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From the New World to the Whole World

CIAT

Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture
Consultative Group on International Agricultural Research

Eco-Efficient Agriculture for the Poor

Contents

Message from the Board Chair and the Director General

Eco-Efficient Agriculture for

CIAT and Corpoica will give particular attention to the improvement of agricultural production and natural resource management in the Orinoquía.

Through cutting-edge science, CIAT seeks to make developing country agriculture more eco-efficient—that is, more productive, profitable, competitive, sustainable, resilient, and equitable. The Center puts science to work for the poor by means of carefully cultivated partnerships. The results they deliver enable rural people to derive more benefits from agriculture using fewer resources, which is the essence of eco-efficiency.

No partnerships are more critical for the relevance and impact of CIAT's collaborative research than those arising from its relationships with a dynamic host country, Colombia, and with an evolving Consultative Group on International Agricultural Research (CGIAR). The year 2010 saw positive developments in both these spheres, which will translate into new opportunities for fostering eco-efficient agriculture in Colombia and many other developing countries.

CIAT in Colombia—More than a Guest, a Strategic Partner

CIAT's productive relationship with Colombia received a powerful boost this year, which promised to elevate their collaboration to a more strategic plane. The impetus came from a remark made by the country's newly elected president, Juan Manuel Santos, in his inaugural address on 7 August. Responding to the President's call for a more competitive and sustainable agriculture, the incoming Minister of Agriculture and Rural Development, Juan Camilo Restrepo, visited CIAT headquarters soon afterwards to propose a new research alliance for helping realize that vision.

The alliance was launched during a meeting of the Center's Board of Trustees in November, with the signing of an agreement between CIAT, the Ministry of Agriculture and Rural Development (MADR), and the Colombian Corporation of Agricultural Research (Corpoica). It reflects the three organizations' shared intention to transform the longstanding host-guest arrangement between Colombia and CIAT into a strategic research partnership. The MADR has already allocated US$3 million for the new initiative.

The partnership will address major challenges for Colombia's agriculture —especially climate change. It will also realize some of the country's most compelling opportunities for rural development, specifically by promoting the production of diverse tropical fruits and by helping realize the vast agricultural potential of the Orinoquía region, referred to as the *Llanos Orientales*, or Eastern Plains.

The agreement recognizes Corpoica's ample experience in research on a variety of annual and perennial crops as well as its strong expertise in other areas, such as agro-energy, soil management, and plant health. It also underlines CIAT's exceptional capacity to apply geographical information systems,

Colombia and the World

its pioneering use of biotechnology for crop improvement and its recent advances in the development of environmental services.

In combining these strengths, CIAT and Corpoica expect to give particular attention to the improvement of agricultural production and natural resource management in the Orinoquía. Colombia's ambition is to achieve an agricultural transformation in this region similar to that made possible by national research in the Brazilian Cerrados, where CIAT has also provided valuable technical input through strong partnerships. Much previous research has focused on the Orinoquía, and this work seems more relevant now than ever in light of the global food price crisis in 2008, which prompted a renewal of concern about long-term food security and reinforced commitment to sustainable agricultural development for economic growth.

CIAT in the New CGIAR—A New Way of Working

The implementation of CGIAR reforms in 2010 created further possibilities for CIAT to foster eco-efficient agriculture, building on its strong Colombian base and on its firm ties with other international centers and numerous national partners.

The reforms resulted in the creation of two mutually reinforcing pillars, which make up the CGIAR's new structure. One pillar consists of the CGIAR Fund, through which donors can provide stable support for major collaborative research programs. The other is the Consortium, with its own legal status, chief executive officer, and board, which unites 15 international research centers. The two pillars are joined by a conceptual bridge—the Strategy and Results Framework—which provides a platform for the creation and funding of new programs.

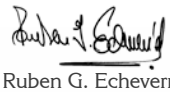
In 2010, the Consortium solicited proposals for programs on seven key development themes. Four proposals were designated for "fast-track" development, and two have already been approved and launched. They represent a new way of working, whose hallmarks are research integration, strong partnerships, and a sharp focus on development impact. Proposals for other programs are now under review, with approval of several expected early in 2011. CIAT contributed significantly to many of the proposals, and it plays central roles in the two programs already under way.

The Center figures as one of six international partners in the Global Rice Science Partnership, or GRiSP. With an initial 5-year budget of nearly US$600 million, this program will mount a concerted campaign to boost rice yield growth and improve the management of water and other resources on which more intensive production depends. Among other tasks, GRiSP will embark on an unprecedented effort to deploy rice genetic diversity for the development of new high-yielding varieties with traits that are essential for adapting production to climate change. Working under the overall coordination of the International Rice Research Institute (IRRI), CIAT will bring renewed commitment to the task of strengthening the rice sector in Latin America and the Caribbean.

In addition, the Center is coordinating the new CGIAR program on Climate Change, Agriculture and Food Security, or CCAFS. Involving all of the CGIAR centers and key non-CGIAR partners, the program is designed to cope in a comprehensive way with climate change in developing country agriculture. Its official launch at the 2010 United Nations Conference on Climate Change, held last December in Cancún, Mexico, marked the beginning of a long-term effort with an initial 5-year budget totaling US$392 million. CCAFS will develop tools and policies for climate change adaptation and mitigation, targeting the smallholder farmers who are most vulnerable to climate change impacts.

CIAT's renewed partnership with Colombia and its significant role in new CGIAR programs are landmark achievements, which few would have thought possible just a few years ago. They bear eloquent testimony to the unflagging commitment of our staff and to the enduring value of our research assets.

Juan Lucas Restrepo
Board Chair



Ruben G. Echeverría
Director General

From the New World to the Whole World

African farmers continue to reap the rewards of CIAT-supported networks for collaborative bean research.

CIAT was established in 1967 to serve Latin America and the Caribbean (LAC) through what came to be called "ecoregional" research. But within a decade or so after its inception, the Center had shown that agricultural research in the so-called "neo-tropics" is highly relevant not just to this region but to Africa and Asia as well. That discovery gave rise to a steady stream of South-South scientific exchanges, in which Center scientists fostered the flow of crop germplasm and new knowledge both within LAC and from this region to others.

The exchanges continue to this day, as illustrated by the examples that follow, yielding significant benefits for farmers across the developing world. The first two cases provide updates on early examples of CIAT's unique role in bean improvement and biological control of cassava pests. And the third reports on research dealing with tropical fruits in LAC, a field that is rich with untapped possibilities for further South-South collaboration.

Sub-Saharan Africa
Bean Barrage

African farmers continued to reap the rewards this year of CIAT-supported networks for collaborative bean research. These respond effectively to needs across the region, building on strong foundations provided by the Center's strategic research in Colombia. This work has led recently to the release of four new varieties that offer marked nutritional benefits and, during 2010, to the launch by the Rwanda Agricultural Research Institute (ISAR) of some 15 improved varieties that show advantages such as heat tolerance and multiple-disease resistance.

The nutritionally superior varieties, which possess high levels of iron and/or zinc, are among the early products of a major response to widespread micronutrient deficiencies in Africa.

Often referred to as "hidden hunger," these deficiencies reduce children's cognitive development and leave them and adults more susceptible to various diseases, including malaria. CIAT scientists are devising new solutions to the scourge of micronutrient malnutrition, in collaboration with the HarvestPlus Challenge Program of the Consultative Group on International Agricultural Research (CGIAR), through an approach called "biofortification." It involves the use of modern plant breeding to raise micronutrient levels in staple food crops.

In Africa, bean researchers have put in place a dual strategy to achieve this purpose. First, they have collected and evaluated a wide range of varieties and landraces already available in the region to identify those with the highest micronutrient levels. And second, they are evaluating lines derived from crosses made at CIAT headquarters, as described in a later section of this report.

The first, "fast-track" approach has yielded tangible results in recent years, thanks to regional bean networks that form part of the Pan-Africa Bean Research Alliance (PABRA). One of their key functions is to promote the exchange and joint evaluation of genetic resources. Zimbabwe was among the first beneficiaries of the Alliance's work on biofortified beans, releasing a new variety that is rich in both iron and zinc. Two such varieties were also released in Malawi, and a high-iron bean landrace was offered to farmers in Burundi, with several more biofortified lines in the pipeline for this country.

The barrage of bean variety releases in Rwanda is a "major partnership success story," said Daphrose Gahakwa, ISAR's Director General. "This work responds to several key opportunities for realizing the great potential of beans to strengthen food security and raise rural incomes," added Robin Buruchara, CIAT's regional coordinator for Africa. One of these opportunities centers on the superior productivity of climbing beans, which are generally best suited to cool, highland environments. Since the 1980s, Rwanda has witnessed remarkable success with these varieties. And the country's bean researchers have generously shared their success through the PABRA networks, helping make climbing beans popular in other highland areas as well.

As pressure on the land grows in these densely populated regions, farmers are increasingly interested in shifting the production of climbers to warmer, drier environments at lower elevations. But to accomplish this without sacrificing high productivity, they need new varieties that are adapted to these conditions. In response, CIAT scientists have bred climbing bean lines that perform well at mid-altitudes, and PABRA partners are evaluating and selecting these and other materials developed across the region.

A number of the climbing bean varieties released in Rwanda during 2010 have resulted from this collaborative work, showing good tolerance to heat and drought. In addition to boosting bean production, they demonstrate how farmers can adapt bean production to climate change impacts in the future.

Asia

A Sting Operation in Thailand

In the start of a carefully crafted emergency campaign to thwart an alarming outbreak of the cassava mealybug, Thailand's Department of Agriculture (DOA) along with the Thai Tapioca Development Institute (TTDI) released hundreds of thousands of parasitic wasps during 2010 in selected parts of the country. Biological control using *Anagyrus lopezi*, the wasp's scientific name, is the fastest, most reliable solution available, as demonstrated by experience in sub-Saharan Africa more than 2 decades ago.

Originally from South America, the cassava mealybug (*Phenacoccus manihoti*) feeds only on this root crop, sucking sap from the plants and causing them to shrivel. Also a South American native, cassava was carried by Portuguese traders to Africa and Asia, where it thrived in the absence of insect pests inhabiting its home territory.

As the mealybug finds its way to new countries and regions, the wasps can be sent in to kill mealybugs quickly and effectively.

But eventually, the cassava mealybug and other pests caught up with their host plant, devastating crops first in sub-Saharan Africa and now in Southeast Asia. Spread of the cassava mealybug has been confirmed in eastern and northeastern Thailand, where the pest is causing yield losses of about 20%. Since the country's cassava industry generates at least US$1.5 billion in farm income each year, losses of that magnitude translate into severe economic hardship, which will worsen if the pest is allowed to spread further.

More than 4 million small-scale farmers in the Greater Mekong Region, including Thailand, depend on the cassava industry for a livelihood. While some cassava is consumed by farm families or fed to animals on farm, most is sold to both domestic and foreign processing industries, which convert the roots into animal feed and biofuels and also extract starch from them for use in a wide variety of food and other products.

In mounting the emergency campaign, Thai scientists received support from the International Institute of Tropical Agriculture (IITA) and CIAT. Working with various partner organizations, these two centers had curbed devastating mealybug attacks on Africa's cassava crop during the 1980s through a highly successful biocontrol campaign, which ended a major food security catastrophe. Within a year after confirming the presence of *P. manihoti* in Thailand, the DOA and the TTDI had arranged for importation of the pest's most effective natural enemy from Africa (following strict quarantine procedures), tested its efficacy and safety, carried out mass multiplication, and begun widespread releases.

Measuring just 2 millimeters in length, *A. lopezi* is a formidable natural enemy of the cassava mealybug. Even when infestations are low, female wasps are able to detect and home-in on their prey, injecting their eggs into the pest. The pest population is then gradually reduced, as the wasp larvae grow and as adult females feed on the host insect. The wasps pose no threat to humans or animals, including other insect species.

CIAT scientists are aware that the cassava mealybug has already spread to Cambodia, causing serious damage, and has also been observed in Laos and Burma. It could reach other parts of Southeast Asia as well, including Vietnam, southern China, and eventually Indonesia and the Philippines.

"It's going to be an international game of cat-and-mouse," said Tony Bellotti, a CIAT entomologist, who has spent 35 years investigating cassava pests. "As the mealybug finds its way to new countries and regions, the wasps can be sent in to kill mealybugs quickly and effectively."

Latin America and the Caribbean

A Tropical Fruit Triumph

Collaborative research on a tropical fruit grown in South America's Andean region paid off handsomely this year, offering benefits for farmers, consumers, and the environment. The source of these gains is an innovative technology that consists of grafting a productive and flavorful new variety of the species *Solanum quitoense* onto selected roots of two closely related wild species with resistance to pests and soil-borne diseases.

In Colombia, this fruit is referred to as lulo (from the indigenous Quechua

language) and in Ecuador as naranjilla (meaning "little orange" in Spanish). These countries account for most production of *S. quitoense*, though it is found in other countries of the region as well. A total of about 30,000 rural families rely on this species, growing it at 700-2200 meters above sea level on 0.5- to 1.5-hectare hillside plots, usually in mixtures with staple food crops.

Smallholder farmers like two things about *S. quitoense*. First, it grows quickly, delivering weekly harvests of fruit after just 8 months, which then continue for 2 or 3 years. Second, demand is high in local markets, which crave the fruit for use in fresh juice and increasingly in yoghurt and ice cream. Farmers also have the option of catering to export markets for frozen fruit pulp, assuming they can meet stringent quality requirements. This combination of steady supplies and brisk demand can translate into a continuous stream of income for farm families —if all goes well.

But frequently the fruit succumbs to fungal diseases and pests, particularly nematodes and fruit borer. Until recently, farmers have lacked satisfactory solutions.

Traditional varieties of *S. quitoense*, while possessing good flavor and aroma, are highly susceptible to disease and pest damage. Many farmers have dealt with this problem by planting the fruit in new plots cleared from primary tropical forest. At the end of the crop cycle, by which time disease and pest pressures have built up, growers then have two options: either clear a new plot or plant again in the current one, applying large amounts of toxic agrochemicals to control diseases and pests. Both options harm the environment and drive up production costs. In addition, the latter poses a significant health threat for both growers and consumers while also making the fruit ineligible for export.

For years, Colombian and Ecuadorian scientists have sought to develop commercial varieties from hybrids between *S. quitoense* and various related species that show disease and pest resistance. In Ecuador, for example, the interspecific hybrids INIAP Puyo and INIAP Palora, developed by the country's National Autonomous Institute for Agricultural Research (INIAP), have been widely adopted. But their inferior fruit quality gives them less market appeal than traditional varieties.

This is the background against which collaborative research has delivered a better solution. The members of a CIAT-led international research consortium tested a wide range of *Solanum* spp. samples in the lab and field, identifying some with good resistance to nematodes and fungal diseases. In the meantime, INIAP scientists developed and released the variety INIAP Quitoense 2009, which combines high productivity with quality traits that make it well suited for use in fresh form or for processing. These scientists also hit on the idea of grafting the new *S. quitoense* variety onto rootstocks from two related and highly compatible species, which the consortium had selected for nematode and disease resistance.

"The cumulative fruit production of the grafted plants over 12 months is an astonishing 10 to 15 times more than for the interspecific hybrids," said Alonso González, who leads CIAT tropical fruit research. "On top of that, the plants show no nematode damage and drastically reduced disease infection."

Under an agreement between INIAP and a private nursery, more than 230,000 plants of the new variety (enough for planting 115 hectares) were distributed and sold during 2010 in a dozen provinces of Ecuador. Because of the variety's strong market appeal, combined with pest and disease resistance, adopting farmers receive better prices locally and are also better placed now to export frozen pulp. An economic analysis of this research showed an investment return rate of 290%.

Agrobiodiversity: New Contributions to a Food-Secure World

If we are serious about achieving global food and nutrition security, then we must do much more to converse, understand, and use genetic resources.

In 2010, the United Nations' International Year of Biodiversity, CIAT joined many others in celebrating the value of this vital resource for human well-being (see box). The celebratory activities at CIAT carried a clear message: If we are serious about achieving global food and nutrition security, especially in the face of climate change and other growing pressures on agriculture and the environment, then we must do much more to converse, understand, and use genetic resources.

CIAT scientists began to act on this proposition long ago, making agrobiodiversity a central focus of their research. The stories that follow—which chronicle recent advances in the improvement of beans, cassava, tropical forages, and rice—demonstrate the robust capacity of this research to deliver results that translate directly into better supplies of more nutritious food and larger incomes for the rural poor.

The Past and Future of a Twice-Tamed Bean

To secure future food supplies, it helps to know about the distant past of major crops. More than a matter of botanical curiosity, such knowledge yields new insights into "our agricultural heritage" (as renowned plant explorer and geneticist J.R. Harlan termed it), which can aid the conservation of plant genetic resources and their use in crop improvement. This is what CIAT scientist Daniel Debouck and several Colombian university colleagues had in mind when they embarked on a recent study aimed at determining the multiple origins of lima bean (*Phaseolus lunatus* L.) in the Americas.

To determine where and how many times lima bean was brought into cultivation, the researchers analyzed a geographically diverse collection of 59 wild and 50 domesticated lima bean samples from the CIAT genebank, which safeguards the world's largest collection of *Phaseolus* species. For this purpose, they calculated the genetic distances between samples, using chloroplast and ribosomal DNA as molecular markers. The researchers gained an overall picture of the evolutionary relationships implied by these data, with the aid of various types of sophisticated software and colorfully

Platforms for Partnerships

AGRONATURA Parque Científico CIAT CIAT Science Park

CIAT established a new alliance with Colombia, its host country, in 2010. To expand its research partnerships with national entities, the Center focused on two mechanisms: FUNDACIAT and the Agronatura Science Park. These entities would help enhance the national partners' impact on their country's development.

FUNDACIAT is a new foundation that was created in late 2009. It aims to find new ways of pursuing CIAT's mission in Colombia and across Latin America and the Caribbean. This year, in collaboration with the Ministry of Agriculture and Rural Development (MADR) and the Colombian Corporation of Agricultural Research (Corpoica), both of Colombia, FUNDACIAT examined possibilities of establishing new research networks that would deal with topics as diverse as cereals and cocoa. The transfer of research results to end-users would also be emphasized. The main focus, however, would be for FUNDACIAT to help strengthen the research agenda of those Colombian national research centers.

The **Agronatura Science Park** constitutes the Center's second mechanism for collaborating with Colombian research and development entities. The Park brings together 12 national and international entities, which serves as a platform at Center headquarters for promoting alliances with like-minded organizations.

Agronatura has conducted retrospective studies of its experiences and of the role it plays in CIAT. Practices that have worked well were identified. Aspects that required improvement such as broadening and strengthening this collaborative platform were also found. Attention was paid to CIAT's relationships with its immediate neighbors such as Corpoica and the National University of Colombia. Finally, relationships with the private sector were considered.

In this regard, Agronatura has started developing an innovative model of a science and technology park aiming to contribute to Colombia's competitiveness and productivity. Focus will be put on those sectors defined as "world-class sectors" by the national government. The proposal is being prepared with support from the Agri-Science Park @ ICRISAT, which has already developed its Agri-Business Incubator (ABI) and Ag-biotech Innovation Center (AIC).

The 2010 International Year of Biodiversity gave Agronatura an important focal point for paying homage to a life-giving resource. A visit was organized for 40 delegates attending the ninth meeting of the CBD's Working Group on Access and Benefit-Sharing in Cali, March 2010. The delegates showed keen interest in what CIAT and Agronatura are doing to help conserve Colombia's enormous biodiversity.

To celebrate International Day for Biological Diversity, Agronatura held a seminar on 21 May 2010. The seminar, entitled Biodiversity, Biotrade, and Sustainable Development, was attended by more than 80 people. Related to this issue, Agronatura began working with the Colombian Biotrade Fund to create a regional committee for biodiversity and competitiveness. Active collaborators include Bioversity International, Corporación BIOTEC, and the Institute of Marine and Coastal Research "José Benito Vives de Andréis" (INVEMAR).

The signs are that the two mechanisms augur well for the new alliance with Colombia. There is a strong commitment and vitality in every action, aiming to contribute to the sustainable and advantageous development of this country.

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named bioinformatics tools, like "neighbor-joining topologies" (assessed by means of "1,000 bootstrap replicates") and "haplotype networks" (built under the "parsimony criterion").

The results, published during 2010 in the journal *Crop Science*, indicate that lima bean was domesticated at least twice in two parts of the Americas, giving rise to distinct gene pools. One consists of large-seeded landraces inhabiting mid- to high-elevation areas, which resulted from the domestication of wild beans in the Andean region of South America, specifically in Ecuador and northern Peru. The other gene pool encompasses small-seeded landraces occurring at lower elevations —the product of domestication in Mesoamerica, specifically in an area to the north and northwest of the Isthmus of Tehuantepec in Mexico.

Lima and common bean are among the few known cases in which populations of the same species were domesticated at different times and in different places from widely dispersed wild species.

These gene pools are genetically quite remote from the more widely grown common bean (*P. vulgaris*)—another twice-tamed species, whose dual domestication also produced large-seeded Andean types and small-seeded Mesoamerican ones. Even so, lima bean landraces are potentially quite relevant to common bean improvement, offering a greater degree of hardiness, which could better enable common bean to withstand the harsher growing conditions expected to result from climate change. New gene technologies offer the possibility of overcoming the sexual barriers that have previously prevented such transfers of valuable genetic material.

"Lima and common bean are among the few known cases in which different populations of the same species were domesticated at different times and in different places from widely dispersed wild species," said Debouck, who leads CIAT's Genetic Resources Program.

"The genetic diversity of these species is geographically structured, so pinpointing the areas where domestication happened represents an important step toward better understanding the genetic architecture of key traits."

Researchers also learned from this analysis that domestication drastically reduced the genetic diversity in cultivated lima bean, compared with its wild ancestors—a phenomenon referred to as the "founder effect." The Andean gene pool underwent an especially marked reduction of 50% or more, which is considerably higher than that observed in common bean.

"The severe founder effect in lima bean," said Debouck, "underlines the importance of conserving the wild predecessors of this species for future genetic improvement of *Phaseolus*."

A Double Dose of Food Security

CIAT researchers observed noteworthy improvement this year in the parent lines they use in breeding beans of the small-seeded Mesoamerican type. A large proportion of these lines now contain good levels of iron, an essential micronutrient, combined with other useful traits, especially drought tolerance. As a result of this advance, national partners in a number of countries—including El Salvador, Guatemala, Honduras, and Rwanda —will soon be able to get their hands on these genetically segregating materials, thus speeding the process of local adaptation.

"The resulting varieties will offer consumers a double dose of food security, which consists of higher micronutrient content plus better performance under drought," said Stephen Beebe, who leads CIAT's bean research.

Resilient small-seeded beans of Mesoamerican origin (that is, from Central America and southern Mexico) grow well in many of the world's toughest bean-producing regions, which are characterized by poor soils, severe drought, and high temperatures. Whether in their ancestral home or distant lands, like Brazil, Haiti and various countries of eastern Africa, these beans stave off hunger and nourish children, providing large amounts of protein and minerals.

As the global climate changes in the coming decades, many of these regions will see more severe and frequent droughts. That and other pressures will contribute to food price inflation and volatility, forcing consumers to rely more on affordable basic staples like beans. As part of a larger effort to combat malnutrition in the face of climate change and other pressures, bean researchers are genetically enhancing the dietary advantages of an already nutritious crop through a breeding approach referred to as biofortification. Growing numbers of lines now possess the target iron level, showing an increase of 40 parts per million (ppm) over the baseline of 50 ppm in standard beans.

At the same time, researchers are improving the drought tolerance of these small-seeded beans. Many of them now yield about as much as the drought-tolerant check, red-seeded SER 16. Over the last several years, researchers have come to realize that plant traits associated with drought tolerance translate into better crop performance both under favorable growing conditions and to some degree under low soil fertility as well.

Recent progress in raising the iron content of these beans builds on 15 years of work, starting with genetic resources safeguarded in the genebank at CIAT. Sources of this trait include common bean landraces plus a sample of *P. dumosus*, a sister

One key challenge is to broaden the range of grain types in beans that combine high iron with drought tolerance and other valuable traits.

species known as year-long bean. The high iron levels observed in recent crosses is a direct result of this combination of genes from multiple sources.

What lies ahead? One key challenge, Beebe explained, is to broaden the range of grain types in beans that combine high iron with drought tolerance and other valuable traits. "Bean consumers the world over have diverse preferences with respect to grain shape, size, and especially color. Most of the elite lines now available have the cream-striped carioca type, which is preferred in Brazil and parts of Africa."

Beebe's team is now selecting to create elite lines of other colors. In addition, they are examining the nutritional impact of high-iron beans on human health, in collaboration with nutritionists. They are also putting more emphasis on tolerance to poor soils, especially those low in phosphorus, in search of ever-more versatile and hardy beans.

A Climate-Hardy Cover Crop for Central America

New findings on the performance of the leguminous forage species *Canavalia brasiliensis*, which is native to Latin America, provided further evidence of its significant potential for improving food security and rural incomes in Central America and possibly other regions. When grown as a cover crop, Canavalia fixes nitrogen from the air and channels it into the soil. When used as an animal feed, it provides abundant, high-quality fodder during dry months, when natural vegetation and crop residues are scarce.

In a greenhouse study, CIAT researchers identified two superior accessions, or samples, of this highly drought-tolerant plant. In the process, they identified the trait—deep rooting ability—that accounts for much of Canavalia's excellent performance under drought and low soil fertility. This knowledge should make it easier to identify superior samples in the future.

Once integrated into traditional crop-livestock systems, the plant could offer smallholder farmers a way out of a common predicament, which is likely to worsen as a result of climate change. Intensive cropping in Central America's hillsides has led to chronically low soil fertility. This has depressed the productivity of the region's main food crops—maize and beans—which are grown during two short, successive rainy seasons. Farmers generally cannot afford to apply enough mineral fertilizers to replace the nutrients removed through cropping. A further problem is that, during the 5- to 6-month dry season, families run short of livestock feed, thus lowering milk production and undermining the diets of young children while stifling a critical source of income needed to compensate for dwindling supplies of maize and beans.

In search of solutions, CIAT researchers introduced Canavalia several years ago in Nicaragua. The farmers who tested it were struck by

In search of solutions, CIAT researchers introduced Canavalia several years ago in Nicaragua.

both its appearance and performance. In stark contrast with the desiccated vegetation all around it, the plant stayed green throughout the dry season, while adding 20-50 kilograms of nitrogen per hectare and boosting milk production by 1 kilogram per animal.

To determine the physiological basis of Canavalia's adaptation to drought and low soil fertility, CIAT scientists and their partners from the Swiss Federal Institute of Technology (ETH) measured differences in root development and distribution between four Canavalia accessions under simulated drought and both high and low soil fertility. The results indicate that the robust performance of these plants under stress is associated with deep rooting ability together with vigorous development of fine roots. Two accessions proved especially noteworthy in terms of total root length under the combination of drought and low soil fertility.

"The superior performance of these two accessions in the greenhouse study is consistent with the results of on-farm experiments conducted in Nicaragua," said Michael Peters, who leads CIAT's research on tropical forages. "We'll further test them with farmers to determine how they can best be integrated into crop-livestock systems across the Central American hillsides."

Heightening Cassava's Market Appeal

Through a succession of pioneering discoveries and achievements, CIAT's cassava team and their national partners have opened up previously unimagined prospects for adding value to this productive root crop and thus raising the incomes of the millions of rural people who depend on it.

Center researchers have known for a long time that enabling the rural poor to derive greater benefits from cassava is more than a matter of boosting and stabilizing its yield. Strengthening market demand for the crop's starchy roots is also critical. The importance of markets was reinforced by a major cassava initiative carried out nearly a decade ago by the Food and Agriculture Organization of the United Nations (FAO). In response, CIAT scientists and their national partners have moved quickly to lay the genetic foundations for new cassava markets, based on effective exploitation of a whole series of novel crop characteristics.

One of these traits is the high content of carotenoids (orange pigments that serve as chemical precursors for vitamin A) found in some cassava cultivars. Because this trait is highly heritable, cassava breeders were able to adjust their methodologies and achieve unprecedented rates of genetic gain, more than doubling cassava's carotenoid level in just 5 years. "At the start, some considered this goal unthinkable," said Hernán Ceballos, former leader of CIAT's cassava research. "But the results speak for themselves. They translate into large nutritional benefits for the many poor consumers whose diets are deficient in vitamin A and also into significant advantages for the animal feed industry."

Another cassava quality trait with strong market potential is the waxy-starch mutation, which CIAT first reported in 2007. Thai scientists are developing a commercial cassava variety that possesses this trait. More recently, CIAT researchers discovered the small-granule starch type, another induced genetic mutation. In a 2008 article published in the *Journal of Agricultural and Food Chemistry*, they suggested that the small size of the granule and its rough surface could be advantageous for ethanol production. They went on to develop a method to evaluate cassava for this purpose.

Two new studies demonstrate that the small-granule mutation makes cassava a highly desirable starch

Center researchers have known for a long time that enabling the rural poor to derive greater benefits from cassava is more than a matter of boosting and stabilizing its yield.

source for ethanol production by permitting more efficient processing and thus making the crop more competitive as a feedstock. These findings have aroused particular interest in China, which has set ambitious targets for ethanol production and where cassava is already grown for industrial use. The Chinese government has opted not to use maize or sugarcane as bio-ethanol feedstocks out of concern about the implications for food security as well as water and land use.

Cassava's newfound potential for bio-ethanol production could also be realized by remote rural communities. For this purpose, the Latin American and Caribbean Consortium to Support Cassava Research and Development (Clayuca), a consortium of public and private organizations, has developed a system for cassava-based bio-ethanol production. From 5 hectares of cassava, four or five rural families can generate year-round 3-5 hours of electricity daily.

A Two-Pronged Approach for Raising Rice Yields

Important developments in CIAT's collaborative rice research this year inspired new confidence in the power of science to overcome the stagnation of crop yields, which has become evident in global rice production over the last decade or more.

Despite widespread adoption of modern high-yielding varieties in Latin America and the Caribbean, farmers' rice yields routinely fall well below those shown to be possible under experimental conditions. The result is a persistent yield gap ranging from 1 to 3 tons per hectare across the region. Concerned that rice productivity growth could fail to keep pace with rising demand during the coming decades, fueling food price inflation and volatility, CIAT scientists and their partners in the Latin American Fund for Irrigated Rice (FLAR) are pursuing a two-pronged approach to stimulate growth in rice yields.

One part of the strategy focuses on closing yield gaps through improved management of the rice crop and key resources, especially water and fertilizer. Begun during 2003 in two countries and later expanded to a total of 10, this work initially involved vigorous promotion of six improved crop management practices through a "hybrid" extension system that incorporated farmer leaders and groups. This approach produced spectacular results in South America's Southern Cone, which accounts for a large proportion of total rice production in Latin America.

FLAR scientists Edward Pulver and Luciano Carmona have reported that in Brazil's southernmost state, Rio Grande do Sul, the approximately 5,000 farmers participating directly in extension activities increased their

rice yields by 1.7 tons per hectare, on average, within 3 years. Statewide, rice yields rose by a ton (from 6 to 7 tons per hectare) in just 4 years. At the previous rate of yield growth, it would have taken 40 years to achieve an increase of this magnitude. Parallel efforts in several tropical countries also demonstrated the potential to boost yields in irrigated rice by several tons per hectare. But weak extension systems and limited financing in these countries have slowed the adoption of better management practices.

Another promising opportunity to raise rice yields in the tropics involves the use of earthen dams for rainwater harvesting (a common practice in the Southern Cone) to permit irrigated production during the dry season. In areas of Costa Rica, Mexico, and Nicaragua, where production has previously depended entirely on rainfall during the rainy season, early results from 2010 indicate that farmers can double rice yields with the new system. It also provides them an incentive to diversify production, offering higher yields of maize and beans as well as the option of raising fish.

The second part of CIAT and FLAR's yield strategy involves a search for novel approaches to raise the crop's genetic yield potential. This work recognizes that to break the current pattern of yield stagnation requires that researchers treat the rice yield gap as a moving target, encouraging farmers to continually improve crop management to realize the genetic potential of new and better rice varieties.

Researchers have pursued various options over the last 15 years or so for raising the genetic yield potential of rice. Some of these have centered on the development of a new plant type but with disappointing results. Only hybrid rice has consistently shown a yield advantage over the best inbred varieties. Hybrids have the disadvantage, however, of obliging farmers to purchase new seed every cropping season rather than plant their own seed.

In search of an alternative, CIAT researchers have experimented in recent years with the use of wild species to bring yield-related genetic material into the cultivated crop through conventional breeding methods with the aid of molecular tools. One option is to use the resulting lines as parents in hybrids.

Researchers are also seeking to increase the number of grains per square meter in rice by selecting for a particular combination of yield-related traits. In evaluations carried out during 2010, they identified two lines that show a 10%-20% yield advantage over top commercial varieties. Moreover, molecular marker studies confirmed that these lines contain genetic material introduced from the species *Oryza rufipogon* that previous studies have shown to be associated with higher grain yield.

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Tropical Soils: Finding Strength in Agricultural Diversity

During its first phase (2006-2008), CIALCA evaluated with some 4,000 rural households a wide range of options for raising crop yields, restoring soil fertility, and enhancing the resilience of diverse agricultural systems.

The vast diversity harbored within the gene pools of major food crops is a potent resource for agricultural development. But it is especially useful when deployed as part of a larger effort to enhance and better manage the diversity of whole agricultural systems and landscapes for stronger food and nutrition security as well as rapid poverty reduction. CIAT's research on tropical soils provides an especially suitable arena for such efforts. Focusing on the big picture of rampant land degradation in developing countries, it offers integrated solutions for enhancing soil fertility and managing land more sustainably. As the following stories illustrate, this research is finding new ways to tap the huge development potential of agricultural diversity both above ground and below.

A Collective Will and Way to Succeed in Central Africa

Agricultural development is not easy under any circumstances but least of all in a place like Central Africa's Great Lakes Region, which is struggling to recover from decades of conflict and civil strife. Yet, rural people working in these conditions can register rapid and substantial gains, as demonstrated by a collaborative initiative that links CIAT and two other CGIAR centers with numerous local and international partners.

A midterm review in 2010 singled out several features of this project—called the Consortium for Improving Agriculture-based Livelihoods in Central Africa (CIALCA)—that mainly account for its success. These are the openness of the project's partnership, its integrated approach to research on multiple cropping systems, its

participatory style of development, and its much-appreciated commitment to sharing knowledge and strengthening local capacity.

The particular way in which CIALCA combines these ingredients has resulted from a growing recognition of the need for collective action in agricultural research for development. In response to a call for project proposals from the Belgian government, Bioversity International, CIAT's Tropical Soil Biology and Fertility (TSBF), and the International Institute of Tropical Agriculture (IITA) each sent a submission but then "agreed to operate as one," as the midterm review put it, to achieve greater efficiency and synergy.

CIALCA clearly prefigures the new way of working called for by recent reforms in the CGIAR. Operating in a total of 10 areas of Burundi, the Democratic Republic of the Congo, and Rwanda, the project has advanced on many fronts all at once and in a remarkably short time. It will likely be integrated into one of the CGIAR Consortium's new research programs, specifically that focusing on integrated agricultural systems for the humid tropics, which is now at the proposal development stage.

During its first phase (2006-2008), CIALCA evaluated with some 4,000 rural households a wide range of options for raising crop yields, restoring soil fertility, and enhancing the resilience of diverse agricultural systems. The products of this work include improved crop varieties, simple techniques for mass propagation of banana and other species, a cassava-legume system that triples the yields of legumes and doubles those of cassava, measures for managing plant diseases and pests, soybean processing methods, and techniques for reducing soil erosion.

In connection with this work, the project is supporting 20 B.Sc., 19 M.Sc., and 18 Ph.D. students, representing a major contribution to the reconstruction of regional research capacity. At the same time, CIALCA has begun to address other issues on which agricultural transformation depends, such as farmers' links with output and input markets and their access to credit.

As the development of new technologies and services continues

in a second phase, the project is scaling out interventions identified in phase 1 through active engagement with a growing number of national and civil society partners. This involves large-scale training for technicians and members of farmer associations, in which 60% of the participants are women.

CIALCA has thus transformed itself from a specific project with its own objectives into a broad platform for rural development involving different agricultural systems and services, various donors, and many other actors. A new Knowledge Resource Center being established with support from the German government will provide a critical focal point for sharing research results more widely and opening up new pathways to impact.

CIALCA has transformed itself from a specific project with its own objectives into a broad platform for rural development involving different agricultural systems and services, various donors, and many other actors.

Below-Ground Biodiversity: The Life Beneath Our Feet

As surprising as it may seem, the living diversity that resides below the ground is greater than that found above ground in agricultural systems. It is thus ironic that until recently researchers have tended to neglect the secret world of below-ground biodiversity, largely overlooking the many opportunities it offers for contributing to more sustainable land management.

In an effort to shed light on this potentially valuable resource, CIAT's TSBF researchers embarked 8 years ago on a major global project, supported by the United Nations Environment Programme (UNEP) and the Global Environment Facility (GEF) in the World Bank, to explore below-ground biodiversity with national partners at 15 sites in 7 countries across the tropics (Brazil, Côte d'Ivoire, India, Indonesia, Kenya, Mexico, and Uganda). An international conference held in May 2010 at the headquarters of the World Agroforestry Centre in Nairobi, Kenya, marked the conclusion of the project, providing an overview of its many achievements.

According to extensive inventories carried out by project partners at "hotspot" locations, below-ground biodiversity is declining as a result of more intensive land use. Harmful nematodes, for example, are increasing at the expense of useful bacteria and fungi, while important earthworm populations are decreasing. Project scientists further confirmed the existence of rare earthworm and ant species and in some countries reported previously unknown species for the first time.

The inventory results constitute a baseline against which future biodiversity losses can be measured across locations. For this purpose, the project developed standardized methods for sampling and characterizing below-ground

biodiversity and published these in its Handbook of Tropical Soil Biology. Other books, journal articles, and project documents published under the project describe proven methods for conserving and managing this biodiversity, which were tested with farmers. Many of the methods were developed through the work of about 80 scientists, 120 M.Sc., and 30 Ph.D. students participating in the project.

Particularly promising are various techniques for inoculating the soil with earthworms, rhizobia, fungi, and other organisms to accomplish tasks such as the improvement of nutrient uptake and cycling, plant disease and pest control, soil moisture retention, and soil structure improvement. Researchers also identified indirect methods for better management of the soil biological community, including changes in cropping systems, the use of leguminous cover crops, and the introduction of "antagonistic" plants, which produce chemicals in their roots that are toxic or repellant to pests and pathogens. Smallholder farmers at various project sites are using project recommendations to improve soil and crop productivity. In southern Mexico, for example, farmers have adopted the use of manure and crop rotations to combat viral infections in the production of lily bulbs. Growers in Uganda have used rhizobia inoculants to expand the area sown to soybean, making the crop an important cash earner in the study area. In Indonesia, the use of antagonistic plants to combat white roots disease has proved effective in smallholder rubber plantations.

In addition to organizing a closing workshop, the project presented its findings in 2010 at major meetings of the United Nations Convention on Biological Diversity, including its 10th meeting of the Convention of the Parties, held in Japan, marking the culmination of the International Year of Biodiversity.

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Knowledge and Tools that Quicken the Pace of Change

CIAT contributes importantly to the collective construction of problem-solving knowledge by developing and experimenting with a wide range of innovative tools and methods.

While many products of CIAT's research take the form of improved germplasm—the classical international public good—this work also generates a wealth of new knowledge together with better tools for putting this resource to work in technology development, policy formulation, and decision making.

Knowledge in action is sometimes the product of individual genius and initiative, but more often it springs from a collective effort that blends diverse perspectives—for example, that of agricultural scientists with that of farmers and other rural people. Such an approach is especially necessary for responding to complex challenges like global economic and climate change. As the following stories illustrate, CIAT contributes importantly to the collective construction of problem-solving knowledge by developing and experimenting with a wide range of innovative tools and methods.

Better Decisions from Field to Forest

CIAT's Decision and Policy Analysis (DAPA) Program has recently provided a diverse set of tools and analyses that should lead to better decisions about research for development at widely differing scales. Some of these products are especially relevant to the challenge of coping with climate change.

One of them involves the use of computer simulation models to help set long-term priorities for crop breeding strategies, given the types of production constraints that a changing climate is likely to present within the next 2 decades. Carried out in close consultation with crop improvement researchers in CIAT and other CGIAR centers, this analysis has

produced some surprising conclusions.

The instincts of most plant breeders tell them that to help farmers adapt to climate change is chiefly a matter of boosting heat and drought tolerance. While this is clearly the right antidote for common bean, cassava breeders will need to deal with quite a different set of constraints, including increased pest and disease pressures and problems associated with water-logging. Analyses carried out in collaboration with researchers at the International Potato Center (CIP) suggested that, while heat tolerance merits some emphasis in future breeding strategies, cold tolerance will continue to be a major constraint in 2030 and beyond.

A second tool—Terra-I, developed in partnership with The Nature Conservancy—provides practically real-time figures on deforestation rates across all of Latin America. These have been a major concern for several decades—especially in the Amazon, which is the world's largest tropical forest, providing ecosystem services on a truly global scale. But now, with the emergence of REDD+ (reducing emissions from deforestation and forest degradation) as a potentially cost-effective mechanism for mitigating climate change, a comprehensive solution to deforestation may finally be within reach. It is therefore more important than ever for decision makers to know exactly what is going on in the Amazon, so they can ensure that REDD+ produces the best environmental and social outcomes in this vital region.

Terra-I has been incorporated into the Amazon Initiative (IA) Viewer—an easy-to-use, online tool that provides policy-relevant data for any area within the Amazon Basin. These data apply to what are perhaps the three most important and difficult-to-determine variables in planning effective REDD+ initiatives: (1) carbon storage; (2) the likelihood of future deforestation under a business-as-usual scenario; and (3) the opportunity costs of avoided deforestation, that is, an approximation of the minimum payment required for forest conservation.

The IA Viewer should improve the effectiveness of REDD+ in the Amazon by providing decision makers with a practical solution to the monumental task of prioritizing policy interventions over approximately 500 million hectares of potentially eligible forest. Moreover, because the IA Viewer provides detailed information on biodiversity and poverty, the tool allows policy makers to identify opportunities for deriving environmental and economic co-benefits from REDD+ initiatives.

A third initiative—referred to as the Site-Specific Agriculture based on Farmers Experiences (SSAFE) project—aims to determine the optimum growing conditions for high-value tropical fruits. This is important to know, since it can take several years for some species to begin bearing fruit, creating considerable risks for smallholder growers, as they attempt to diversify production or respond to changes in market demand.

The Site-Specific Agriculture based on Farmers Experiences (SSAFE) project aims to determine the optimum growing conditions for high-value tropical fruits.

The experimentation with KS techniques continued during the KM4Dev meeting, which contributed further to the creation of a strong KM4Dev movement in Latin America and the Caribbean.

The SSAFE project will provide a means to help these growers analyze their options by compiling information about fruit crop suitability in quite specific areas from hundreds of thousands of small-scale farms—treating each one as a kind of experiment station. Moreover, by using global positioning system technology together with specially developed software, the project will process the information in a fraction of the time it would ordinarily take scientists to build up such a detailed picture of fruit production constraints and opportunities.

This is participatory research on an enormous scale, designed to help farmers address current and future challenges, such as changing markets and a changing climate.

Dialog for Development

A pair of events held at CIAT headquarters around midyear examined the past and future roles of two bodies of thought and practice that have profound implications for the way CIAT and other Centers conduct research for development. One of these approaches is referred to as "knowledge sharing" (KS) or "knowledge management" (KM), while the other is called "gender-responsive participatory research" (GRPR). How centers incorporate these perspectives more fully into their agricultural and environmental research is especially important now, as the CGIAR embarks on major new programs that involve intensive interaction with diverse partners, aimed at achieving massive impact at the community and household levels.

The first event, held in May, was the Knowledge Share Fair for Latin America and the Caribbean, accompanied by a regional gathering of the Knowledge for Development (KM4Dev) community—a network of KM practitioners working in diverse organizations around the world. The share fair formed part of a series of follow-up activities prompted by an initial event organized in Rome, Italy, during 2009. Other such events have since taken place in Belgium, Ethiopia, and Nicaragua, and further gatherings are planned for 2011. Their overall objective is to raise awareness of innovative KS practices, with the fair at CIAT focusing specifically on their relevance and application to agricultural development in the Center's home region.

From more than 100 proposals, the organizers identified in advance 45 experiences, dealing with different KS issues and tools in diverse contexts. Grouped according to themes (such as KM and participatory research), these experiences provided the focal point for inclusive discussions in a variety of formats, such as the world cafe, chat show, and so forth. The fair also featured exhibitions; a half-day open space session, which allowed participants to pursue discussions on topics of their choice; and brief training sessions on tools and methods, such as wikis, blogs, and Twitter. Many participants used these tools to report on the fair in real time.

Those and related activities helped consolidate the region's KS "community of practice" by generating interest in further collaborative activities and informal networking. The

experimentation with KS techniques continued during the KM4Dev meeting, which contributed further to the creation of a strong KM4Dev movement in Latin America and the Caribbean.

The ultimate aim of this movement is to make research results more relevant, accessible, and useful by providing scientists with effective ways to "communicate throughout the entire research process, not only at the end, with a focus on the final product," said Enrica Porcari, who leads a CGIAR program on KM. With this program's support, various centers have steadily built up their KM capacity over the last decade and are poised to apply it more strategically.

A second event was a workshop, entitled "Repositioning gender-responsive participatory research in times of change." It was held by the Participatory Research and Gender Analysis (PRGA) Initiative in Cali, Colombia, during 16-18 June, 2010. Various formats were used to guide deliberations on gender research. This approach uses a variety of concepts and tools to encourage women and men farmers to work with researchers to pursue sustainable development options to enhance their communities' well-being.

In this way, PRGA strengthened its position as a hub of gender and participatory research in order to support CGIAR Research Programs (CRPs) seeking new ways forward in relation to gender research. Issues covered by the workshop included:

- Insights from experts experienced with gender research across a diversity of organizations based on a demand analysis carried out online prior to the workshop. Discussions during the event indicated that the analysis reinforced the importance of KS, capacity strengthening, and support from high-level leadership.

- Complementing these insights was a panel discussion of workshop participants' experience with gender research in relation to diverse issues such as climate change, natural resource management, human nutrition, and market chains. Experiences were also shared in using KS methods such as the marketplace and open space.

- The issue of repositioning gender research was dealt with in two ways: first, by creating lists of approaches and outcomes that indicated the development of gender strategies in the CRPs; and, second, by identifying the next steps for continuing to foster gender research in the CGIAR, including the establishment of an interim committee to support this participatory work.

Through this renewed vision that entails promoting gender research in each of the program's interventions, the PRGA will continue to support NARSs and partner organizations other than the CRPs. Hence, these partners will also gain experience in using this approach to make their work more relevant to the people who are often excluded from development, that is, women and youth who are overrepresented among the poor generally.

New Initiatives to Strengthen Capacity

Training and related efforts to strengthen institutional capacity are fundamental for achieving more effective use of knowledge in research for development. Over the past 40 years more than 11,500 professionals from Latin America, Africa, and Asia have benefited from training at CIAT, whether through specialized courses, group events, individualized training, or thesis work. In 2010 this was the case for more than 1,100 professionals (almost 400 in Colombia, and between 200 and 300 in Africa and Asia, respectively).

In pursuit of a more coordinated approach to this vital work, CIAT has embarked on a new initiative to strengthen capacity in Latin America and the Caribbean, with several regional partners such as the Inter-American Institute for Cooperation on Agriculture (IICA) and the Tropical Agricultural Research and Higher Education Center (CATIE). Among its immediate aims are to assess regional demand and supply as well as gaps in particular areas and to tap new financial resources for meeting high-priority needs.

One area in which the region urgently requires capacity strengthening, given the proliferation of public-private partnerships, is the management of intellectual property in agricultural research for development. A group formed to address this issue—including national and international organizations in Chile, Colombia, Costa Rica, and Mexico—held an international workshop at CIAT headquarters in November 2010 to examine case studies and capacity strengthening needs. Participants formed a virtual network in order to continue the exchange of information and to plan joint capacity strengthening activities.

An Overview of CIAT

CIAT and the New CGIAR

Given its broad mandate related to food security and climate change research, CIAT is actively involved in research partnerships in several CGIAR Research Programs (CRPs). As mentioned in this report's introductory message, CIAT researchers are substantially involved in the CGIAR Global Rice Science Partnership (GRiSP) and in the Climate Change, Agriculture and Food Security (CCAFS) Programs.

CIAT is also a major research partner in four other key CRPs in the new CGIAR portfolio:

- Integrated systems for the humid tropics
- Roots, tubers and bananas for food security and income
- Grain legumes: enhanced food and feed security, nutritional balance, economic growth and soil health for smallholder farmers
- Durable solutions for water scarcity and land degradation

In addition, CIAT is actively participating in the following programs:

- Agriculture for improved nutrition and health
- Livestock and fish: sustainable staple food productivity increase for global food security
- Policies, institutions, and markets to strengthen assets and agricultural incomes for the poor

CIAT Mission

To reduce hunger and poverty, and improve human health in the tropics through research aimed at increasing the eco-efficiency of agriculture.

Vision

CIAT will engage its key scientific competencies to achieve significant impact on the livelihoods of the poor in the tropics. Interdisciplinary and applied research will be conducted through partnerships with national programs, civil society organizations, and the private sector to produce international public goods that are directly relevant to their users. These goods include improved germplasm, technologies, methodologies, and knowledge.

Values

- **Impact orientation**
  Research and related activities are demand driven, and are monitored and evaluated for social and environmental impact and relevance.

- **Scientific integrity**
  Research is carried out with integrity and transparency, and according to an agenda that is socially and environmentally responsible.

- **Innovation, creativity, diversity, and continuous learning**
  Innovative approaches in research and organizational activities are pursued by taking advantage of gender and cultural diversity, and applying effective approaches for knowledge sharing and learning.

Financial Results for 2010

CIAT's revenues increased by 27% to US$62.2 million in 2010. This was the result of three key developments:

1. Higher project income, which reached $42.7 million, an increase of 21%
2. More unrestricted income, amounting to $13.4 million, a 7% increase
3. Increased revenues from other sources primarily from financial management, accounting for $6.1 million, an increase of 413%

For the first time in over a decade, CIAT's reserves, now at 84 days of daily operating requirements, are within the current CGIAR guidelines of 75-90 days. The surplus of $6.1 million is a result of good financial management of donor funds and the generation of other income.

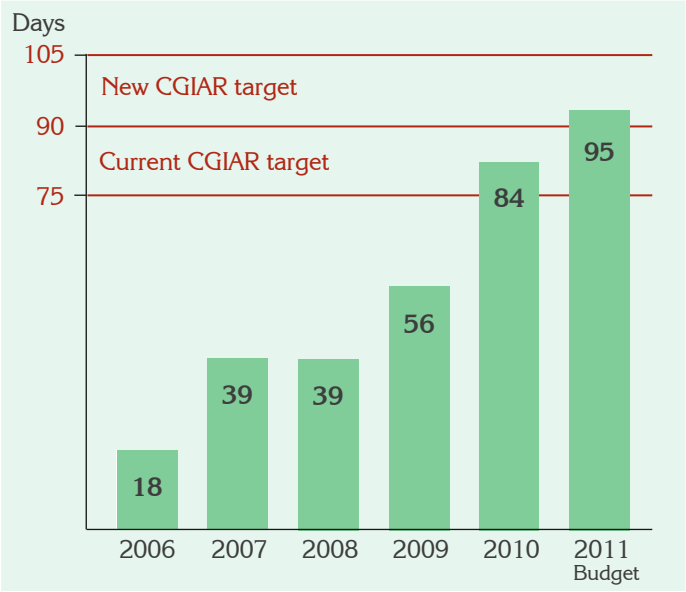
As a result of strong research execution and thanks to the Full Cost Recovery (FCR) policy implemented in 2008, CIAT specific research costs are covered by each research project. In other words, the Center has essentially reached an operational break-even point, although the FCR policy still does not include the generation or replenishment of reserves and of capital for fixed assets. The FCR policy is now a standard requirement for approval of every project proposal prior to submission. As a result, indirect cost recovery increased from $4.1 million to $4.9 million, representing an indirect recovery rate of 80%.

Direct cost recovery has also increased from $4.2 million to $5.1 million, representing a direct recovery rate of 96%.

Net assets, excluding capital invested in fixed assets, increased from $6.8 million in 2009 to $12.5 million in 2010. This year, CIAT limited its hedging operations to protect the budget exchange rate (which again has proven to be a very valuable tool), to instruments that mature within the fiscal year.

CIAT continues to renovate its infrastructure. For example, CIAT is consolidating and improving its Guest Housing infrastructure. In total, 45% of available capital was invested in research infrastructure and research equipment, while 42% was dedicated to research services, including the replacement of computer equipment for research. Only 13% of capital was invested in non-research and general infrastructure.

CIAT – Days of Operating Reserves



CIAT Statement of Financial Position
December 31, 2010 and 2009
(US$ in thousands)

	2010	2009
Current assets	32,196	36,582
Non-current assets	25,569	8,017
Total assets	**57,765**	**44,599**
Current liabilities	34,988	27,773
Non-current liabilities	4,395	3,950
Total liabilities	**39,383**	**31,723**
Undesignated net assets	9,169	3,035
Designated net assets	9,213	9,230
Temporary net assets	-	611
Total net assets	**18,382**	**12,876**
Total liabilities and net assets	**57,765**	**44,599**

CIAT Statement of Activity
December 31, 2010 and 2009
(US$ in thousands)

	2010	2009
Grants	56,100	47,682
Other revenues and gains	6,058	1,182
Total revenues and gains	**62,158**	**48,864**
Program-related expenses	54,957	45,622
Management and general expenses	5,128	4,504
Other losses and expenses	870	605
Subtotal expenses and losses	**60,955**	**50,731**
Indirect cost recovery	(4,914)	(4,077)
Total expenses and losses	**56,041**	**46,654**
Net surplus	**6,117**	**2,210**
Operating expenses by natural classification		
Personnel costs	27,142	22,578
Supplies and services	15,135	12,678
Collaborators and partnerships costs	12,713	10,258
Operational travel	4,107	2,925
Depreciation of fixed assets	1,858	2,292
Indirect cost recovery	(4,914)	(4,077)
Total operating expenses, net	**56,041**	**46,654**

Financial Outlook for 2011

Starting in 2011, the CGIAR centers will operate within a matrix structure consisting of CGIAR Research Programs, or CRPs, and center-specific research. Two CRPs have already been launched with CIAT leading CCAFS, while others, where CIAT participates, should gradually come online during the year. This will entail significant changes in CIAT's revenue streams. The CGIAR Consortium and Fund Council have agreed to a 2011 transition funding mechanism, which should provide stability as the year progresses and new CRPs are launched.

The budget approved by CIAT's Board of Trustees is based on the conservative assumption of $57.7 million in total revenues, with a surplus of $1.5 million. This budget will allow CIAT to reach the new CGIAR reserve target of 95-105 days of operating reserves, which applies from 2012 onwards. The budget is also based on the relatively conservative assumption of a COP 1,800/US$ exchange rate, in line with the trend of a strengthening Colombian peso. The significant exchange rate fluctuations experienced during the past 3 years are expected to moderate, but the strengthening of the Colombian currency will continue to pose financial and operational challenges.

Board of Trustees

CIAT is pleased to announce that Dr Juan Lucas Restrepo, recently appointed Executive Director of the Colombian Corporation of Agricultural Research (Corpoica), will continue as Board Chair during 2011. A new Board Chair will be appointed starting January 2012. We welcome Dr Wanda Collins as the new Vice Chair of the Board. The Center acknowledges the support received in 2010 from former Board members Dr Pietro Veglio, Dr Andrés Fernández, Dr Arturo E. Vega, and Dr Gordon MacNeil. Our deep gratitude to all of them, especially Dr MacNeil who was instrumental in guiding CIAT through a delicate period of extensive administrative and programmatic changes for the Center.

With great pleasure CIAT welcomes its new Board members Dr Geoffrey Hawtin, Dr J. Graham Joscelyne, and Dr Juan Camilo Restrepo.

Juan Lucas Restrepo
(Board Chair)
Executive Director
Corpoica
Colombia

Wanda Collins
(Vice Chair)
Private Consultant
USA

Anthony Cavalieri
Private Consultant
USA

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Ministry of Agriculture and Rural Development of Colombia
Colombia

Moisés Wasserman
President
National University of Colombia
Colombia

Further details on Board members can be accessed at:
www.ciat.cgiar.org/AboutUs/People/Pages/BoardofTrustees.aspx

Donors, Partners, and Collaborators

CIAT receives funds through the CGIAR or for specific projects from different countries and organizations. The Center also receives, from institutional clients, funds for research and development services that are provided under contract.

CIAT gratefully acknowledges the donors' commitment and confidence, as expressed in their contributions and support. Below is an extract from the 2010 list of donors accessible at www.ciat.cgiar.org/AboutUs/Lists/Donors/Donors.aspx

Academy for Educational Development (AED)
African Wildlife Foundation (AWF)
Alliance for a Green Revolution in Africa (AGRA)
Andean Community
Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)
Australian Centre for International Agricultural Research (ACIAR)
Austrian Development Agency (ADA)
Belgian Development Cooperation (DGDC)
Bill & Melinda Gates Foundation
Canadian International Development Agency (CIDA)
CARE Nicaragua
Catholic Relief Services (CRS)
CGIAR Generation Challenge Programme (GCP)
CGIAR HarvestPlus Challenge Program
CH2M Hill, Inc.
Citizens Network for Foreign Affairs (CNFA)

Colombia
- Administrative Department of Science, Technology and Innovation (Colciencias)
- Colombian Agricultural Company, Ltd. & JSC (COACOL)
- Colombian Corporation of Agricultural Research (Corpoica)
- Colombian Institute of Family Welfare (ICBF)
- Creative Associates International, Inc. Colombia (Creative)
- Mayagüez S.A.
- Ministry of Agriculture and Rural Development (MADR)
- National Federation of Oil Palm Growers (Fedepalma)
- National Federation of Rice Growers (Fedearroz)
- Paper Manufacturing Company PLC (PROPAL)
- Primavera Colombia Ltda.
- Sustainable Alternative Development (MIDAS Program)
- University of Valle
- Vegetable and Fruit Growers' Association of Colombia (ASOHOFRUCOL)

Common Fund for Commodities (CFC)
Department for International Development (DfID)
Donald Danforth Plant Science Center, USA
Food and Agriculture Organization of the United Nations (FAO)
Ford Foundation, USA
Forum for Agricultural Research in Africa (FARA)
French Agricultural Research Centre for International Development (Cirad)
German Corporation for International Cooperation (GIZ–BMZ)
Global Biodiversity Information Facility (GBIF)
Global Crop Diversity Trust (GCDT)
Global Environment Facility (GEF)
The Global Forum on Agricultural Research (GFAR)
Government of the People's Republic of China
Green Mountain Coffee Roasters (GMCR)
Inter-American Institute for Cooperation on Agriculture (IICA)
International Cooperation Center for Agricultural Education (ICCAE), Japan
International Fund for Agricultural Development (IFAD)
International Organization for Migration (IOM)
Iowa State University, USA
Islamic Republic of Iran
Japan International Research Center for Agricultural Sciences (JIRCAS)
The Kilimo Trust
Kirkhouse Trust
Koppert Biological Systems
National Institute of Agriculture and Food Research and Technology (INIA), Spain
The Nature Conservancy (TNC)
Nippon Foundation, Japan
Norwegian Institute for Agricultural and Environmental Research (Bioforsk)
The OPEC Fund for International Development (OFID)
Organization of American States (OAS)
Oxfam International (Oxfam)
Panama Institute of Agricultural Research (IDIAP)
Pan-American Agricultural School of Zamorano (EAP Zamorano)
Pennsylvania State University, USA
Rainforest Alliance
RiceTec, Inc., USA
Sustainable Food Laboratory, USA
Swedish International Development Cooperation Agency (SIDA)
Swiss Agency for Development and Cooperation (SDC)
Syngenta Foundation for Sustainable Agriculture (SFSA)
The Technical Centre for Agricultural and Rural Cooperation ACP–EU (CTA), The Netherlands
The Thai Tapioca Development Institute (TTDI)
United Nations Environment Programme (UNEP)
United States Agency for International Development (USAID)
Wageningen University, The Netherlands
World Bank
World Vision

CIAT takes this opportunity to sincerely thank all national and international agricultural research institutes, universities, advanced research institutes, other CGIAR centers, NGOs, private sector, and farmer organizations for their confidence, commitment, and support during 2010.

CIAT thanks its host country, Colombia, for the renewed spirit of collaboration and looks forward to jointly conduct research with Corpoica and several public and private research institutions.

An alphabetical list of partners, together with their links, can be accessed at:
www.ciat.cgiar.org/AboutUs/Paginas/partnersandcollaborators.aspx

Awards

2010 Fontagro Award to Scientific Excellence, granted to CIAT for the project "Strengthening plantain value chains: Technological innovations to reduce agrochemicals", led by Elizabeth Álvarez.

Distinguished Leadership Award for Internationals, granted by the University of Minnesota, USA, to Ruben Echeverría in recognition of his global contributions to agricultural development.

The Frank N. Meyer Medal for Plant Genetic Resources, granted by the Crop Science Society of America (CSSA) to Daniel Debouck for his tireless work to collect and conserve crop plant diversity.

Award for Second Best Thesis Work, granted to Emmanuel Zapata-Caldas during the XVIII National Meeting on Geography held at the University of Cauca, Colombia.

The Exemplary Colombian Award, in the category of Science and Technology, granted by El Colombiano newspaper to CIAT in recognition of the scientific research that it carries out on behalf of the country.

Award to the Best Results of Scientific-Technical Research, granted by the Academy of Sciences of Cuba to the following research institutions in recognition of their contribution to the biofertilization of common bean (*Phaseolus vulgaris* L.) in Cuba—basic and applied aspects: Directorate of the Soils Institute (Havana), the Ministry of Agriculture (MINAG) of Cuba, the Agriculture and Livestock Research Center of the "Marta Abreu" Central University of Las Villas (UCLV), the Ministry of Higher Education (MES) of Cuba, the Holguín Agricultural Extension and Training Unit, the Vinales Forestry Experimental Station in Pinar del Río, the Catholic University of Leuven (Belgium), the University of Gent (Belgium), and the International Center for Tropical Agriculture (Colombia).

A complete list of awards granted to CIAT staff is available at: www.ciat.cgiar.org/AboutUs/Lists/Awards/Awards.aspx

Publications

In 2010, CIAT researchers again published widely, with 126 articles in refereed journals and another 223 documents in other sources. A list of these and other documents published in the last 13 years can be accessed at: www.ciat.cgiar.org/AboutUs/Library/Lists/Publications/2010.aspx

A collection of over 14,600 documents published by CIAT researchers during the Center's 44 years of existence can be retrieved through CIAT's electronic library catalog at: http://ciat.catalog.cgiar.org/ciat_bibliography.html

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Agrobiodiversity Research Area

Joseph Tohme, Research Area Director

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* Left CIAT in 2010.
** Cassava Program leader till December 2010.
*** Started in January 2011.

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