Peru, USA, Venezuela
Workshop: NCM-ELISA in potato (12)		India, Indonesia, Nepal, Sri Lanka
Meeting: Sweetpotato pig-feeding project in Vietnam: Lao Forage Smallholder Project (11)		Vietnam
Workshop: True potato seed (14)		Bangladesh, China, India, Nepal, Pakistan, Peru, Sri Lanka, Vietnam
Courses: Potato seed production, held in Huanuco and Cajamarca, Peru (77)	DFID	Peru
Course: Potato seed production at farmers' field level in Bangladesh (17)	BARI	Bangladesh, India
Course: Modeling for crops (DSSAT: decision support system for agrotechnology transfer, version 3.5) and milk production (13)	PRONAMACHS	Ecuador, Peru
Workshop: Challenges in integrated mountain watershed management (37)	IDRC	Belgium, Bhutan, Bolivia, Canada, Chile, China, Ecuador, Ethiopia, Kenya, Nepal, Peru
Workshop: Geographic information systems for phytogenetic resources management (34)	IPGRI	Argentina, Bolivia, Brazil, Colombia, Ecuador, Italy, Peru
Workshop: In situ conservation of agrobiodiversity (41)	SDC, SGRP	Bolivia, Burkina Faso, Chile, Ecuador, France, Germany, Indonesia, Italy, Mexico, Nepal, Peru, Philippines, Spain, Switzerland, UK, USA

Workshop: Prevention and control of tuber moth (*Tecia solanivora*) (29)	ICA, SENASA, SESA	Colombia, Ecuador, Peru
Workshop: Economic impact evaluation in agricultural technology (18)	FAO, IFAD, McKnight Foundation, PAPA ANDINA	Bolivia, Colombia, Ecuador, Netherlands, Peru, Switzerland, USA
Course: Scientific paper and proposal writing and oral scientific presentation (26)	PRAPACE	Burundi, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Tanzania, Uganda, UK, Zaire
Seminar: Biotechnology and development in Andean countries (101)	CamBioTec (Canada), Ministerio de Relaciones Exteriores (Peru), UNIDO	Austria, Belgium, Bolivia, Canada, Chile, Colombia, India, Mexico, Peru, USA
Workshop: Progress and prospects of participatory selection of advanced potato clones (12)	FDR, FOVIDA, INIA (Peru), CODESE	Ecuador, Peru
Course: Diagnosis of viruses and viroids in the main crops grown in Chanchamayo Valley (20)	Universidad Nacional Daniel Alcides Carrión (Peru), SENASA	Peru
Meeting: Appropriate methodology for urban and peri-urban agricultural research planning (29)	ACIAR, RUAF	Bangladesh, Belgium, Germany, Ghana, Indonesia, Kenya, Mexico, Peru, Philippines, Senegal, South Africa, Tanzania, UK, USA, Vietnam, Zimbabwe
2nd Latin-American symposium on roots and tubers (89)	SLART, Universidad Nacional Agraria La Molina (Peru)	Argentina, Brazil, Canada, Colombia, Costa Rica, Cuba, Czech Republic, Denmark, Ecuador, Finland, Italy, Mexico, Peru, Spain, Uruguay, USA, Venezuela
Workshop: Crop protection research program (30)	DFID	Bolivia
Symposium: Sweetpotato: Food and health for the future (95)	Universidad Nacional Agraria La Molina (Peru), ISHS	Argentina, Austria, Bangladesh, Belgium, Canada, China, Cuba, Egypt, Ethiopia, Germany, India, Indonesia, Italy, Japan, Malawi, Malaysia, New Zealand, Nigeria, North Korea, Peru, Philippines, South Africa, South Korea, Spain, Tunisia, Turkey, Uganda, Uruguay, USA
Workshop: Review and planning of IDM/FFS activities in Nepal (25)	SDC	Afghanistan, India, Indonesia, Nepal, Pakistan, Philippines, Vietnam
Workshop: Participatory monitoring and evaluation for integrated crop management (49)	SDC, UPWARD	Bangladesh, Bhutan, Indonesia, Nepal, Pakistan, Philippines, Sri Lanka, Vietnam
Course: Participatory research and development (38)	UPWARD	Bangladesh, Bhutan, Cambodia, Ethiopia, India, Indonesia, Laos, Nepal, Nigeria, Philippines, Tanzania, Trinidad & Tobago, Vietnam, Zimbabwe
Training for breeders: Marker-assisted breeding (6)		Ethiopia, Kenya, South Africa, Uganda
Course: Use of ELISA kits for detection of *Ralstonia solanacearum* in seed potatoes (13)	FCRI, NCVESC	Vietnam
Workshop: Training of trainers for FFS (89)	EARO, IFAD, SHDI	Ethiopia
Course: Participatory research methodologies (27)	McKnight Foundation	Kenya
Workshops: 1. Potato seed systems. 2. Quality control techniques (120)		China, North Korea, Vietnam
Workshop: ELISA kits for pathogen diagnosis (30)		China, North Korea, Vietnam
Course: Participatory monitoring and evaluation (37)	UPWARD	Philippines
Study tour and workshop: Integrated pest management (13)	PRGA	Indonesia, Philippines, Thailand
Course: Sustainable agro-enterprise development in a micro-regional context (3)	UPWARD	Philippines
Workshop: Review of recent development in sweetpotato utilization research in China (20)		China

Full names of external sponsors can be found in the list of Donor Contributions (page 89) or the list of CIP's Partners (pages 98–99)

CIP's PARTNERS

AARI Aegean Agricultural Research Institute, Turkey • **AARI** Ayub Agricultural Research Institute, Pakistan • **AAS** Academy of Agricultural Sciences, North Korea • **AB-DLO** Institute for Agrobiology and Soil Fertility, Netherlands • **ADT** Akukuranut Development Trust, Kenya • **AFRENA** African Resource Network in Agro-Forestry, Uganda • **AFRICARE**, Uganda • **AGDIA** Inc, USA • **AGERI** Agriculture Genetic Engineering Research Institute, Egypt • **A**gricultural Research Council, South Africa • **A**gricultural Research Institute, Tanzania • **A**griculture and Agri-Food, Canada • **AHI** African Highland Ecoregional Program, East Africa • **A**inshams University, Faculty of Agriculture, Egypt • **AIT** Asian Institute of Technology, Thailand • **AKF** Aga Khan Foundation, Switzerland • **A**lemaya University of Agriculture, Ethiopia • **A**ngola Seeds of Freedom Project • **A**nhui Academy of Agricultural Science, China • **APPRI** Agricultural Plant Protection Research Institute, Egypt • **APROSEPA** Asociación de Productores de Semilla de Papa, Bolivia • **A**rapai College, Uganda • **ARARIWA** Association for Andean Technical-Cultural Promotion, Peru • **ARC** Agriculture Research Centre, Egypt • **ARC** Agricultural Research Corporation, Sudan • **ARC** Agricultural Research Council, South Africa • **ARCS** Austrian Research Centers Seibersdorf, Austria • **ARDC** Agricultural Research and Development Centre, Uganda • **AREA** Agricultural Research and Extension Authority, Yemen • **ARI** Agricultural Research Institute, Pakistan • **ARI** Agricultural Research Institute, Tanzania • **ARO** Agricultural Research Organization, Israel • **ASAR** Asociación de Servicios Artesanales y Rurales, Bolivia • **ASARECA** Association for Strengthening Agricultural Research in Eastern and Central Africa, Uganda • **ATDTP** Agricultural Technology Development and Transfer Project, Rwanda • **AT**-Uganda Appropriate Technology Uganda • **AVRDC** Asian Vegetable Research and Development Center, Taiwan • **A**wasa Research Centre, Ethiopia • **BADC** Bangladesh Agricultural Development Corporation • **BAR** Bureau of Agricultural Research, Department of Agriculture, Philippines • **BARI** Bangladesh Agricultural Research Institute • **BBA** Federal Biological Research Centre for Agriculture and Forestry, Institute for Biological Control, Germany • **B**enguet State University, Philippines • **BIOGEN** Biodiversidad y Genética, Peru • **BRAC** Bangladesh Rural Advancement Committee • **BRC** Biotechnology Research Center, Vietnam • **BRRI** Bangladesh Rice Research Institute • **BTA** Biotecnología Agropecuaria SA, Chile • **BUCADEF** Buganda Cultural Development Foundation, Uganda • **B**vumbwe Research Station, Malawi • **CAAS** Chinese Academy of Agricultural Sciences • **CABI** Bioscience, Kenya, UK • **CAB** International, Kenya • **CAF** College for Agriculture and Forestry, Vietnam • **C**amBioTec, Canada • **CARDI** Caribbean Agricultural Research and Development Institute, Trinidad • **CARE** Cooperative for Assistance and Relief Everywhere, USA • **CARE**-Bangladesh • **CARE**-Kenya • **CARE**-Peru • **CARE**-Rwanda • **C**atholic University of Leuven, Belgium • **CavSU** Cavite State University, Philippines • **CBC** Centro Bartolomé de las Casas, Peru • **CECOACAM** Central de Cooperativas Agrarias de Cañete y Mala, Peru • **CEDEPAS** Centro Ecuménico de la Promoción y Acción Social, Peru • **CEMOR** Cemor Editores & Promotores, Peru • **CENA** Civil Engineers Network Africa, South Africa • **C**endrawasih University, Indonesia • **C**entro de Investigación en Biotecnología, Costa Rica • **C**entros de Reproducción de Entomógenos y Entomopatógenos, Cuba • **CERGETYR** Centro Regional de Recursos Genéticos de Tuberosas y Raíces, Peru • **CFP** Cities Feeding People, Canada • **CGIAR** Consultative Group on International Agricultural Research, USA • **C**hiang Mai University, Thailand • **C**hina Agricultural University, China • **C**hristian AID, DR Congo • **CIAAB** Centro de Investigaciones Agrícolas A Boerger, Uruguay • **CIAD** Center for Integrated Agricultural Development, China • **CIAT** Centro Internacional de Agricultura Tropical, Colombia • **CICA** Centro de Investigación en Cultivos Andinos, Peru • **CIED** Centro de Investigación, Educación y Desarrollo, Peru • **CIMMYT** Centro Internacional de Mejoramiento de Maiz y Trigo, Mexico • **CIRAD** Centre de coopération internationale en recherche agronomique pour le développement, France • **CIRNMA** Centro de Investigación de Recursos Naturales y Medio Ambiente, Peru • **CLADES** Consorcio Latinoamericano de Agroecología y Desarrollo, Peru • **C**lemson University, USA • **CLSU** Central Luzon State University, Philippines • **CNCQS** Chinese National Centre for Quality Supervision and Test of Feed • **CNPH** Centro Nacional de Pesquisa de Hortaliças, Brazil • **CODESE** Comite de Semilleristas, Peru • **C**omunité de Yaounde, Cameroon • **CONAM** Consejo Nacional del Ambiente, Peru • **CONCYTEC** Consejo Nacional de Ciencia y Tecnologia, Peru • **CONDESAN** Consortium for the Sustainable Development of the Andean Ecoregion, Peru • **C**onsorcio Surandino, Peru • **COPASA** Cooperacion Peruano Aleman de Seguridad Alimentaria, Peru • **C**ornell University, USA • **CORPOICA** Corporación del Instituto Colombiano Agropecuario, Colombia • **CPPI** Chongqing Plant Protection Institute, China • **CPRA** Centre de perfectionnement et de recyclage agricole de Saïda, Tunisia • **CPRI** Central Potato Research Institute, India • **CPRS** Central Potato Research Station, India • **CRIBA** Centro Regional de Investigación en Biodiversidad Andina, Peru • **CRIFC** Central Research Institute for Food Crops, Indonesia • **CRIH** Central Research Institute for Horticulture, Indonesia • **CRP-CU** Centre de recherche public – Gabriel Lippmann, Luxembourg • **CRS** Catholic Relief Services, Kenya, Uganda, Sudan • **CTCRI** Central Tuber Crops Research Institute, India • **DAE** Department of Agricultural Extension, Bangladesh • **DARHRD** Department of Agricultural Research and Human Resource Development, Eritrea • **DECRG**, Development Economics Research Group, World Bank, USA • **D**epartment of Agriculture, Philippines • **D**epartment of Agriculture, Thailand • **D**epartment of Agriculture, Phichit Horticultural Research Center, Thailand • **D**irección Nacional de Sanidad Vegetal, Cuba • **D**irectorate of Root Crop Production, Ministry of Agriculture, Indonesia • **DPP** Department of Plant Protection, Ministry of Agriculture and Rural Development, Vietnam • **DRCFC** Dalat Research Center for Food Crops, Vietnam • **DRDS** Department of Research and Development Services, Bhutan • **EARO** Ethiopian Agricultural Research Organization (formerly IAR), Ethiopia • **EARRNET** Eastern Africa Rootcrops Research Network, Uganda • **ECABREN** Eastern and Central Africa Bean Research Network, Uganda • **EMBRAPA** Empresa Brasileira de Pesquisa Agropecuária, Brazil • **E**mpresas de Cultivos Varios del Ministerio de Agricultura, Cuba • **ENEA** Comitato Nazionale per la Ricerca e per lo Sviluppo dell'Energia Nucleare e delle Energie Alternative, Italy • **E**rbacher Foundation, Germany • **ESH** Ecole supérieure d'horticulture, Tunisia • **ETH** Eidgenoessische Technische Hochschule, Switzerland • **FAO** Community IPM Program, Vietnam and Indonesia • **FAO** Food and Agriculture Organization of the United Nations, Italy • **FAPESP** Fundação de Amparo à Pesquisa do Estado de São Paulo, Brazil • **FCRI** Food Crops Research Institute, Vietnam • **FDR** Fundación para el Desarrollo Rural, Peru • **FOFIFA/FIFAMANOR** Centre national de la recherche appliquée au developpément rural, Madagascar • **FONAIAP** Fondo Nacional de Investigaciones Agropecuarias, Venezuela • **F**ood Crop Research Institute, Vietnam • **FOODNET** (ASARECA network implemented by IITA) • **FORTIPAPA** Fortalecimiento de la Investigación y Producción de Semilla de Papa, Ecuador • **FOVIDA** Fomenta de la Vida, Peru • **FSP** Forages for Smallholders Project, CIAT, Colombia • **FUNDAGRO** Fundación para el Desarrollo Agropecuario, Ecuador • **FUNDANDES** Fundación para el Ambiente Natural y el Desarrollo, Argentina • **GAAS** Guangdong Academy of Agricultural Sciences, China • **GILB** Global Initiative on Late Blight, Peru • **GKF** Grameen Krishi Foundation, Bangladesh • **GLKS** Institute of Plant Genetics and Crop Plant Research, Germany • **HAU** Hanoi Agriculture University, Vietnam • **H**ong Doc University, Vietnam • **H**ong Kong University, China • **HORDI**, Horticultural Research and Development Institute, Sri Lanka • **HRI** Horticulture Research Institute, Egypt • **HUAF** Hue University for Agriculture and Forestry, Vietnam • **H**ung Loc Agriculture Research Center, Vietnam • **H**asanuddin University, Indonesia • **IAC** International Agricultural Centre, Netherlands • **IAF** Inter-American Foundation, USA • **IAI-ISP** Inter-American Institute for Global Change Research, Initial Science Program, Brazil • **IAN** Instituto Agronómico Nacional, Paraguay • **IAO** Istituto Agronomico per l'Oltremare, Italy • **IAS** Institute of Agricultural Sciences, Ministry of Agriculture and Rural Development, Vietnam • **IASA** Instituto Agropecuario Superior Andino, Ecuador • **IAV** Institut Agronomique et Vétérinaire Hassan II, Morocco • **IBC** Institute for Breeding of Crop Plants, Federal Center for Breeding Research on Cultivated Plants, Germany • **ICA** Instituto Colombiana Agropecuaria, Colombia • **ICAR** Indian Council of Agricultural Research, India • **ICASA** International Consortium for Agricultural Systems Applications, USA • **ICIMOD** International Centre for Integrated Mountain Development, Nepal • **ICIPE** International Centre for Insect Physiology and Ecology, Kenya • **ICO CEDEC** Instituto de Capacitación del Oriente, Bolivia • **ICRAF** International Centre for Research in Agroforestry, Kenya • **ICRISAT** International Crops Research Institute for the Semi-Arid Tropics, India • **ICRW** International Center for Research on Women, USA • **IDEA** Instituto Internacional de Estudios Avanzados, Venezuela • **IDIAP** Instituto de Investigación Agropecuaria de Panamá, Panama • **IEBR** Institute of Ecology and Biological Resources, Vietnam • **IESR/INTA** Instituto de Economía y Sociología Rural del INTA, Argentina • **IFDC** International Fertilizer Development Center, USA • **IFPRI** International Food Policy Research Institute, USA • **IHAR** Polish Plant Breeding and Acclimatization Institute, Poland • **ISHS** International Society for Horticultural Sciences, Belgium • **IIN** Instituto de Investigación Nutricional, Peru • **IIRR** International Institute of Rural Reconstruction, Philippines • **IITA** International Institute of Tropical Agriculture, Nigeria • **ILRI** International Livestock Research Institute, Ethiopia and Kenya • **IMA** Instituto de Manejo de Agua y Medio Ambiente, Peru • **INCAGRO** Innovación y Competitividad para el Agro Peruano, Peru • **INERA**, Institut nationale d'etudes et de recherches agricoles, DR Congo • **INIA** Instituto Nacional de Investigacão Agronómica, Mozambique • **INIA** Instituto Nacional de Investigación Agraria, Peru • **INIA** Instituto Nacional de Investigaciones Agropecuarias, Chile • **INIA** Instituto Nacional de Investigaciones Agropecuarias, Uruguay • **INIA** Instituto Nacional de Investigaciones y Tecnologia Agraria y Alimentaria, Spain • **INIAP** Instituto Nacional de Investigaciones Agropecuarias, Ecuador • **INIFAP** Instituto Nacional de Investigaciones Forestales y Agropecuarias, Mexico • **INIVIT** Instituto Nacional de Investigación de Viandas Tropicales, Cuba • **INRA** Institut national de la recherche agronomique, France • **INRA** Institut national de la recherche agronomique, Morocco • **INRAT** Institut national de 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Research, Netherlands • **ISTPC** Instituto Superior Tecnológico Público de Cañete, Peru • **IWMI** International Water Management Institute, Sri Lanka • **IZ** Instytut Ziemniaka, Poland • **JAAS** Jiangsu Academy of Agricultural Sciences, China • **J**erusalen de Porcon Cooperative, Peru • **JKUAT** Jomo Kenyatta University of Agriculture and Technology, Kenya • **JTTK** Jaringan Tani Tanah Karo, Indonesia • **KARI** Kenyan Agricultural Research Institute • **K**augu & Katheri Farmers, Kenya • **KEPHIS** Kenya Plant Health Inspectorate Service • **L**a Habana University, Chemistry Faculty, Cuba • **L**ake Basin Development Authority, Kenya • **LDI** Landscape Development Intervention, Madagascar • **L**ouisiana State University, USA • **L**ucana, Bolivia • **MAE** Ministère des affaires etrangères, France • **M**akerere University, Uganda • **MARDI** Malaysia Agriculture Research Development Institute, Malaysia • **MARS** Mwara Agricultural Research Institute, Indonesia • **M**ax 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Agricultural Research Institute, China • **NARC** National Agricultural Research Centre, Pakistan • **NARC** Nepal Agricultural Research Council • **NARO** National Agricultural Research Organization, Uganda • National Institute of Animal Husbandry, Vietnam • **NCGR** National Center for Genome Resources, USA • **NCVESC** National Center for Variety Evaluation and Seed Certification, Vietnam • **N**ijmegen University, Netherlands • **N**jabini Farmer Group, Kenya • **N**kozi University, Uganda • **NOMIARC** Northern Mindanao Agricultural Research Center, Philippines • **N**omorionteetab Kibagenge, Kenya • **N**orth Carolina State University, USA • **NPRCRTC** Northern Philippines Root Crops Research and Training Center, Philippines • **NPRC** National Potato Research Centre Tigoni, Kenya • **NPRP** National Potato Research Program, Nepal • **NRI** Natural Resources Institute, UK • **NRSP-6 USDA** Potato Production Introduction Station–Wisconsin, USA • **NUS** National University of Singapore • **ODER** Oficina de Desarrollo Rural–Chalaco, Peru • **O**hio State University, USA • **O**regon State University, USA • **ORS** Oficina Regional de Semillas, Bolivia • **PCARRD** Philippine Council for Agriculture, Forestry and Natural Resources Research and Development, Philippines • **PDL** Proyecto Desarrollo Lechero, Bolivia • **PDP** Potato Development Program, Nepal • **REDCAPAPA** Red Estrategica para el Desarrollo de Cadena Agroalimentaria de la Papa, Ecuador • **PGS** Plant Genetic Systems, Belgium • **P**hilippine Root Crops Research and Training Center • **PIA** Programa de Investigación Agropecuaria, Bolivia • **PICA** Programa de Investigación de Cultivos Andinos, Peru • **PICTIPAPA** Programa Internacional de Cooperación del Tizón Tardío de la Papa, México • **P**lan International, Kenya • **P**lant Gene Expression Center, University of California–Berkeley, USA • **P**lant Research International, Netherlands • **PNS-PRODISE** Programa Nacional de Semillas del 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• **PRONAMACHCS** Proyecto Nacional de Manejo de Cuencas Hidrográficas y Conservación de Suelos, Peru • **P**royecto Papa Andina, Peru • **PROSHIKA**, A Centre for Human Development, Bangladesh • **PRP** Potato Research Programme, Nepal • **PSPDP** Pakistan-Swiss Potato Development Program • **R**ANTIK Ltd, Bangladesh • **RAU** Rajendra Agricultural University, Bangladesh • **RDA** Rural Development Agency, Korea • **RDRS** Rangpur Dinajpur Rural Society, Bangladesh • **REFSO** Rural Energy and Food Security Organization, Kenya • **R**egional Agricultural Research and Development Centre, Sri Lanka • **RIAP** Research Institute for Animal Production, Indonesia • **RIFAV** Research Institute for Fruits and Vegetables, Vietnam • **RIFCB** Research Institute for Food Crops Biotechnology, Indonesia • **RILET** Research Institute for Legume and Tuber Crops, Indonesia • **RIV** Research Institute for Vegetables, (formerly LEHRI), Indonesia • **RNC-RC** Jakar, Bhutan • **RCRC–VASI** Root Crop Research Center, Vietnam Agricultural Science Institute • **R**othamsted Experiment Station, UK • **RUAF** Resource Centre for Urban Agriculture and Forestry, Netherlands • **SAAS** Shangdong Academy of Agricultural Sciences, China • **SAAS** Sichuan Academy of Agricultural Sciences, China • **SARDI–UMCOR** Sustainable Agricultural and Rural Development Initiative–United Methodist Committee on Relief, DR Congo • **SARIF** Sukamandi Research Institute for Food Crops, Indonesia • **SARRNET** Southern Africa Root Crops Research Network • **SASA** Scottish Agricultural Science Agency, UK • **S**asakawa-Global 2000, Ethiopia • **S**ave the Children (UK Ltd), Ethiopia • **SCRI** Scottish Crop Research Institute, UK • **SEAG** Servicio de Extensión Agrícola y Ganadera, Paraguay • **SEARCA** Southeast Asian Ministers of Education Organization (SEAMEO) Regional Center for Graduate Study and Research in Agriculture, Philippines • **SEMTA** Servicios Múltiples de Tecnologías Apropiadas, Bolivia • **SENASA** Servicio Nacional de Sanidad Agraria, Peru • **SENASAG** Servicio Nacional de Sanidad Agropecuaria e Inocuidad Alimentaria, Bolivia • **SENASEM** Service national de semances, DR Congo • **SEPA** Unidad de Producción de Semilla de Papa, Bolivia • **SESA** Servicio Ecuatoriano de Sanidad Agropecuaria, Ecuador • **SGRP** System-wide Genetic Resources Program, CGIAR • **SGUA** Support Group on Urgan Agriculture, Canada • **SHDI** Self-Help Development International, Ethiopia • **SINITTA** Sistema Nacional de Investigación y Transferencia de Tecnología Agraria, Peru • **SITIOS** Servicios Inteligentes y Tecnologías Complejas Superiores Ltd, Bolivia • **SLART** Sociedad Latinoamericano de Raíces y Tubérculos, Peru • **SM-CRSP** Soil Management Collaborative Research Support Program, USA • **SNSA** Service national des statistiques agricoles, DR Congo • **SOCADIDO** Soroti Catholic Diocese Development Organization, Uganda • **S**okoine University of Agriculture, Tanzania • **S**outh China Agricultural University • **S**outh China Potato Center • **S**outhern Regional Agricultural Bureau, Ministry of Agriculture, Ethiopia • **S**outhwest Agricultural University, China • **SPG** Sociedad Peruana de Genética, Peru • **SPI** Smart Plant International, USA • **SPPC** Centro de Investigación de Semilla de Papa, Yemen • **S**ukarami Agricultural Technology Assessment Institute, Indonesia • **S**wedish University of Agricultural Sciences, Sweden • **S**YNGENTA, USA • **TALPUY** Grupo de Investigación y Desarrollo de Ciencias y Tecnología Andina, Peru • **TARI** Taiwan Agricultural Research Institute • **TCA** Tarlac College of Agriculture, Philippines • **TCRC** Tuber Crops Research Centre, Bangladesh • **T**echnova Inc, Japan • **T**eso Community Development Project, Kenya • **TFNC** Tanzania Food and Nutrition Centre • **T**hai Nguyen University, Vietnam • **T**hang Binh District Agriculture and Rural Development Bureau, Vietnam • **T**he Sainsbury Laboratory, UK • **T**ibetan Academy of Agricultural and Animal Science, China • **T**im Petani Pemandu PHT Pengalengan, Indonesia • **UANRDEN** Urban Agriculture National Research, Development and Extension Network, Philippines • **U**gunja Community Resource Centre, Kenya • **UNDP** United Nations Development Programme • **UNIDO** United Nations Industrial Development Organization • **U**niversidad Austral, Chile • **U**niversidad Cajamarca, Peru • **U**niversidad Católica de Santa Maria, Peru • **U**niversidad Central, Ecuador • **U**niversidad Central de las Villas, Cuba • **U**niversidad de Ambato, Ecuador • **U**niversidad de Caldas, Colombia • **U**niversidad Federal Rio de Janeiro, Brazil • **U**niversidad Jorge Basadre Grohmann de Tacna, Peru • **U**niversidad Jujuy, Argentina • **U**niversidad Mayor de San Simón, Bolivia • **U**niversidad Nacional Agraria, Peru • **U**niversidad Nacional Daniel Alcides Carrión, Peru • **U**niversidad Nacional de Bogotá, Colombia • **U**niversidad 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Kassel, Germany • **U**niversity of Kiel, Germany • **U**niversity of Minnesota, USA • **U**niversity of Missouri, USA • **U**niversity of Nairobi, Kenya • **U**niversity of Naples, Italy • **U**niversity of New Brunswick, Canada • **U**niversity of Queensland, Australia • **U**niversity of the Philippines–Los Baños • **U**niversity of Tübingen, Germany • **U**niversity of Veszprem, Hungary • **U**niversity of Wisconsin, USA • **U**niversity of Yaounde, Cameroon • **UNSPPA** Uganda National Seed Potato Producers' Association, Uganda • **UPM** University Putra Malaysia • **UPWARD** Users' Perspectives with Agricultural Research and Development, Philippines • **USDA** United States Department of Agriculture • **US** Potato Genebank, USA • **USVL** United States Vegetable Laboratory, USA • **VASI** Vietnam Agricultural Science Institute • **V**ietnamese–German Technical Cooperation Potato Promotion Project • **V**irginia Polytechnic Institute and State University, USA • **V**irus-free Potato Tubers and Cutting Production Centers of Yunnan Agricultural Department, China • **VISCA** Visayas State College of Agriculture, Philippines • **V**olcani Institute, Israel • **VSSP** Vegetable Seed and Seed Potato, Pakistan • **WE** World Education (and local partner NGOs) • **W**inrock International, Uganda • **W**orld Vision, Angola, Burundi, Kenya, Rwanda, Uganda, USA • **WRC** Wheat Research Centre, Bangladesh • **WUR** Wageningen University Research Centre, Netherlands • **XSPRC** Xuzhou Sweet Potato Research Center, China • **YPPP** Yemeni Plant Protection Project • **YPPSE** Foundation for Socio-Economic Development, Indonesia • **Y**unnan Agricultural University, China

Staff

CIP's staff is comprised of a diverse group of highly qualified individuals with varied backgrounds and nationalities. This diversity is integrated into a coordinated effort to achieve a common goal: alleviate poverty and increase food security while protecting the earth's natural resource base. Each and every one of CIP's more than 400 employees worldwide, from scientists to clerical staff to field workers, contributes to this mission in the various functions they perform, and all form an essential part of CIP's working team. Although all their names do not appear in this Annual Report, we recognize and greatly appreciate all their efforts.

Director General—Hubert Zandstra

Deputy Director General for Finance and Administration—Hector Hugo Li Pun

Deputy Director General for Research—Wanda Collins[2]

Director for International Cooperation—Roger Cortbaoui

Director General's Office

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Mariella Corvetto, Communication Services Coordinator
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Godofredo Lagos, Print Chief
Paul Moncada, Webmaster[1]

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Carmen Lara, Secretary
Ricardo Rodriguez, Agronomist, Field/Greenhouse Supervisor (Santa Catalina) (CIP-Quito)

* Project leader
1 Joined CIP in 2001
2 Left CIP in 2001
3 Funded by special project
4 Joint appointment
5 Transferred from CIP-Quito in August

Global contact points

CIP's main contact points are listed below. For more details, please contact the International Cooperation Office at the CIP Headquarters address below, or using the following email: cip-international-cooperation@cgiar.org.

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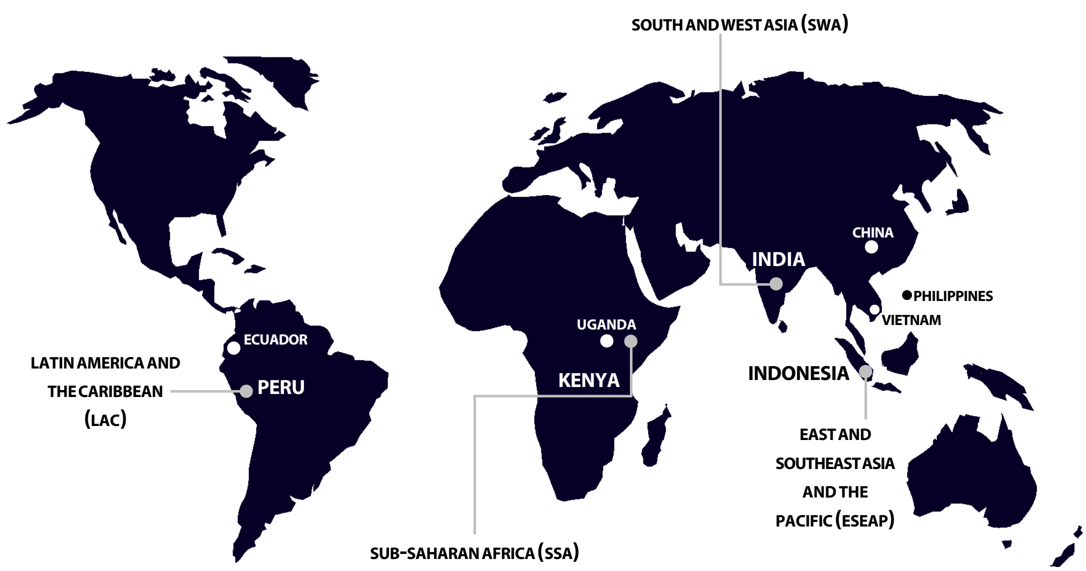
CIP IN THE WORLD



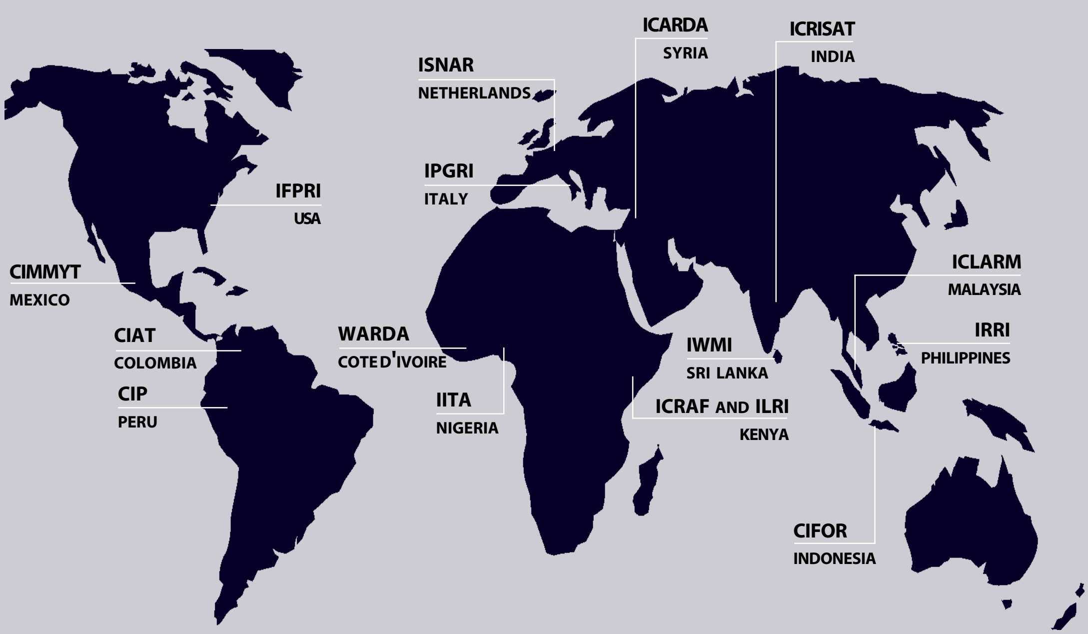
Future Harvest

CIP is one of 16 food and environmental research organizations known as the Future Harvest Centers. The centers, located around the world, conduct research in partnership with farmers, scientists, and policymakers to help alleviate poverty and increase food security while protecting the natural resource base. The Future Harvest Centers are principally funded through the 58 countries, private foundations, and regional and international organizations that make up the Consultative Group on International Agricultural Research (CGIAR).

In 1998 the centers supported by the CGIAR created Future Harvest as a charitable and educational organization designed to advance the debate on how to feed the world's growing population without destroying the environment, and to catalyze action for a world with less poverty, a healthier human family, well-nourished children and a better environment. Future Harvest reaches out to media, academics, scholars, and scientists in the world's premier peace, environment, health, population and development research organizations, as well as to policy-makers and civil society, and it enlists world-renowned leaders to speak on its behalf. Future Harvest raises awareness and support for research, promotes partnerships, and sponsors on-the-ground projects that bring the results of research efforts to farmers' fields in Africa, Asia and Latin America.

For more, visit www.futureharvest.org or www.cgiar.org

Future Harvest Centers



CIAT	Centro Internacional de Agricultura Tropical
CIFOR	Center for International Forestry Research
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo
CIP	Centro Internacional de la Papa
ICARDA	International Center for Agricultural Research in the Dry Areas
ICLARM	International Center for Living Aquatic Resources Management
ICRAF	International Centre for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
IPGRI	International Plant Genetic Resources Institute
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
IWMI	International Water Management Institute
WARDA	West Africa Rice Development Association

Photo Credits

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(clockwise from top left) Alejandro Balaguer (2), CIP Archives, Gordon Prain, Robert Hijmans, Jesús Alcázar

From the Director General
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86 (counter clockwise from top left) ACIAR (2), CIP Archives, Oscar Hidalgo

CIP in 2001
87 (clockwise from top left) Candelaria Atalaya, Pedro Baca (2)

Back cover
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The International Potato Center (CIP) seeks to reduce poverty and achieve food security on a sustained basis in developing countries through scientific research and related activities on potato, sweetpotato and other root and tuber crops, and on the improved management of natural resources in the Andes and other mountain areas
www.cipotato.org

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