CIAT Annual Report 2006-2007

Partners in Research Cultivating the Future

CIAT 40 1967-2007
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture
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Contents

Introductory Message
from the Board Chairman

The global, regional, and scientific context in which CIAT operates today is rapidly changing. Revolutions in molecular biology, information technology, and nanotechnology are creating new challenges and opportunities for the Center to achieve its mission.

At the same time, global institutional and development policy agendas are increasingly driven by the Millennium Development Goals, the Paris Declaration, and soon by the 2008 World Development Report and the International Assessment of Agricultural Science and Technology for Development (IAASTD) Report. These are refocusing attention on agriculture and its importance for achieving a world free of hunger and absolute poverty.

The entry of the Bill and Melinda Gates Foundation into agricultural development in the tropics is also creating a new dynamic in agricultural R&D, especially in Africa. We hope it opens the way for other large foundations to become involved.

In the CGIAR itself, the Science Council and the Secretariat have come under new leadership. A "third pillar" of the CGIAR, known as the Alliance of the 15 centers of the CGIAR, has emerged as a major tool to foster collective actions. These changes are creating conditions for more productive working relationships between the main parts of the system. They also provide a unique opportunity for a new covenant with our donors that may help stabilize the core funding base that the centers require to achieve their mission.

To effectively meet the new challenges, CIAT has changed its working approach from that of a multi-project organization into one based on targeted outcomes. An outcome is the adoption of a new research output, often an improved technology, that satisfies a current or anticipated want or need of poor people while sustaining the environments in which they live.

Outcome lines, developed by outcome development teams, are grouped under three overlapping programs. These are *Sharing the Benefits of Agrobiodiversity*, *People and Agroecosystems*, and the *Tropical Soil Biology and Fertility (TSBF) Institute*. The essential feature of this new approach is the focus on CIAT's major strengths in research: its interdisciplinary capacity and ability to develop strong partnerships.

Over the last year, CIAT has made significant progress in at least three areas:

1. Integrated land, soil fertility, and water management from a landscape-and-livelihood perspective, particularly in eastern and southern Africa. The TSBF Institute is leading this activity.

2. The deployment of genetic resources of beans, cassava, tropical forages, and rice together with analyses of their interactions with markets and the natural resource base of tropical agriculture.

Edith Hesse

Joachim Voss

3. Market and social institutional research, which helps small producers benefit from new markets and new technologies.

The outputs resulting from these three areas are developed and disseminated with the collaboration of partners in Latin America, sub-Saharan Africa, and Southeast Asia.

Some of these activities and their outputs are described in this report under *Research Highlights*.

During 2007, the Center also underwent its Sixth External Program and Management Review. The Review Panel especially recognized the high quality and relevance of science at CIAT, and lauded the progress the Center has made over the last seven years to strengthen and build excellent regional programs in Africa and Asia. It also praised the high quality of partnerships built with the Challenge Programs and other entities.

Yves Savidan

The Panel furthermore noted CIAT's special strengths and capacity to put science at the service of people by integrating high quality social and spatial analyses with advances in life sciences. It also recommended that CIAT concentrates more on focusing and integrating its priority agendas, and rebuilding excellence in several disciplines that were affected by recent downsizing. This will be achieved in part by the Center developing, with its major partners, a new strategy for Latin America.

The past year has also been challenging in several other ways. For the second time in two years, the Center underwent a significant downsizing—a response to the lasting financial crisis due to a combination of highly unfavorable local currency conditions, further significant reductions in core income, and the Center's failure to implement in due time, full-cost, special-project budgeting. Within this context, the Panel's quest for solutions to reinvigorate the Center was much appreciated.

On behalf of the Center, the Board thanks the outgoing Director General, Dr Joachim Voss, for seven years of service as head of CIAT and welcomes Dr Geoff Hawtin as the Center's Interim Director General. Dr Hawtin is a former Director General of IPGRI (now Bioversity International) and former chair of the Global Crop Diversity Trust. Board and staff feel confident that Dr Hawtin is the right person to take up the challenge of providing leadership for the Center during this phase of transition.

Yves Savidan
Board Chair
CIAT

Research Highlights

CIAT's research was lauded as "excellent" by the recent External Program and Management Review. In this section, we intend to give the reader a flavor of the exciting research currently being carried out at the Center by selecting highlights from each research area.

Research for Development Challenge: Sharing the Benefits of Agrobiodiversity (RDC-SBA)*

Goal:
To help reduce the risk of genetic collapse of crops by producing, preserving, and disseminating germplasm specifically adapted to multiple biotic and abiotic stresses in the tropics.

Objective:
To contribute to the sustainable increase of productivity and quality of mandate and other priority crops, and to the conservation of agrobiodiversity in tropical countries for the benefit of the poor.

www.ciat.cgiar.org/agrobiodiversity.htm

Genetic Resources Unit

http://isa.ciat.cgiar.org/urg/main.do?language=en

Objectives:

- To conserve the FAO Designated Collections.
- To employ modern biotechnology to identify and use genetic diversity for broadening the genetic base and increasing the productivity of mandate and selected non-mandate crops.

The Genetic Resources Unit (GRU) works to safeguard the genetic diversity of beans, cassava, forages, and their wild relatives through a mix of conservation methods. About 60,000 samples of seeds and other reproductive plant materials of 720 species are kept in collections that are either *in situ* (i.e., in a natural outdoor habitat) or *ex situ* (i.e., within the controlled environment of gene bank facilities). The Unit's work is essential to global agriculture, food security, and the R&D efforts that support them.

International standards

The Unit is one of 11 gene banks belonging to the CGIAR system of gene banks. This system has recently upgraded itself through an initiative called *Rehabilitation of Global Public Goods in the CGIAR Genetic Resources System—Phase 1*. Progress was made according to prefixed milestones—indeed, most have been exceeded—and completed in 2006.

Genetic and social relevance of conservation

For the reporting period, progress was made in several activities:

- Seed conservation protocols for *Carica papaya*, tree tomato, and some of their wild relatives continued to be defined.
- Seed physiology studies determined the best time for harvesting seed for long-term conservation in terms of fruit development on the mother plant.

* For definition of technical terms, please refer to box on pages 14-15.

In vitro conservation of cassava.

JULIO CÉSAR MARTÍNEZ

- Research, using seven unlinked SSR markers, identified 90 redundant accessions held in the Colombian collection of cassava. Cooperative research with CORPOICA showed a low level of redundancy, with only two duplicates, in the Colombian collection of avocado.

- The use of SDS-PAGE electrophoresis has so far revealed 62 unique banding patterns for phaseolin, a protein found in bean seeds that provides resistance to storage pests, especially weevils. The reference bean materials are now being maintained and distributed as genetic stocks by GRU.

- GRU also distributed 5046 samples of accessions that were registered in the Multilateral System of FAO's International Treaty on Plant Genetic Resources for Food and Agriculture.

- On 16 October 2006, CIAT signed an agreement of cooperation with the Governing Body of the International Treaty. The Center has since registered 64,870 accessions in the System, that is, 35,231 of *Phaseolus* beans, 23,140 of tropical forages, and 6499 of cassava.

About 60,000 samples of seeds and other reproductive plant materials of 720 species are kept in collections that are either *in situ* (i.e., in a natural outdoor habitat) or *ex situ* (i.e., within the controlled environment of gene bank facilities).

Activities for 2006-2007

Some of CIAT's major activities during the past year were:

Quantity	Activity
11,752 materials	Planted at the stations
5346 materials	Regenerated in 2006
5016 seed materials	Secured under long-term storage (at -20ºC)
630 cassava clones	The entire core collection is now being maintained in liquid nitrogen
4937 bean seed accessions	Tested for the absence of diseases of quarantine importance
2511 forage seed accessions	Tested for the absence of diseases of quarantine importance
159 cassava clones	Certified and made available for distribution (77% of total collection)
5917 seed accessions of beans and forages	Shipped to CIMMYT as security backup (30% of total collections)
3544 accessions of *in vitro* cassava	Shipped to CIP as security backup (85%)
Bar coding	Successfully installed in the Viability Laboratory

Julio César Martínez

Part of the bean seed collection held at the Genetic Resources Unit.

Outcome Lines: Improved Germplasm for the Developing World

Beans

www.ciat.cgiar.org/beans/index.htm

Objective:
To increase bean productivity through enhanced access and use of improved cultivars and management practices in partnership with NARS and regional networks, and through them, with farmers.

We suggest that selection for drought resistance has also favored genes for plant efficiency, probably manifesting as improved photosynthate mobilization, which thus benefited yield across different environments.

Drought and yield potential

Drought has long been a priority for the CIAT bean-breeding program. Recently, we reported that levels of drought resistance have increased significantly in improved lines. However, drought is seldom a yearly event and the question becomes whether drought-resistant varieties yield well in well-watered years.

To answer this question, yield trials of selected drought-resistant lines were established in three different environments under well-watered and fertile conditions. The lines, and the standard commercial checks used for comparison, belonged to the small-red, small-black, and cream-striped (carioca) classes.

Although most lines yielded neither significantly less nor more than the respective checks, some lines performed much better than cv. Carioca (G 4017), a check that is also resistant to phosphorus stress. Moreover, the lines were earlier maturing and often presented a significantly greater daily yield than did the checks.

We suggest that selection for drought resistance has also favored genes for plant efficiency, probably manifesting as improved photosynthate mobilization, which thus benefited yield across different environments.

Wider use of marker-assisted selection in Africa

Marker-assisted selection (MAS) has been employed in CIAT headquarters for several years to obtain resistance to viruses, first BGYMV and then BCMV. This activity was transferred to Africa, and was expanded significantly to include selection for genes for resistance to other diseases. More than 1000 plants were assayed in Uganda for resistance genes (both recessive and dominant) against BCMV and BCMNV. Markers developed at CIAT headquarters to detect the gene for resistance to *Pythium* found in RWR 719 (a Rwandan bred line) were also tested in Uganda on 111 backcrossed progeny and 54 families derived from double crosses. Meanwhile, at headquarters, 282 F_2-derived families were tested for

Seed classification area.

Julio César Martínez

the presence of anthracnose-resistance genes derived from G 2333.

This sort of targeted selective use of markers at specific points in the breeding program will make breeding more efficient. It will become more directed towards the deployment of recognized, highly useful resistance genes. CIAT's decentralized strategy in Africa aims to carry out this work in the laboratory facilities of NARS, thus exposing the Center's partners to routine application of these techniques.

Domestication events in common beans

The study of non-coding regions in chloroplast DNA of wild common bean led to the discovery of 14 haplotypes distributed throughout the plant's range in the Americas. This meant we could then locate where some of the domestication events of common bean occurred in Central and South America. We could also organize wild common bean into three major lineages, linking them to their sister taxa in the *Phaseoli* section. The haplotypes' organization could be explained through isolation by distance and two major migrations, one of which was from Mesoamerica into the Andes, and the other from northern South America into Mesoamerica.

A penalized likelihood analysis had been applied to previously published data on many legumes to estimate when *P. vulgaris* and its sister taxa diverged from each other. The use of this same tool indicated that *P. vulgaris* diverged from its sister taxa in the Mesoamerican *Phaseoli* section about or before 1.3 Ma. That is, migrations and isolation events during early Pleistocene are the reasons why current gene pools could have existed in the wild before domestication (which then led to subsequent separation into the cultivated gene pools).

The section *Acutifolii* of the genus *Phaseolus*, which includes the tepary bean, has been shown to include a species, *Phaseolus parvifolius* Freytag, other than the cultigen and its immediate wild relative, thus establishing a secondary gene pool for that crop. This finding was significant, as breeders are always happy to know that they can explore a wider genetic diversity to improve a crop, particularly, as in this case, for superior tolerance of drought. Recent work conducted elsewhere has confirmed the close degree of relatedness of this section vis-à-vis the *Phaseoli* (which includes the common bean), thus strengthening further the relevance of this research.

CIAT's decentralized strategy in Africa aims to carry out this work in the laboratory facilities of national agricultural research systems (NARS), thus exposing the Center's partners to routine application of these techniques.

Julio César Martínez

Evaluating cassava plants in the field.

Cassava

www.ciat.cgiar.org/yuca/inicio.htm

Objective:
To develop germplasm methods and tools for increased productivity and add value to the cassava crop, thus leading to increased income and development for rural communities involved in the crop's cultivation and processing.

At the Agricultural Research Institute (ARI)-Mickocheni (Tanzania), 60,000 seeds were produced from 300 families derived from crosses between AR or CR germplasm and local clones.

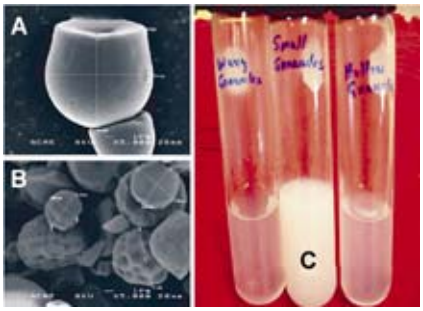
Cassava mosaic disease

One major development for the project in 2006 was the mass application and adoption of MAS for resistance to cassava mosaic disease (CMD) and other biotic stresses (e.g., green mite). For this viral disease and green mites, MAS is now standard technology, with proven capacity to provide useful results. CIAT has developed two sets of germplasm by selecting for resistance to these biotic stress factors, using molecular markers: AR, which has combined resistance to CMD and green mite; and CR, which has resistance only to CMD. The materials were grown with excellent results in Tanzania, Nigeria, Uganda, India, Ghana, and the Republic of South Africa.

Because of its resistance to CMD, this was the first time that germplasm from CIAT could be directly used in breeding nurseries. Previous shipments had been highly susceptible and of little use. At ARI-Mickocheni (Tanzania), 60,000 seeds were produced from 300 families derived from crosses between AR or CR germplasm and local clones. The clones were either farmer-preferred and/or resistant to the cassava brown streak virus disease, another prevalent disease in eastern Africa. The large population is now being screened for resistance to CMD, using the three markers identified at CIAT. This is the first example of successful MAS in cassava.

New starch quality mutants

For many years, to help small cassava farmers link with markets, the cassava-breeding project at CIAT has gradually, but consistently, shifted its attention to the production and identification of cassava clones with high-value industrial uses. For the feed industry, the identification of clones with increased nutritional value is a key target, and has led to the discovery of a group of clones with protein levels that are 2 to 3 times higher than normal.



HERNÁN CEBALLOS

Grains of normal cassava starch (A) and the much smaller starch granules from an induced mutant (B). The mutant possesses twice the normal levels of amylose and produces distinctive gels (C), with significant nutritional and commercial implications.

The starch industry consistently requests clones whose roots carry starch with altered properties. For example, producers of ethanol fuels and bioplastics request clones whose starch has molecules that are simpler than those of normal starch. Thousands of partially inbred plants were therefore grown and evaluated, including several mutagenized populations (which had been artificially induced to mutate, through irradiation with gamma rays, fast neutrons or heavy ions). As a result, several mutants have been identified with either markedly reduced levels of amylose content in their starch (waxy starch) or twice the normal levels (leading to resistant starches), and with distinctive amylograms, indicating different pasting properties. The starch produced by these cassava plants offers distinct advantages for starch and ethanol industries.

These value-added characteristics are economically significant, as similar mutations in maize have led to 30% increases in their market value. The discoveries are also important because they prove that inbreeding cassava can help identify useful recessive traits. The *Manihot* gene pool seems to carry mutations that are similar to those found in cereals and potato.

Overcoming the problem of postharvest physiological deterioration

When cassava roots are harvested, they deteriorate rapidly, within 1 to 2 days, because of a phenomenon known as postharvest physiological deterioration (PPD). This deterioration leads to high marketing costs and/or large losses between harvest and consumption.

An interspecific cross between *Manihot esculenta* and *M. walkerae* produced a material whose roots did not deteriorate, even as long as 3 weeks after harvesting. The cross has since been backcrossed to cassava and subjected to MAS to accelerate the elimination of the wild donor parent genotype. However, the first elite lines did not have a long shelf life. Genotypes from the first backcross (which carried 75% of genes from the *M. esculenta* parent) able to maintain tolerance of PPD has since been recovered. Unexpectedly, a similar genotype was also found in a mutagenized population. A long-sought-after trait for the cassava finally seems to have at last been obtained; ironically, almost simultaneously through two different approaches.

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Julio César Martínez

Evaluating *Brachiaria* grasses under greenhouse conditions.

Multipurpose Forages

www.ciat.cgiar.org/forrajes/index.htm

Goal:
To conserve and exploit the genetic diversity of tropical grasses and legumes through either breeding or natural variation, and thereby attain the following objectives:

- The improvement of livelihoods of poor farmers producing crops and livestock.
- The development of links between farmers and traditional and emerging markets.
- Increased access to high-quality wholesome animal products by poor urban consumers.
- The exploitation of the forages' potential to enhance the natural resource base and provide environmental services.

We successfully used recurrent selection (which improves population performance) to develop enhanced levels of resistance to spittlebugs in a *Brachiaria* breeding population.

Brachiaria grass hybrids with multiple resistance to spittlebugs

The African genus of grasses known as *Brachiaria* is widely grown throughout tropical South America as pastures. Probably as many as 40 million hectares have been planted to improved varieties of this genus. Spittlebugs are intractable pests that can destroy hundreds of hectares of these grasses, causing losses that range between US$161 million to $211 million per year.

Our goal is to breed resistant varieties of these susceptible but economically significant grasses. This research is supported by Papalotla, a private-sector seed company that also enhances the dissemination of research results. Nearly 50 t of cv. Mulato seed and over 60 t of cv. Mulato II seed were sold in 18 different countries during 2005 and 2006. Seed sales of Mulato II are particularly encouraging, as the cultivar was first released commercially only in 2005. Mulato and Mulato II seed sells not only in the more traditional grass-seed markets of Latin America, but also in such far-flung places as New Caledonia, Vanuatu, and Thailand.

We successfully used recurrent selection (which improves population performance) to develop enhanced levels of resistance to spittlebugs in a *Brachiaria* breeding population. The resulting sexually reproducing clones possess higher levels of resistance than the parental accessions of the breeding population. Indeed, the hybrids show better spittlebug resistance than the entire *Brachiaria* germplasm collection maintained at CIAT. Details of this research have already been published in *Crop Science*.

In 2004, we reported different levels of resistance to *Prosapia simulans* (a major spittlebug species attacking *Brachiaria* in Mexico) in 34 apomictic

Belisario Hincapié

A seed production plot of the *Brachiaria* cultivar Mulato, an apomictic hybrid grass.

hybrids. These hybrids had been preselected in Mexico for good adaptation and desirable agronomic characteristics. A series of replicated tests was then carried out in 2005 to evaluate the resistance of these genotypes to *P. simulans* and to four other major species of spittlebug in Colombia (*Aeneolamia varia*, *A. reducta*, *Zulia carbonaria*, and *Mahanarva trifissa*). Six apomictic hybrids were selected for resistance to all five species of spittlebugs.

In 2005, we also tested almost 600 new sexual hybrids for resistance to three spittlebug species (*A. varia*, *A. reducta*, and *Z. carbonaria*). Resistance levels to all three species were almost 95%.

Improved forages adopted by small farmers in SE Asia increased income and returns to labor and provided opportunities for linking with markets

CIAT began forage research in Southeast Asia in 1992 by introducing a large range of forage accessions. In 2005, the Center completed two major forage projects: the regional *Livelihood and Livestock Systems Project*, and the bi-lateral *Forages and Livestock Systems Project* in Laos. Such long-term commitment from CIAT and its partners has led to significant livelihood benefits and adoption of planted forages by many households in the region. These were documented in a survey and impact studies carried out in 2005.

Results showed that planted forages, as opposed to native grasses, significantly improve household income and, most importantly, the returns to labor from livestock production. The initial benefit from planted forages was in the saving of labor through easy access to feed. Subsequently, animals showed improved growth from feeding on planted forages, encouraging farmers to maximize the opportunities provided by the new feed resources. Participatory approaches to technology development were an essential component of success.

Such success encouraged development agencies to accept that planted forages can play a key role in enabling small farmers to intensify their extensive livestock production system and become more market-oriented. The participatory approaches used to develop and scale out the forage technology likewise attracted interest from development practitioners.

New forages for Central America

In Central America, new forage technologies have been developed to increase livestock productivity for the extensive systems prevailing in the tropical lowlands and hillsides. CIAT has distributed 11 selected grasses, mostly from the *Brachiaria* genus, for use as commercial cultivars. Another 16 forage legume cultivars were also distributed.

Such long-term commitment from CIAT and its partners has led to significant livelihood benefits and adoption of planted forages by many households in the region.

Belisario Hincapié

A field of *Brachiaria* grass (cv. Mulato).

Brachiaria grasses accounted for much of the milk and beef production.

Of all the pasture cultivars available, grasses from the *Brachiaria* genus currently dominate the market. During the last 5 years, they have made up between 84% and 97% of all grass seed sales in Mexico and Central America. Most of the seed was probably allocated to renovate pastures in advanced stages of degradation or naturalized pastures with low productivity. The largest volumes of *Brachiaria* seed sales and planted areas correspond to Mexico, followed by Costa Rica, Honduras, Nicaragua, and Panama (see table below).

When *Brachiaria* grasses were compared with local species in on-farm experiments, they showed superior biomass production, leading to higher milk production. *Brachiaria* grasses accounted for much of the milk and beef production in the above-mentioned countries. The 2003 figures for Costa Rica indicated that 55% of the national milk production (i.e., 437,000 t fluid milk) and 18% of beef produced (26,000 t) came from *Brachiaria*-based pastures. The grasses increased production of milk and beef in Mexico by 24% and 5%, respectively, and in Honduras, by 25% and 12%. The adoption rate of *Brachiaria* grasses in the region was lowest in Nicaragua and Panama, leading to an increase in milk production of 11% and 5%, respectively.

Furthermore, we developed technologies to increase feed availability and quality throughout the dry season, including forage legumes like *Lablab purpureus*, *Vigna unguiculata*, and *Canavalia brasiliensis*. Silage, hay, and improved crop-residue grazing increased the quality of feed, resulting in higher livestock productivity (milk production) at lower costs.

Volumes of seed sales and planted areas in major *Brachiaria*-growing countries of Central America. Most of this grass seed is probably allocated to renovate pastures or improve naturalized pastures with low productivity.

***Brachiaria* seed**	**Mexico**	**Honduras**	**Nicaragua**	**Costa Rica**	**Panama**
Proport. of sales (%)	84	84	90	85	97
Seed volumes (t)	9100	671	134	1692	40
Area planted (ha)	2,616,130	186,788	35,822	437,516	10,952

Evaluating for blast resistance: rice plants being sprayed.

Julio César Martínez

Rice for Latin America and the Caribbean

www.ciat.cgiar.org/riceweb/index1.htm

Objective:
To contribute to food security and employment through rice production, emphasizing the improvement of health, nutrition, and economic options for small farmers.

Blast, caused by the fungus *Pyricularia grisea*, is the most destructive disease of rice in the world. It is found in all rice production systems in both temperate and tropical climates, destroying every year enough rice to feed more than 60 million people. Controlling the disease is difficult because of the pathogen's broad genetic diversity and the wide range of mechanisms it has evolved to break down genetic resistance of rice varieties. Current interdisciplinary and multi-institutional research on the pathogen and host plant is taking advantage of recent advances in science. The successes so far achieved are paving the way to developing sound breeding strategies towards the creation of more durable resistance. Farmers will then be able to increase rice yields to cope with increasing demand.

Identifying molecular markers linked to blast resistance

We made progress in identifying molecular markers that are highly linked to genes for blast resistance in rice. We did this by combining near-isogenic progeny analysis with the rice genome information available in public databases. Although only a few polymorphic markers can be expected when near-isogenic lines are used as progenitors, we nevertheless found six polymorphic markers in a region of only 13 cM that surrounds the blast resistance gene *Pi-1(t)*. Moreover, two of these markers (RM1233*I and RM224) were closely linked to the gene.

Our results show the usefulness of these DNA markers in MAS and gene pyramiding for those rice-breeding programs aiming to improve blast resistance in rice cultivars. Eventually, these markers will lead to the mapping and cloning of the gene. The speed, simplicity, and reliability of PCR-based approaches make microsatellite analysis on agarose gels an attractive tool for MAS in rice-breeding programs aiming to develop rice cultivars with durable blast resistance.

We also demonstrated that polymorphic markers, linked to resistance genes in near-isogenic populations, can be expected to detect polymorphism and presence of linked genes in those commercial rice cultivars that have some degree of inbreeding.

Blast resistance in Oryzica Llanos 5

The study of inheritance of blast resistance is essential for understanding how such resistance

We made progress in identifying molecular markers that are highly linked to genes for blast resistance in rice. We did this by combining near-isogenic progeny analysis with the rice genome information available in public databases.

Julio César Martínez

Evaluating for blast resistance: rice plants being injected with inocula of the fungus.

works and therefore developing more effective strategies to combat this economically damaging disease. The inheritance of durable (i.e., lasting for more than 15 years) blast resistance in the rice cultivar Oryzica Llanos 5 was found to be highly complex. Durable broad-spectrum resistance in Oryzica Llanos 5 is associated with multiple genes of major and minor effects, inducing resistance to different blast isolates. So far, 21 QTLs in nine chromosomes have been detected and associated with resistant traits in Oryzica Llanos 5. Most, but not all, of the QTLs appeared in the same genomic regions of other genes reported in the literature. No one QTL was effective against all blast isolates, as each was isolate-specific. One QTL was found in a region on chromosome 9 where, previously, no blast resistance genes had been mapped. Another QTL, near the bottom of rice chromosome 11, was found to be significantly associated with partial resistance.

Some Definitions

Apomixis: a process in which a botanical seed of a plant repeats exactly the genotype of that plant. That is, the plant is cloned through botanical seed because no sexual reproduction actually occurs.

Broad-spectrum resistance: resistance that is effective against a wide array of races, isolates, or biotypes of an insect pest or pathogen.

Durable resistance: resistance that is not eroded by the emergence of new races of an insect pest or pathogen attacking the plant.

Gene pyramiding: the accumulation of desirable genes by following a structured strategy.

Haplotype: a combination of alleles (or forms of a gene) of closely linked loci found in a single chromosome; sometimes, a combination of particular nucleotide variants within a given DNA sequence.

MAS (marker-assisted selection): selection that is based on a molecular marker rather than on how the plant looks.

Microsatellite: pieces of small DNA sequences that are repeated (or appear repeatedly in sequence within the DNA molecule) next to a specific gene within the DNA molecule. Microsatellites are aligned with that specific gene.

Molecular marker: particular DNA sequences and/or segments that are closely linked to a gene locus and/or a morphological or other character of a plant. Those segments can be detected and visualized by molecular techniques.

Multiple genes: when a desired trait depends on the simultaneous occurrence of two or more genes located in different loci in the genome.

Mutagenized populations: populations that have been exposed to different kinds of mutagenic agents to generate new genetic variability. Mutations comprise one of the natural sources of variation.

Near-isogenic progeny: progenies that are almost identical, differing in only a few genes, and carefully selected to fulfill a particular purpose.

Non-coding regions: life depends on proteins, themselves made up of chains of amino acids. The acids' functions are strongly determined by the order in which they are found in a protein chain. This order, in its turn, is determined by the genes located in a chromosome (a type of protein chain). However, many regions within the chromosome do not codify for any particular amino acid. Indeed, within the sequence of a gene, portions have frequently been found to have information that is irrelevant to the building of a protein, being ignored during de-codification. These regions are known as non-coding regions.

PCR (polymerase chain reaction): a technique for the continuous amplification of DNA and/or DNA fragments *in vitro*. The DNA sequence must be known so that oligonucleotides can be synthesized that complement each extreme of the fragment to be amplified. Thus, certain regions of the DNA can be specifically targeted for amplification.

QTL (quantitative trait locus): a DNA segment that carries more genes which code for an agronomic or other trait gene.

Recessive/dominant genes: generally speaking, a plant has two copies for each gene: one from the mother, and the other from the father. The two copies interact with each other. In some cases, the result of this interaction is that the plant has a characteristic that is intermediate between those observed in the parents. In other cases, however, the result of the interaction would be that one copy of the genes suppresses or masks the information provided by the other gene. The copy of the gene that manages to prevail is known as dominant, and the one that fails to express is known as recessive.

Recurrent selection: a gradual process by which a population is improved through repeated cycles of evaluation, selection, and recombination of the best genotypes.

SSR markers (simple sequence repeat markers): a genetic mapping technique that uses the fact that microsatellite sequences repeat (i.e., appear repeatedly in sequence within the DNA molecule) in such a way that they can be used as markers.

We thank Dr Hernán Ceballos for his valuable assistance in compiling these terms.

Julio César Martínez

Seed viability area.

Challenge Programs

Generation Challenge Programme

www.generationcp.org/index.php

Objective:
To use plant genetic diversity, advanced genomic science, and comparative biology to develop tools and technologies that enable plant breeders in the developing world to produce better crop varieties for resource-poor farmers.

With support from the Generation Challenge Programme (GCP), CIAT has conducted three commissioned research projects. One project deals with DREB, a gene technology that is believed to act as a master switch (transcription factor) that regulates many downstream genes related to abiotic stress responses. DREB genes have been cloned in common bean and their expression patterns are being evaluated under various abiotic stresses with the expectation of developing genetic markers to test the concept of MAS for drought tolerance.

We also developed a mutagenized population of common beans that is amenable to genetic analysis through an approach called TILLING. This approach identifies gene function by analyzing mutants of specific genes.

When conducting drought screening for rice in the field we learned important lessons in establishing drought screening in specific environments, using, for example, rainout shelter conditions—no easy task!

In April 2007, the Japanese MAFF invited CIAT to participate in a new project called *Promotion of Research Targeting the Stable Supply of Global Food*. The project aims to develop drought-tolerant rice genotypes through transgenic approaches, using genes identified by JIRCAS.

Furthermore, the competitive grant proposal *Bridges: Interspecific Bridges that Give Full Access to the African Rice Allele Pool for Enhancing Drought Tolerance in Asian Rice*, now led by IRD, was selected from among 60 other proposals. Its goal is to build new kinds of genetic materials that will make the genetic diversity present in African rice species more accessible to breeders. Cutting-edge genotyping tools will be developed and used.

Children—main beneficiaries of biofortified food.

D. Marchand, IDRC

HarvestPlus Challenge Program

www.harvestplus.org

Objective:
To reduce micronutrient malnutrition by harnessing the powers of agriculture and nutrition research to develop staple foods with high nutrient contents.

To be healthy, we need to eat not only enough food, but also enough nutritious food. Food should contain nutrients such as vitamins, zinc, iron, and calcium. Yet, billions of poor people in developing countries suffer from a lack of these nutrients in their diets. The CGIAR's HarvestPlus Challenge Program seeks to improve the nutrition of these people by breeding "biofortified" varieties of food staples. To successfully achieve this goal, HarvestPlus needs to confront four major challenges:

- The germplasm of the crops used must have sufficient genetic variation to permit breeding higher levels of nutrients into them,
- These biofortified crops must improve human nutrition when consumed,
- Farmers must be willing to grow these biofortified crops, and
- The malnourished populations being targeted must want to consume the biofortified crops.

HarvestPlus scientists have already demonstrated that the first challenge of sufficient genetic variation can be met.

The biofortification of beans and cassava

At CIAT, for example, Steve Beebe, the Bean Crop Leader for HarvestPlus, points out that in Africa, the selection of potential varieties for higher mineral content is now routine. Reaching the goal of doubling iron concentration is a gradual process, but lines with varying levels of increased iron and/or zinc have been distributed to 16 countries in Africa under the HarvestPlus program (see table, next page).

Likewise for cassava, Hernán Ceballos, the Cassava Crop Leader for HarvestPlus, explains that considerable efforts were invested in producing segregating progenies that would contribute towards developing cassava roots with 15 micrograms (µg) of beta-carotene per gram of fresh root. Both in Brazil (EMBRAPA) and Colombia (CIAT), breeding nurseries have increased the frequency of genotypes with more than 10 µg of beta-carotene per gram of fresh root. The maximum levels of beta-carotene attained during 2004 to 2006 ranged from 6.0 to 10.9 µg/g of fresh root. In addition, genotypes having more than 85% of total carotenoids as beta-carotene were identified.

The HarvestPlus Challenge Program seeks to improve the nutrition of people by breeding "biofortified" varieties of food staples.

The HarvestPlus Challenge Program distributed biofortified bean lines among 16 countries in Africa. These lines have increased levels of iron and/or zinc.

Country	Quantity	Observations
Rwanda	9000 kg of five fast-track bean lines	Produced and distributed to communities in six districts (Ruhuha, Ruhengeri, Gihara, Kigali, Kigoma, and Rwamagana) in partnership with the ATDT Health and Agriculture Project. The lines were Maharagi Soja, Ngwenurare, AND 620, MLB-40-89A, and MLB-49-89A.
Kenya	Six bush bean lines and seven climbing beans	Entered the National Performance Trials as the first step towards formal varietal release.
Ethiopia	16 bean lines	Advanced to national variety trials. Six promising lines (GLP-2, PVA 8, Kirundo, K132, AFR 708, and Simama) showed good performance.
Malawi	Several bean lines high in iron content	Selected by farmers in several communities.

These results show that effective progress can be achieved and that the crop is responsive to gradual but consistent gains. We are now conducting research to better understand the inheritance of carotenoid content in cassava roots, identify molecular markers, and harness the power of genetic engineering as an alternative for increasing carotenoid content in cassava roots. We are also studying the influence of soil iron and zinc, and soil pH on the concentration of these two elements in cassava roots.

AgroSalud's decentralized seed production approach brought together a large group of partners from different regions and countries in Central America, thereby providing not only sufficient seed for farmers but also adding an interesting case study to CIAT's work on seed systems within and across regions.

AgroSalud Project

www.agrosalud.org

A project operating with the support of HarvestPlus and funded by CIDA is the AgroSalud Project. This consortium of partners from 13 countries also includes international and regional institutions such as CIAT, CIMMYT, CIP, CLAYUCA, and EMBRAPA. All the partners collaborate to develop, evaluate, and disseminate biofortified crops and food products in Latin America and the Caribbean (LAC), that is, to improve, in a sustainable way, the nutritional content of crops important to vulnerable populations living in LAC, particularly beans, cassava, maize, rice, and sweet potato. Specifically, it aims to increase the contents of iron and zinc in rice, beans, sweet potato, and maize; tryptophan and lysine in maize; and beta-carotene in sweet potato and maize.

The planned employment of a human nutritionist in 2007 will add a significant component to the regional team's work.

This year, AgroSalud intensified its work on seed production of biofortified crops especially maize. Two new quality proteins maize (QPM) varieties were released in April 2007 in Nicaragua. AgroSalud's decentralized seed production approach brought together a large group of partners from different regions and countries in Central America, thereby providing not only sufficient seed for farmers but also adding an interesting case study to

IRRI

Child enjoying a bowl of biofortified rice.

CIAT's work on seed systems within and across regions.

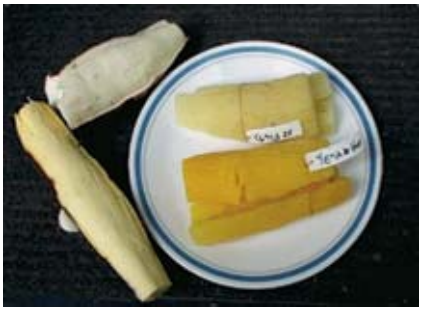
We also built a clean facility for polishing and milling rice with minimal mineral contamination. This will improve the throughput of rice samples that can be tested for iron and zinc levels. A researcher from CIP visited CIAT to install calibration curves on a Near-InfraRed Spectroscopy (NIRS) machine. This machine will now run protein, iron, zinc, calcium, potassium, phosphorus, and sulfur analyses for beans. We will also use it to run protein, total carotenoids, and beta-carotene analyses in the best cassava lines taken from the HarvestPlus cassava breeding program for use in developing biofortified food products. The NIRS and the calibration curves will also substantially increase throughput for analyzing samples of beans and cassava for the above-mentioned nutrients.

Plant breeders made significant advances in identifying lines with high nutrient levels, crossing them with lines containing superior agronomic characteristics, and testing these crosses under different environmental conditions. For example, at CIAT, rice researchers have identified a commercial rice variety with double the amount of iron than rice usually sold to consumers. Bean researchers have identified black bean lines that, not only have 20% more iron, but are also resistant to drought and golden yellow mosaic virus. Furthermore, the Nicaraguan NARS released a maize hybrid 'Mazorca de Oro' and an open-pollinated variety 'Nutrader'. These materials, with double the levels of tryptophan and lysine than conventional maize, were developed, tested, and released with support from CIMMYT and AgroSalud.

To develop food products from biofortified crops, postharvest specialists have progressed in selecting, adapting, and validating different processing technologies, including extrusion and bakery processes to produce foods such as pastas and breads. Further details are given on pages 21-22.

Impact specialists have refined cartographic models to identify suitable sites in LAC for agricultural and human nutrition trials. They have also collected data for use in applying an economic model known as disability-adjusted life years (DALYs). It will be used to predict the potential economic impact of consuming biofortified crops in LAC. Assessments have already begun in Brazil, Colombia, and Nicaragua to identify food-distribution programs into which biofortified crops could be incorporated.

Plant breeders made significant advances in identifying lines with high nutrient levels, crossing them with lines containing superior agronomic characteristics, and testing these crosses under different environmental conditions.



Hernán Ceballos

One of CLAYUCA's activities in the AgroSalud Project is to identify varieties of cassava and sweet potato with high contents of carotene, beta-carotene, protein, iron, and zinc. These cassava roots from Haití show the difference between nonbiofortified (top) and biofortified (bottom) roots, with raw roots on the left and cooked roots sitting on the plate.

Public-Private Partnerships

Latin American and Caribbean Consortium to Support Cassava Research and Development (CLAYUCA)

www.clayuca.org

Objectives:

- To help improve living standards and sustainable resource management in regions of LAC where cassava plays an important role in agricultural production systems.
- To generate, transfer, and exchange technologies, information, and scientific knowledge among institutions of the public and private sectors and farmer groups.

This preliminary processing of roots into a liquid biomass for biofuel processing facilitates small-farmer participation in the crop-to-fuel value chain.

Innovative, decentralized approach to enhance the participation of small farmers in cassava ethanol production

Cassava is increasingly gaining attention in developing countries as an attractive feedstock for biofuel processing. The crop's popularity is based on familiar reasons: the plant thrives under rainfed conditions on marginal lands not suitable for most other crops, it grows with few inputs, and its production technology is easily mastered by small farmers. The cassava crop's recent wave of popularity is based on its potential to contribute to agroindustrial and small-farmer development in the tropics, with one alternative being its use as feedstock for fuel alcohol production.

During 2006-2007, CLAYUCA, in close collaboration with CIAT, CORPOICA, and Diligent Energy Systems (a Dutch NGO), began implementing a pilot project financed by the Colombian Ministry of Agriculture and Rural Development. The goal was to establish a small-scale, low-capital-cost, pilot plant to process ethanol from cassava, sweet potato, and other sources of biomass. The plant's processing capacity would be about 800 liters per day.

The approach proposed by CLAYUCA and its partners is based on a decentralized process that can, at a local level, transform cassava roots into ethanol at 50% concentration. This preliminary processing of roots into a liquid biomass for biofuel processing facilitates small-farmer participation in the crop-to-fuel value chain. The 50% alcohol is later taken to a central distillery to produce fuel alcohol at 99.55% concentration. A major constraint to producing biofuel efficiently from plant biomass is the high cost of transporting bulky materials over long distances. This approach, however,

Luis Fernando Cadavid, CLAYUCA

Weighing harvested cassava roots on the property of Caltech Ventures Limited, Ghana. Through a collaborative agreement, two agronomists were contracted for an initial period of 2 years from the National Institute for Research on Tropical Roots and Tubers (INIVIT, Cuba). They provide technical assistance in crop establishment, soil management, production of planting materials, and crop production of cassava.

overcomes this problem by processing the material at the village into an intermediate product with a higher energy density (alcohol) and therefore lower transportation costs.

This innovative approach aims to position cassava as an agricultural option that can help small cassava farmers in Colombia improve their income and quality of life. It could also help the Colombian Government validate agricultural options that promote sustainable and competitive agroindustrial development in the country.

Innovative alliance to promote the sustainable, added-value management and processing of wastes from cassava, sugarcane, and paper agroindustries

CLAYUCA became part of a collaborative alliance with CIAT; three sugarcane mills and one paper company, all from the Department of Valle del Cauca, Colombia; and three companies from the State of Wisconsin, USA. The alliance is currently working on a project, entitled *International Research and Production Center for Waste Transformation Technology*. The goal is to develop, adapt, and transfer modern technologies for the sustainable and competitive management of wastes generated in the production of sugar, cassava starch, ethanol, and paper.

A pilot plant facility was established at CIAT's headquarters to discover ways of managing the above-mentioned agroindustrial wastes. The technologies generated will also help reduce the environmental impact that agroindustrial wastes have on the region's soil and water resources.

CLAYUCA, with the collaboration and active participation of all the institutions forming the alliance, will operate the plant. The three USA-based companies have already developed proprietary and/or patented processes and technologies, which they will release to the alliance's members in the context of activities conducted at the pilot plant.

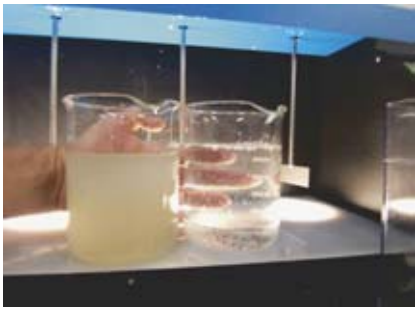
CLAYUCA has used these technologies to initiate experimental work in managing and processing wastes. Promising results have already been obtained in processing the liquid and solid effluents generated by ethanol, starch, and paper agroindustries into value-added products with potential for use as animal feed and fertilizers.

Financial support for building the pilot plant is being sought through the three U.S. companies. The facility is expected to be fully operating by 2008.

Alleviating hunger with biofortified cassava and sweet potato products

CIDA has approved a project to be run by CIAT under the aegis of AgroSalud (see page 18). The project is entitled *Combating hidden hunger in Latin America: biofortified crops with increased contents of vitamin A, essential minerals, and high quality protein*. CLAYUCA is responsible for implementing the component comprising postharvest technologies. Its collaborative partners are the

Promising results have already been obtained in processing the liquid and solid effluents generated by ethanol, starch, and paper agroindustries into value-added products with potential for use as animal feed and fertilizers.



Alcardo Roa, SoilNet, LLC (USA)

The alliance's technical work began at SoilNet, LLC (Wisconsin, USA), a CLAYUCA partner. The company selected samples of agroindustrial residues for conversion into ethanol. After flocculation, the residues are processed into products with added value such as fertilizers and animal feeds.

Embrapa-Food Agroindustry (the former Center for Agrifood Technology or CTAA) of EMBRAPA; the Nicaraguan Institute of Agricultural Technology (INTA); and CORPOICA.

The objectives of the postharvest component of the AgroSalud Project are to select and evaluate biofortified varieties of cassava and sweet potato, and principally to validate processing technologies that produce biofortified food products based on these and other biofortified crops. If the products can be promoted at low cost, they could become an important component in the diet of school-age children and pregnant and nursing women in pilot regions of each participating country (Brazil, Nicaragua, and Colombia).

The varieties of cassava and sweet potato used in the project were selected according to their contents of beta-carotene, iron, zinc, and protein; good agronomic yields; high dry matter content; and resistance to pests and diseases.

We also test and promote those processing technologies that have been selected for their adaptation and efficiency in producing food products likely to become dietary items. The project has identified and adapted processing technologies that produce intermediate products such as drying and refining to produce flour for use in making soups, cookies, bread, and cakes; drying, refining, and extrusion to produce pre-cooked flour for use in soups and bakery products; cooking and sun-drying to produce flakes for instant soups; cooking and artificial drying to produce croquettes and baked tortillas; and normal cooking to produce cooked mash for making drinks, desserts, and other products.

An expected outcome of the project is the identification and establishment of linkages with food programs to facilitate diffusion and dissemination of the technologies and products generated by the project.

In June 2006, Ghana, through the company Caltech Ventures Limited, became the third African country, after the Republic of South Africa and Nigeria, to join CLAYUCA.

Ghana joins CLAYUCA

In June 2006, Ghana, through the company Caltech Ventures Limited, became the third African country, after the Republic of South Africa and Nigeria, to join CLAYUCA. This company's principal objective is to establish, in the Volta Region of eastern Ghana, a cassava-based agroindustrial project to process ethanol. CLAYUCA has begun giving technical assistance in collaboration with two agronomists from the National Institute for Research on Tropical Roots and Tubers (INIVIT, its Spanish acronym) from Cuba. Efforts have included crop establishment, soil management, production of planting materials, and training of technical personnel. Caltech Venture Limited hopes to produce an annual 6 million liters of ethanol by 2008 for domestic consumption and export to other West African countries.

Uruguayan farmers exchange experiences during a field day held by FLAR's agronomy program.

FLAR

Latin American Fund for Irrigated Rice (FLAR)

www.flar.org

Objective:
To meet partners' needs for continuous innovations in irrigated rice production to make it more competitive, profitable, and efficient, while employing environmentally friendly crop-management practices and lowering prices for rice consumers.

The alliance has recently accepted a new country member, the Dominican Republic, which signed the Act of Acceptance on 26 April 2007. The number of member countries is now 15. Chile is expressing interest and may become a new member at the end of 2007.

Breeding continues to be the core of FLAR activities. In Colombia, two new varieties were released: Fedearroz 60 (FL 3188) and Fedearroz 174 (FL 3174). Improved germplasm is being released every year both to the tropical and temperate rice regions of LAC.

The project funded by the Common Fund for Commodities (CFC) to improve yields of irrigated rice in Venezuela and Brazil concluded in 2006. Encouraged by its success, FLAR decided to continue and expand activities in agronomy and technology transfer, using its own funds. Today, 12 of the member countries have technology transfer programs in different stages of development.

A new project was presented to the CFC for improving market opportunities of rice-based systems in Central America. Its focus is water-harvesting technologies that would allow farmers to change from upland to irrigated rice, and explore high-value crops and fish production. The project is in the final steps of evaluation by the CFC. The chances of approval are believed to be good.

The CFC has also financed by a short-term (March-October 2007) project for an on-going study on rice markets. The results of this diagnostic study in three countries (Colombia, Costa Rica, and Argentina) will provide proposals for non-market and market-based instruments to manage rice-price fluctuations. The use of these instruments will help manage marketing and financial risks associated with trade liberalization and the extension of high-yielding rice technologies.

The CGIAR awarded special recognition, during its 2006 AGM in Washington, DC, to FLAR and CIAT as one of four outstanding alliances of Centers with civil society organizations (CSOs). The recognition included a $30,000 check.

FLAR's Administrative Committee met in Uruguay, 25-28 March 2007. One resolution was to send a proposal to organize a CIAT-FLAR Workshop during mid-2007 to address medium-term solutions to rice research funding and possible improvements in the alliance.

Breeding continues to be the core of FLAR activities. In Colombia, two new varieties were released: Fedearroz 60 (FL 3188) and Fedearroz 174 (FL 3174).

CIAT Africa Office

Farmers selecting bean seed.

Research for Development Challenge: People and Agroecosystems (RDC-P&A)

Goal:
To improve the capacity of poor people and communities to innovate for food security, economic productivity, and improved agroecosystem health and human welfare in the tropics, while ensuring the provision of global environmental goods and services.

Objective:
To contribute with technical, institutional, and policy innovations for the improved management of tropical agroecosystems that benefit poor communities and the local and global environment by linking market-based approaches with natural resources management.

www.ciat.cgiar.org/agroecosystems.htm

Outcome Line

Markets, Institutions, and Livelihoods

www.ciat.cgiar.org/agroempresas/ingles/index.htm

Objective:
To address key research questions on the approaches to use in R&D, particularly systems approaches (i.e., "where to do what"), organizational models, and learning approaches.

Scaling up and out of the agroenterprise learning alliance

In 2006, activities carried out by the CRS-CIAT Agroenterprise Learning Alliance focused on moving from learning to action. In East Africa, the Learning Alliance is now shifting towards a platform for value chain development. The CRS has made a strategic decision to emphasize higher value export pulse crops, which have the advantage of being grown by small farmers for both food and export. In Ethiopia, work is targeting the export of white pea beans (baked beans) to European markets, with exports reaching between 30,000 and 40,000 t, at a value of about US$12 million. In Tanzania, the focus is on exporting chickpeas to India.

CIAT is working with several partners to identify critical constraints in the value chain of white pea beans in Ethiopia. Likewise, CIAT and its partners are designing methods and tools to facilitate upgrading in terms of varietal development and evaluation, seed supply systems, farmer marketing-group organizations, and supply systems with traders. Value chain interventions are also being made, partly on the basis of recent market research undertaken by CIAT as part of its collaborative work with the IPMS project at ILRI. Germplasm is being supported through the PABRA team, as is the development of informal seed systems. The CRS is playing a key role in providing seed to farmer groups through smart subsidies and using newly developed skills in farmer marketing-group management to organize supplies to major trading companies. To support the transition from producing to marketing this crop, the CRS has recently hired new staff with marketing skills and is working in close collaboration with leading trade houses.

ERI project leader, Susan Kaaria (in foreground), working with farmers in Uganda.

Carlos Arturo Quirós

In Tanzania, the chickpea crop is undergoing similar support processes so that farmers can become more competitive and thereby increase demand for their new Kabuli chickpea varieties.

In both cases, as a recent output from the Learning Alliance, a research paper and guide for developing multi-skilled farmer groups is being used as a "best practice" to help increase economies of scale and empower farmers to engage more effectively with dynamic markets.

A comparative analysis of approaches to link small farmers with markets, and implications for gender equity, intra-household dynamics, and investments

A growing body of research, development, and private-sector organizations are linking small farmers with markets, using various approaches. One approach was developed by IPRA. Termed Enabling Rural Innovation (ERI), it seeks to strengthen the capacity of small farmers, especially women and the poor, to link with and benefit from markets. A comparative analysis was carried out of this and other approaches in terms of their effectiveness in promoting pro-poor market linkages, achieving gender equity in the distribution of benefits, and promoting re-investments in natural resource management.

Results showed that ERI, compared with the other approaches, is effective in reaching women and the poor, and building their skills to analyze and engage in markets. The approach is changing gender decision-making patterns at household level towards more gender equity. Households also benefit significantly from linkages with markets through the ERI approach. Although women have benefited, results also showed that significant income disparities continue to exist between women and men household members. Women increased their skills in analyzing and understanding markets, in conducting experimentation, and in taking on leadership positions in project activities. Analyses of farmers' investment priorities revealed interesting results with significant differences between sites, countries, wealth categories, and gender groups. For example, households in Malawi invest most of their income in food security and NRM, whereas households in Uganda invest in household items.

Increased usefulness of the topographic database

The Digital Elevation Model, derived from the February 2000 Shuttle Radar Topography Mission (SRTM), is one of the most important new spatial datasets to have been made publicly available in recent years. However, the "finished" grade version of the data still contains data voids (about 836,000 km^2) and other anomalies, which prevent immediate use for a wide range of applications. These voids can be filled by using a range of interpolation algorithms in conjunction with other sources of elevation data but otherwise offers little guidance on the most appropriate void-filling method.

CIAT and its partners are designing methods and tools to facilitate upgrading in terms of varietal development and evaluation, seed supply systems, farmer marketing-group organizations, and supply systems with traders.

CIAT Africa Office

Beans preference testing.

The results of this research suggested that, in the two watersheds studied, the indirect relationships between poverty and water via employment and income linkages may be more important than the direct linkages via domestic supply.

CIAT project scientists and their partners developed (i) a method to fill voids by using a variety of interpolators; (ii) a method to determine the most appropriate void-filling algorithms, using a classification of voids based on their size and a typology of their surrounding terrain; and (iii) the classification of the most appropriate algorithm for each of the 3,339,913 voids in the SRTM data. The scientists used a sample of 1304 artificial but realistic voids across six terrain types and eight void size classes. They found that the choice of void-filling algorithm depends on both the size and terrain type of the void.

The best methods were either the Kriging or the Inverse Distance Weighting interpolation for small and medium-sized voids in relatively flat low-lying areas; spline interpolation for small and medium-sized voids in high-altitude and dissected terrain; Triangular Irregular Network or Inverse Distance Weighting interpolation for large voids in very flat areas; and an advanced spline method for large voids in other terrains.

Watershed management and poverty alleviation in the Colombian Andes

The relationship between water and poverty was assessed in two watersheds in the Colombian Andes. The methodology included both a participatory assessment of current poverty and an analysis of how household poverty status has changed over the last 25 years. Taken together, the results of the two techniques captured both direct and indirect linkages between water and poverty. They identified situations where win-win solutions may be possible, and also where trade-offs were most likely needed, not only between environmental, economic growth, and equity objectives at the watershed scale, but also between household welfare objectives and the strategies used to achieve them.

The results of this research suggested that, in the two watersheds studied, the indirect relationships between poverty and water via employment and income linkages may be more important than the direct linkages via domestic supply. This is consistent with the diversification of rural livelihoods and the importance of off-farm income in poverty reduction. Interventions to enhance domestic supply may have big impact in certain specific communities, but would not generally contribute much to poverty alleviation. Interventions that provide employment in industries like dairying or mining in one watershed or profitability in small-scale agriculture in the other could have significant impact on poverty, as these have been important pathways out of poverty over the past 25 years.

Robin Buruchara

A task force member locates the program's target areas on a map.

Challenge Programs

Sub-Saharan Africa Challenge Program

www.e-fara.org/networking-support-projects/ssa-cp

Objective:
To devise solutions, derived from agricultural research, that will have positive impact on sustainable development, and enhance the productivity and profitability of agricultural and other enterprises based on natural resources in Africa.

The Sub-Saharan Challenge Program (SSA CP), one of the programs under the Forum for Agricultural Research in Africa (FARA), was designed to address issues that have constrained the translation of research outputs into developmental impacts at significant scale. This was intended to be done through novel partnerships and integrated agricultural research for development (IAR4D) approaches. Last year, we reported efforts to establish the partnerships in the Lake Kivu pilot learning site (LKPLS) around three competitive projects that focused on enhancing productivity, maintaining natural resource management, and wealth creation through markets, thus enhancing institutional alliances and enabling policy.

In the course of the year, the three task forces further consolidated their projects into a LKPLS-wide integrated research program. They redefined their focus to address questions at the interfaces between productivity, markets, natural resource management, and related policies. The LKPLS program was therefore envisaged to test a set of impact-driven, prototype, stakeholder-innovation platforms. These platforms would accomplish the following: facilitate multi-stakeholder partnerships; and promote market access, community empowerment, technology adaptation and/or adoption, and investments in beneficial conservation. One good result of this process is an agreement on a central concept of the innovation platform. The platform is to be considered as a flexible alliance framework that would allow a diversity of stakeholders and organizations from both the supply and demand side of value chains to actively and dynamically contribute to an agreed research agenda.

Two external reviews were carried out during the year. One was commissioned by the CGIAR Science Council to review the inception phase of the SSA CP. The Council

One good result is an agreement on a central concept of the innovation platform.

Robin Buruchara

Validation visit to the program's target areas.

The program includes a comparative evaluation component and a process that evaluates the replicability, efficiency, and effectiveness of IAR4D as it moves from a pilot scale to wider implementation.

recommended further adjustments of the SSA CP research program and projects. It looked closely at the SSA CP's research design and the type of international public goods (IPGs) that were likely to be generated.

The analysis led to a suggestion that the SSA CP should first focus on the "proof of concept" of IAR4D as it moves into the implementation (research) phase. It should therefore address three sets of fundamental questions:

1. Does the IAR4D concept work? Can it generate deliverable international and regional public goods for end users?

2. Does the IAR4D framework deliver more benefits to end users than conventional approaches? Did the conventional R&D and extension approach have access to the same resources?

3. How sustainable and usable is the IAR4D approach outside the test environment? That is, can it deal with issues of scaling out for broader impact?

This recommendation led to a consultative process to transform and refine the research program. The program was now expected not only to demonstrate that IAR4D works, but also to include (i) a comparative evaluation component, and (ii) a process that evaluates the replicability, efficiency, and effectiveness of IAR4D as it moves from a pilot scale to wider implementation. We expect to learn lessons and develop generalizable principles from pilot learning sites experiences for (i) conducting and implementing IAR4D, and (ii) documenting the overall efficacy and impact of the approach. As a result, efforts have so far been made to:

- Revise and strengthen PLS-level research programs, drawing on expert consultations. These have resulted in:
  - Alignment of the initial PLS projects with Science Council recommendations.
  - Consolidation of PLS projects into integrated PLS research programs.
  - Definition and adoption of new roles of partnerships to implement the IAR4D paradigm, which goes far beyond agrobiophysical research.

- Capacity building and institutional changes to face IAR4D challenges:
  - Training workshops organized to strengthen knowledge and skills in the IAR4D approach, innovation systems, innovation platform concepts, and interface research.
  - Management structures adapted so they better support IAR4D activities.
  - Development of Memorandums of Understanding between FARA and Lead Institutions to define and implement their roles.

Fish farming on the Mekong River, Lao PDR.

Edith Hesse

- Development of research methodology for proof of the IAR4D approach:
  - Development of a cross-site "proof of concept" research program, including the experimental design for comparing IAR4D with conventional approaches.
  - Transformation of the "Service Provider" model into a "Core Research Support Team" model to backup research at the PLS level and across the PLS (program-wide).

The implementation phase of the SSA CP is expected to start in 2007. Further postponement would put at risk the partnerships assembled for this program.

Challenge Program on Water and Food

http://gisweb.ciat.cgiar.org/sig/cgiar-cpwf.htm

Objective:
To create research-based knowledge and methods for growing more food with less water, and develop a transparent framework for setting targets and monitoring progress, recognizing that most food demand will be met by improving the productivity of rainfed systems.

In 2006, Theme 2 launched an initiative to assess the potential of payment for environmental services (PES) to enhance the adoption and impact of soil and water management practices in upland farming communities.

CIAT is the coordinating institution for Theme 2 *Water and People in Catchments* of the Challenge Program on Water and Food (CPWF). This responsibility covers research, technical, scientific monitoring, and evaluation activities. In 2006, Theme 2 launched an initiative to assess the potential of payment for environmental services (PES) to enhance the adoption and impact of soil and water management practices in upland farming communities. The principal collaborators in the initiative include the international soils research networks in Africa (AfNet/TSBF), Southeast Asia (MSEC), and Central America (MIS). Outputs included a review paper, seven case studies and, in Africa, three training courses on tools and methods to quantify and value soil and water-related environmental services. Theme 2 is also working with the CPWF capacity-building officer and the University of Florida to develop a course curriculum based on Theme 2 concepts and drawing on the experience of Theme 2 research projects.

BORU DOUTHWAITE

CIAT staff member Simon Cook (on right) participating in an Impact Pathway workshop.

One direct result of work on innovation histories (2003-2005) was the Participatory Impact Pathways Analysis (PIPA), developed by the Impact Assessment Project of the Challenge Program on Water and Food (CPWF). This analytical method is designed to help project participants to construct likely pathways by which their project will have impact.

Basin focal projects

The basin focal projects (BFPs) of the CPWF comprise a set of 10 strategic research projects, with a collective budget of US$8.5 million in the following river basins: those of the Andes, Indo-Gangetic, Karkheh, Limpopo, Mekong, Niger, Nile, São Francisco, Volta, and Yellow River. These projects are coordinated by a CIAT scientist seconded to the CPWF. The purpose of the BFPs is to assess the current condition of agricultural-water management and its impact on livelihoods and poverty alleviation. Such analysis provides "basin intelligence" and determines how specific changes in water-management within basins will impact development. Projects are well advanced in the Karkheh, Mekong, São Francisco, and Volta basins. Projects for the Andean, Indo-Gangetic, Limpopo, Niger, Nile, and Yellow River basins are due to start in November 2007. The BFPs include an impact assessment project, which is also led by CIAT.

Developing and using the Participatory Impact Pathways Analysis (PIPA)

One direct result of work on innovation histories (2003-2005) was PIPA, developed by the Impact Assessment Project of the CPWF. This analytical method is designed to help project participants to construct likely pathways by which their project will have impact. These pathways form a type of model of what the project will do, is doing, and what it did (see http://en.wikipedia.org/wiki/Participatory_Impact_Pathways_Analysis).

CIAT led a project to carry out an *ex ante* impact assessment and provide a basis for monitoring and evaluating CPWF projects. A component of the approach—the use of problem and objective trees to clarify and communicate the logic of a project—was adopted by the CPWF Secretariat in the CP's 2007-2009 MTP. The Science Council commented:

> *The CPWF has introduced the use of 'objective trees' at the MTP project and CP level, a useful and innovative complement to the MTP logframe. In addition to providing a useful overview, the process of preparing these flow charts has clearly helped the CP provide the necessary focus, clarity, and cohesion that now exists in the research plans at all levels.*

WorldFish Center, CIMMYT, and ICRISAT have also used aspects of PIPA in their planning processes, including the formulation of their MTPs for 2008-2010. Three projects led by CIP/CIAT, University of Wageningen, and IWMI (Cambio Andino, EULACIAS, and the ICT-KM Project, respectively) are using PIPA as part of their monitoring, evaluation, and impact assessment

Boru Douthwaite

Partners of CPWF's Volta Basin Project discuss the project's logic and problem trees.

strategy. A paper on PIPA has been accepted for publication in the *Canadian Journal of Program Evaluation*.

A follow-up of the outcomes of the first PIPA held in the Volta Basin, Ghana, in January 2006 found the following:

- Inspired by the knowledge gained at the workshop, one project developed a methodology for *Influence Network Mapping*, which was a CGIAR eNews story in June 2007 (www.cgiar.org/enews/june2007/story_04.html).
- PIPA helped a peri-urban wastewater project identify the Ministry of Food and Agriculture (MOFA) and the Accra Metropolitan Assembly (AMA) as key stakeholders. The project subsequently lobbied both organizations to change a crucial by-law.
- A third project attributed their success in organizing a *Capacity-Building Needs Consultation Workshop with Primary Stakeholders* to clarify and crystallize project outputs as derived from the problem and objective trees taught to them in the workshop.
- The workshop motivated projects working in the basin to meet to identify synergies and share impact pathways methodology with colleagues who had not attended the workshop.

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System-Wide Initiatives

Tropical Whitefly IPM Project

www.ciat.cgiar.org/ipm/highlights_whitefly.htm

Objective:
To improve the livelihoods of resource-poor rural and urban communities in the tropics through the effective management of whiteflies and whitefly-transmitted viruses, using integrated pest management strategies to protect traditional and non-traditional (high-value) food crops.

This project of the Systemwide Program on Integrated Pest Management continues to disseminate information on the integrated management of whitefly and whitefly-borne diseases of major staples such as cassava, common bean, sweet potato, tomato, and peppers in Africa, Asia, and Latin America. Technical guidelines and personal technical assistance have

Francisco Morales

Improved tomato varieties, possessing resistance to whitefly-transmitted viruses, are released in southern India.

been delivered to agricultural professionals and farmers on how to manage whitefly-related food production problems associated with significant yield losses and excessive pesticide use. Additionally, the project promotes the release of virus-resistant cassava, sweet potato, common bean, and tomato varieties in the three targeted continents. The IPM package distributed to small farmers with the improved germplasm emphasizes the use of minimum chemical inputs.

Program on Participatory Research and Gender Analysis (PRGA)

www.prgaprogram.org

Objective:
To improve the competencies of the CGIAR System and collaborating institutions to mainstream the use of gender-sensitive participatory approaches in plant breeding and natural resources research.

Currently, a study is being carried out in El Salvador, Guatemala, Honduras, and Nicaragua to assess and document organizational and institutional changes fostered by the learning alliances on rural agroenterprise development as facilitated by CIAT's Rural Agroenterprise Development Project in Central America since 2003.

Building Capacity in Gender Analysis and Gender Mainstreaming in the NARS of ASARECA

This project held a series of workshops and training activities during which participants shared their experiences in their efforts to influence change in their home NARS, and in the field research they had undertaken. As a result of their learning activities, the participants developed action plans, conducted action research activities, and trained colleagues in gender analysis. Their work was carried out mainly in their home NARS of the Democratic Republic of the Congo, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Tanzania, and Uganda.

The participants also agreed to develop an edited book on the experiences and lessons of the project, as little literature on gender mainstreaming in African NARS currently exists.

Assessing CIAT's experiences with learning alliances in Central America

The goal of a learning alliance is to promote institutional innovation that will lead to more effective development practices and policies. These, in turn, would contribute to the generation of sustainable rural livelihoods. To promote effective and sustainable processes of change, the participating organizations of a learning alliance need to identify, systematize, share, adapt, develop, and

Meeting of the PRGA's Advisory Board and EPMR, October 2006.

Claudia Ximena García

apply (i) more effective development practices, (ii) appropriate policies, and (iii) demand-led research for development.

Currently, a study is being carried out in El Salvador, Guatemala, Honduras, and Nicaragua to assess and document organizational and institutional changes fostered by the learning alliances on rural agroenterprise development as facilitated by CIAT's Rural Agroenterprise Development Project in Central America since 2003. The development impact of CIAT's project was assessed in selected sites. Lessons were then learned from the experience and necessary adjustments made to improve effectiveness. Aspects assessed included organizational changes, changes in intervention processes, capacity strengthening, systematization and documentation of new experiences and knowledge, the learning process promoted by the alliance, interaction costs vis-à-vis benefits of the learning alliance, and sustainability of the learning alliance and mechanisms to achieve it.

The project is expected to end in mid-2007.

External review of the PRGA Program

The Program's first external review in its 10-year history was conducted between October 2006 and February 2007. The Review Panel praised the Program's work in participatory plant breeding (PPB) and impact assessment, its publishing ethic, and its former competitive small grants program. The success of much of the work has been dependent on a partnership mode—labeled as a "hallmark" of the Program by the Panel—and therefore equally a credit to partners and donors alike.

New strategic platform

In late February-early March, the Program's Advisory Board drafted a new four-pronged strategic platform, emphasizing PPB, Africa's "rainbow revolution" in seed and seedling systems, learning lessons for effective development, and gender mainstreaming (focusing on the CGIAR centers).

In 2007, the PRGA Program will be developing a new strategic platform with revised logical framework. This strategic platform will have direct implications on both the program of work and on donor relations. It will comprise the following themes: (i) *New Developments in Participatory Plant Breeding*; (ii) *Institutional Innovations in Africa's Seed and Seedling Revolution*; and (iii) *Reframing Effective Action*. It will also support several actions for *Gender Mainstreaming*.

The Program's first external review in its 10-year history was conducted between October 2006 and February 2007.

Pieter Pypers

Legume demonstration trial in Umutara, Murambi, Rwanda.

Tropical Soil Biology and Fertility (TSBF) Institute

Goal:
To conduct research on the role that biological and organic resources play in tropical soil biology and fertility, and on the relationships of these resources with the natural and social environment to better provide farmers with improved soil management practices that sustainably improve their livelihoods.

www.ciat.cgiar.org/tsbf_institute/index.htm

The TSBF Institute's R4D approach is based on an integrated soil fertility management (ISFM) paradigm. This holistic approach to soil fertility research embraces the full range of driving factors and consequences of soil degradation, whether of a biological, physical, chemical, social, cultural, economic, or political nature. That is, this approach attempts to address the full chain of interactions from resources to production systems to markets, and includes sociocultural forces and policies. Investment in soil fertility management is seen as a key entry point to the sustainable growth of agricultural productivity, and as a necessary condition for obtaining positive net returns to other types of farm investments.

Outcome Lines

The strategy for pursuing the approach described above is based on three outcome lines: Livelihoods and Resilient Systems, Sustainable Land Management, and Capacity Building. Research highlights for these three lines are described below.

Livelihoods and Resilient Systems

Objective:
To improve the livelihoods of people reliant on agriculture by developing sustainable, profitable, socially just, and resilient agricultural production systems based on integrated soil fertility management (ISFM).

Dual-purpose soybean value chain and increased income for small-farming families and other rural entrepreneurs in East Africa

The TSBF Institute and its partners helped improve rural livelihoods in East Africa (Kenya, Uganda, and Tanzania) by enhancing income, improving health, and encouraging more sustainable agriculture. Cropping with dual-purpose soybean increased, and links between production and demand were fostered. In less than two cropping seasons, the number of farmer groups (with 15-130 individual members each) growing soybean increased from 3 to 16 in three districts of western Kenya in 2005.

Farmers multiplying soybean in Kabamba, South Kivu, Democratic Republic of the Congo.

Pieter Pypers

The corresponding areas planted to soybean by the groups increased from 4.1 to 16.3 ha in Migori District, and 1.6 to 6.2 ha in Butere-Mumias District. The 2006 results showed that more than 300 networks of farmer groups and 4000 individual farmers from more than 10 districts are currently participating in soybean promotion in Kenya, that is, up from the 9 farmer groups and 180 individual farmers at project inception. The area cultivated to soybean has increased by more than 10-fold, with yields improving from 0.6 to about 1.5 t/ha.

The network of farmer groups is already supplying large-scale feed or food-processing companies with increasing quantities of top quality soybeans with market desired traits. By bulking their produce, the farmers are generating tangible results, with some farmer groups already delivering grains with market-preferred traits to processing companies at agreed market-clearing prices. Many poor farmers testified to being better able to pay their children's school fees and purchase inputs (e.g., mineral fertilizers). Some farmers are beginning to scrub out sugarcane, replacing it with soybean. The market for sugarcane, an erstwhile cash crop, has collapsed under globalization, making it unprofitable.

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CIAT Files

The Quesungual slash-and-mulch agroforestry system (QSMAS).

Sustainable Land Management

Objective:
To develop sustainable land management (SLM) practices in tropical areas while reversing land degradation.

Validation of the Quesungual slash-and-mulch agroforestry system (QSMAS) in Nicaragua has advanced further than expected, with participating farmers extending the system to other regions.

Advances in defining key principles behind the social acceptance and biophysical resilience of the Quesungual slash-and-mulch agroforestry system (QSMAS)

The knowledge generated by the QSMAS Project, funded by CPWF, confirms that food security can be achieved in drought-prone areas of the subhumid tropics without compromising the quality of soil, water, and vegetation resources. Collaborative research by the TSBF Institute and the MIS consortium in Central America for the past 2 years found that (i) QSMAS is a production system that is inserted into the landscape to improve livelihoods, yet conserves the natural resource base; (ii) local biodiversity is favored through the conservation of about 14 species (from 12 families) of trees and shrubs; (iii) losses of soil to erosion are dramatically reduced when permanent soil cover is combined with stones in soil, leading to improved water productivity and quality; (iv) pools of soil nutrients (N and P) are maintained and even increased as soil biodiversity and biological activity are enhanced—these improvements in resource quality were related to the spatial distribution of trees and organic resources; and (v) the system is an important source of firewood for domestic consumption and has no significant negative effects on greenhouse gas emissions.

Validation of QSMAS in Nicaragua has advanced further than expected, with participating farmers extending the system to other regions. The capacity of local farmers and technicians is being enhanced through field days, and that of graduate and undergraduate students from the region through degree training.

Typical workshop dynamics.

CIAT Africa Office

Capacity Building

Objective:
To enhance the human and social capital of all the TSBF Institute's stakeholders for research and management on the sustainable use of tropical soils.

The African Network for Soil Biology and Fertility (AfNet)

This network continues to be a cornerstone of soil fertility research in Africa. It supports research activities in sites scattered all over eastern, western, central, and southern Africa. In 2006, several trials continued to provide vital information on the performance of various soil and water management technologies being developed and tried out by researchers and farmers.

In its effort to build the capacity of researchers in the region, AfNet organized two training workshops on *Gender Mainstreaming* and *Participatory Research, Monitoring, and Evaluation*, which were attended by several AfNet members. These training courses have improved the "T-shaped" skills of the participating scientists, enabling them to address complex issues affecting resource allocation and natural resource management at farm level.

AfNet supported the organization of the Soil Science Society of East Africa (SSSEA) conference and also sponsored several members to attend workshops and conferences where they presented their research findings.

During 2006, AfNet also continued supporting and/or supervising 22 students through their training at either MSc or PhD level. Several papers were also published by AfNet staff in refereed journals.

The African Network for Soil Biology and Fertility (AfNet) continues to be a cornerstone of soil fertility research in Africa.

Robin Buruchara

Farmers selling different bean varieties at the local market.

CIAT regional programs pursue progressive research on technologies and processes that are important for the type of development that helps rural communities build sustainable livelihoods through competitive agriculture, healthy agroecosystems, and rural innovation. In pursuit of these goals, they work closely with national institutions, NGOs, and the private sector, and use participatory methods that offer rural people an active role in devising better ways to improve crops, build rural agroenterprises, and manage soil fertility, pests, and plant diseases. It is in the regions where CIAT's inter- and multi-disciplinary work is carried out.

CIAT in the Regions

Africa

Africa remains a highly distinctive area of operation for CIAT, requiring particularly decentralized approaches. African agriculture is characterized by the predominance of small farming, highly heterogeneous biophysical environments, and great diversity of sociocultural settings—often over short distances. These issues partly explain why an Asian-style "Green Revolution" could not be replicated on this continent.

Farm sizes are declining even as populations grow. Land is lost to burgeoning cities. Soil is eroded away as farming methods, still predominantly focused on food crops, struggle to adapt fast enough to population change. Migration from rural to urban areas is occurring almost everywhere, creating new demand for food products and regional trade, and therefore opportunities for income generation for small producers.

For the first time in 40 years, many African countries are registering good levels of economic growth, not only in urban but also in rural areas. These trends have also created some myths about agricultural development. For example, one myth is that the main emphasis of agricultural R&D should shift significantly away from food crop production. Instead, specialties should be developed to supply growing (local) supermarket businesses and exports. In reality, however, these opportunities are so specialized that small producers have difficulty competing with well-organized large commercial producers (albeit small in number). The tiny scale of small producers in terms of total production and sales potential is too small to lift them out of poverty. Instead, they depend much more on better links with urban food markets across Africa. Awareness of this factor has grown over the past year or two, and is helping to broaden once again the farm-income-generating strategies followed by national research organizations, subregional research organizations such as ASARECA, and the CGIAR Centers.

Typical woman farmer in Africa.

Robin Buruchara

Across eastern and southern Africa, other increasingly important and cross-cutting factors shape the research environment. These include the negative impact of HIV/AIDS on agricultural and household productivity, and climate change, especially in terms of climate variability and risk. Africa Coordination is encouraging strategic research on these themes. It also supports the notion that many more of our research proposals should include elements of these research themes because they interact with other issues. We are now collaborating with CIAT scientists who work in farmer participatory research and decision-support projects based in Africa.

A complex array of institutions is responsible for agricultural research at continental, subregional, national, and rural levels in Africa. The relative weakness of many of these institutions leads to continuing emphasis on capacity development. The Science Council is now recognizing this situation. Indeed, the reality is such that our partners, potential partners, collaborators, and donors are often reluctant to work with the Centers, unless they include capacity strengthening as an explicit objective of project proposals. Capacity strengthening is supported by our strategy of bringing in local and regional partners at early stages of proposal planning. We also encourage and support local partners to take leadership, especially in country-specific proposals.

Reputation for such behavior is also important for maintaining strong research partnerships in those cases where a significant capacity-building element cannot be easily included in a proposal. Even so, increasing national and donor concern to include capacity building in aid portfolios has led to a growing number of national ministries of agriculture receiving direct budget support, instead of being offered project funding for agricultural research.

A notable area where CIAT has contributed considerably to capacity development is at the level of rural institutions. In collaboration with PABRA partners, CIAT has catalyzed partnerships among national and regional organizations to improve the adoption rate, and hence impact, of new bean varieties. In response to the May 2006 CCER, we have refocused our research on enabling rural innovation work from the farmer group and community level to higher level farmer associations, their linkages within broader innovation platforms, and questions of accountability of

Capacity strengthening is supported by our strategy of bringing in local and regional partners at early stages of proposal planning. We also encourage and support local partners to take leadership, especially in country-specific proposals.

Robin Buruchara

Woman farmer tending her bean plants, southern highlands, Tanzania.

Again this year, CIAT actively helped coordinate and integrate activities of institutions working in Africa.

formal research to end users. The Science Council's recent planning for a strategic framework for system priority 5C (*Improving Rural Institutions and their Governance*) is timely.

Again this year, CIAT actively helped coordinate and integrate activities of institutions working in Africa. With leadership from ICRAF and ILRI, we helped develop what is now known as the Alliance for Agricultural Research in Eastern and Southern Africa, which will function as a "network cluster with a hub unit". AARESA's strategic framework responds to several international and regional studies—the Kofi Annan Initiative, NEPAD-CAADP, FARA, SADC, ASARECA, the Terveuren Consensus, and the CGIAR Science Council—as well as the institutions' own self-assessment in those areas of comparative advantage that would most benefit from an integrated approach. Four flagship research proposals were developed, and endorsed by the Science Council, in the areas of iNRM, exploitation of genetic diversity, information and knowledge, and post-conflict rehabilitation of capacity for research-for-development.

ASARECA is the subregion's coordinating body for agricultural research and our key partner. It has developed both a strategic and operational plan. Driven by concern over the region's mounting volume of food imports, and seeing the opportunities for regional trade in food products, CIAT finds most of its own research focus reflected within the region's new set of priorities and is reassured of continuing partnership. However, as ASARECA moves from organizing around networks to research programs, there are, as yet, unanswered questions about the form this support will take for beans and other long-term CGIAR research interests.

Asia

The countries of Southeast and East Asia where CIAT is active continue to experience rapid economic growth. Although most major changes are seen in industrial development and urban growth, particularly in China, significant impact continues to be seen in the agricultural sector. Some of these changes provide pathways out of poverty for the marginalized poor who also continue to exist, and in significant numbers, in the region.

The risk that the region's marginalized poor may be left behind during these periods of rapid growth emphasizes the importance of linking small farmers with markets. Last year was a difficult

Farmers transporting cassava stakes for planting.

Jim Holmes/CIAT Asia

operational year for SADU, the SDC-funded project that focuses on agroenterprise development for small producers in Vietnam and Lao PDR. Nevertheless, it was also a period during which the project's successes are being recognized more widely by governments and many other development partners.

The approach to agroenterprise development focuses on fostering development within a range of value chains in a particular area, thus avoiding a broad subsector approach. The value-chain approach involves activities in many value chains, including annual crops, perennial crops, nontimber forest products, and the livestock sector. Manuals were developed and a range of stakeholders trained in the whole agroenterprise development process and in critical components such as rapid market appraisal and market extension. For some areas and value chains, the creation and promotion of business development services were seen as an important part of the process, with significant direct impact on those involved in these services and indirect impact on a broader group of people as a result of the embedded extension impact of such services. In several cases, this approach of linking farmers with markets has built on CIAT's other research for development activities, particularly livestock feeding and production systems and improved cassava production. The importance of this approach of market linkages is such that it is being increasingly used in other CIAT activities, even those that had not been developed with a specific market focus.

The demand for cassava products continues to expand. Several CIAT activities, particularly in fairly remote areas of Laos and Cambodia, emphasized on-farm use of improved cassava production systems. In these cases, cassava can be used as food and is increasingly being used in animal feed systems in various forms: fresh, dried, and ensiled roots and leaves. Such improved cassava production systems will, in time, benefit from increased market demand for cassava for animal feed, starch production, and bioethanol production. These markets, particularly the burgeoning market in China, but also in Thailand, Vietnam, and Indonesia, are already providing significant options to farmers throughout the region. More and more, marginalized poor farmers in the more remote areas are realizing the possibilities of market linkages.

Research on improved cassava production and utilization systems is being undertaken with partners through specific cassava projects in Laos and Cambodia (funded by the Nippon Foundation), and in Indonesia and East Timor (funded by ACIAR). In addition, cassava production and use are significant components of a broader

Linking farmers with markets has built on CIAT's other research for development activities, particularly livestock feeding and production systems and improved cassava production.

Jim Holmes/CIAT Asia

Cut-and-carry forage used for livestock in Asia.

project, implemented jointly with CIP and funded by IFAD. This project provides methodological and technical support to IFAD investment projects in Laos, Vietnam, and southern China. It has already worked in specific areas of expertise for CIAT and CIP such as cassava, sweet potato, livestock systems, and markets, and other cropping and farming systems. The IFAD project demonstrates the important contribution CGIAR Centers can make to development if the appropriate linkages are made between research and development activities. Because this relationship is seen as so critical, the project provides direct feedback to IFAD on how best this institute can link its technical assistance grants with those of its large loan projects that have specific development objectives.

One activity of the IFAD-supported project, PRDU, conducts livelihood analyses. Results have led to interesting interventions that help communities envisage development goals. This work was complemented by research in a northern province of Laos funded by the Austrian Development Agency (ADA) and implemented in collaboration with the staff and students of BOKU, Vienna. In collaboration with PhD and Masters students, analyses of livelihood strategies, market chains, and the spatial arrangement of these systems are being used to improve understanding on how reduced-risk livelihood strategies can be developed.

CIAT activities in the livestock sector continue in several specific livestock-related projects, as well as in cassava, agroenterprise, and IFAD-supported projects. One research area focuses on improved village-based pig-feeding systems. This ACIAR-funded project evolved from data collected towards the end of an earlier AusAID-funded livestock project that expanded the use of forage-based feeding systems in Laos. These results showed that changing from feeding village pigs with traditional rations to using feeding systems based on *Stylosanthes guianensis* would halve daily labor inputs, made mostly by women, while doubling the pigs' average growth rate. That is, the change results in a four-fold saving in labor over a complete production cycle.

The current research projects aims to study the specific reasons for growth rate changes, assess other legumes that may have a larger impact, develop specific recommendations for complete animal rations based on village production systems, and interact with NGOs and other development partners to ensure that these benefits reach a broad community of small farmers. Some of these findings, as well as other CIAT research experience, will form the basis for a new project on village livestock-feeding systems funded by IFAD under the CGIAR System-wide Livestock Project. In this Project, CIAT will implement a component with

The current research projects aims to study the specific reasons for growth rate changes, assess other legumes that may have a larger impact, develop specific recommendations for complete animal rations based on village production systems, and interact with nongovernmental organizations (NGOs) and other development partners to ensure that these benefits reach a broad community of small farmers.

Woman preparing cassava chips.

Jim Holmes/CIAT Asia

partners in Vietnam, while ILRI and ICARDA will undertake similar activities in Ethiopia and Syria, respectively.

At the same time, CIAT is collaborating with the Lao Department of Livestock and Fisheries and ADB to train and mentor extension staff across the country's northern provinces in improved livestock systems through forage production, animal management, and innovation. This work is being undertaken in preparation for a large ADB-IFAD-SDC loan and grant project that CIAT and ILRI helped to design, and which will start in late 2007.

Links with other interventions in the livestock sectors in Laos and Cambodia continue as support to several ACIAR-funded projects on extension methods, animal health, and cattle systems.

A major factor in all of CIAT's activities in Asia comprises the partnerships that were developed and maintained. The core of these partnerships are the relationships with our partner NARES, which we continue to foster and expand. In 2006, a new collaborative agreement was signed with the Yunnan Academy of Agricultural Sciences. New relationships are being developed or old ones updated with other partner research organizations in China, especially in that country's subtropics and tropics. These collaborative activities will focus on agricultural research for development within China, but will include other countries in the region and beyond where China supports development.

Our relationships with other advanced research organizations continue. An economist from JIRCAS was seconded to our Regional Office in Laos. Our links with universities and research institutions in other countries, especially Australia, remain strong. We continue to host students from several universities, including, for the second year in a row, three graduates from Zamorano in Honduras. These students were funded by the Nippon Foundation on a research exchange with CIAT projects. Other key partners are also donors. That is, in addition to working in the specific projects that the donors fund, CIAT-Asia interacts with and provides support for other activities of these donor partners, specifically ACIAR, SDC, ADB, and IFAD.

CIAT-Asia will consolidate its current activities in Cambodia, China, East Timor, Indonesia, Laos, Thailand, and Vietnam, and will aim to gradually expand the range of activities in these countries and expand to other countries in Southeast, South, and East Asia.

A major factor in all of CIAT's activities in Asia comprises the partnerships that were developed and maintained.

ARROZGUA, 2006

Farmers evaluating new upland rice varieties in Petén, Guatemala.

Central America and the Caribbean

In Central America, CIAT's research for development program is confronted with three major challenges: the unresolved issue of food security for parts of the rural population; the lack of opportunities for small farmers to participate in value chains and access markets; and the increasing deterioration of the natural resource base on which small farmers rely. Increasing water shortages and energy costs has had considerable impact on production and income generation in the region. In large parts of Central America, the second rainy season (Sep-Dec) in 2006 was characterized by erratic rainfall, which affected agricultural production and research activities.

The unpredictable weather conditions highlighted the importance of CIAT's work on drought-tolerant germplasm and dry-season feed systems to the region. Although bean trials were negatively affected during their establishment, we achieved, overall, progress on both drought tolerance and iron content. An alliance of bean researchers succeeded in attracting project funds from Red SICTA (SDC funds) to continue research on drought breeding, emphasizing bean root development. As part of the project, CIAT will continue to provide capacity building for national programs in Nicaragua and Honduras.

More elite cassava germplasm was distributed within Central America, with 21 clones being introduced to Costa Rica. The private sector in particular is showing a growing interest in industrial cassava and bioethanol production. The Nicaraguan national program continued strengthening its *in vitro* propagation capacities and distributing germplasm among small farmers.

For the first time in Nicaraguan history, a forage species was officially released as a cultivar in June 2006. *Cratylia argentea* was launched as 'INTA Cratylia', a result of joint efforts between INTA and CIAT's Tropical Grasses and Legumes Project funded by DANIDA. The donor recognized the importance of the strategic alliance and encouraged further collaborative work on variety development and release.

Annual, drought-tolerant, multipurpose, legume germplasm is already in the pre-release stage for launching in 2008. Work on dry-season feeding systems and strategies in 2006 had impact during the unusually dry, second-rainy season. Unlike their struggling neighbors, the small farmers participating in the research activities benefited from the advantages of drought-tolerant forage species.

The strategic broadening of the research focus in CIAT's Tropical Grasses and

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Participatory evaluation trial of early maturing upland rice varieties in Mazaya, Nicaragua.

Yolima Ospina

Legumes Project towards feeds for monogastrics provides a great opportunity to make significant impact, especially for rural poor women in the region. Women are the main producers of pork and poultry for national markets. Only in Nicaragua is 85% of all pork produced on small farms with a production of 1 or 2 pigs per year. Because feed resources comprise a major constraint and imported concentrates are increasingly expensive, this constitutes a huge opportunity for CIAT and its partners to help small farmers participate successfully in a growing market. A thorough field survey in Nicaragua was conducted during 2006 for targeting purposes and a proposal was developed, bringing together CIAT's forage, agroenterprise, and decision-support capacities. The proposal is currently being reviewed by BMZ. Through a successful proposal to CIM, the important position of a forage agronomist in the region is now funded and filled.

The strategic collaboration of CIAT with CIRAD continued to bear fruit in 2006. Outstanding work on participatory sorghum germplasm development in the northern drought-prone part of Nicaragua led to the pre-release of a new variety of white sorghum.

Considerable advances were obtained in our participatory breeding work for upland rice in Nicaragua. Two varieties for low-input upland cropping systems are being registered by a private project partner (with release in mid-2007). After conclusive validation trials carried out during 2005 and 2006, INTA will release a very early maturing line for upland areas with drought constraints and another line for favorable upland, mechanized-cropping systems. In collaboration with several partners, the national participatory crop improvement (PCI) network in Nicaragua was created during 2006. It was a result of the PPB schemes with associated farmers and NGOs in two areas of Nicaragua. A special issue of the journal *Agronomía Mesoamericana* was published by the network partners on PCI experiences in Latin America.

With regard to favorable upland rice and irrigated cropping systems, two very promising rice lines were advanced into pre-release trials in Nicaragua, El Salvador, and Costa Rica. Our work on germplasm improvement for Central

The strategic collaboration of CIAT with the French Agricultural Research Centre for International Development (CIRAD) continued to bear fruit in 2006. Outstanding work on participatory sorghum germplasm development in the northern drought-prone part of Nicaragua led to the pre-release of a new variety of white sorghum.

Axel Schmidt

"Aporreo" or threshing bean plants in San Dionisio, Nicaragua.

We also made considerable progress in our work on land management. The validation of the nutrient management expert system of the Nutrient Management Support System (NuMaSS) has concluded and a Spanish version is being prepared.

America also included seed distribution to public and private research institutions in Nicaragua, El Salvador, Guatemala, and Costa Rica. Two field selection workshops were also held in Nicaragua for Central American breeders. Nicaragua remains the main platform for rice germplasm development in the region.

Because tropical fruits are an important component of our diversification strategy, we intensified proposal development in collaboration with various partners in El Salvador, Honduras, Nicaragua, and Costa Rica to seek resources for collaborative research work in the region.

The AgroSalud Project funded by CIDA, Canada, and jointly implemented with various institutions, including CIAT, CIP, CIMMYT, CLAYUCA, and EMBRAPA, intensified its work on the seed production of biofortified crops, especially maize. Details of this Project are given on pages 18-19.

During 2006, efforts were made to expand CIAT's work on diversification and product quality management within value chains of the region. Through strategic alliance with the coffee sector in northern Nicaragua and funding from a national foundation, we could begin work on the relationships between product quality and environmental conditions. Information management within this value chain and capacity building will be an additional focus of CIAT's activities. Further proposals to intensify and expand this kind of research in the region have been submitted to a donor. A collaborative PhD project with the University of Hohenheim started in early 2007 to evaluate the cost-benefit ratios of certification schemes in organic coffee supply chains.

The IDRC-funded Learning Alliance project on agroenterprise development entered an important phase during 2006, whereby results and conclusions are being documented and synthesized. This multi-partner platform enabled CIAT also to join partners in Guatemala in a wide range of activities, starting mid-2007.

We also made considerable progress in our work on land management. The validation of the nutrient management expert system of NuMaSS has concluded and a Spanish version is being prepared. The Honduras-based Quesungual project embedded in CPWF has intensified its work on the validation sites in Nicaragua and started activities on the economic analyses of the system. The overall work on sustainable land management is regaining momentum through linkages with a GEF project on dryland management in

Visiting a demonstration plot in Central America.

Axel Schmidt

Nicaragua, the resubmission of a global CIAT-led GEF proposal that includes humid areas of Honduras, and the implementation of an ETH-ZIL project on crop-livestock systems that builds on our multipurpose forage germplasm selection work in Nicaragua.

The February 2006 Financial Retreat decided to phase out the IPRA, C&W, and TSBF-LAC projects, heavily affecting the region. Major efforts were started to fully document the research results of these projects. All current special projects will be terminated in September 2007. We are confident that some of the skills and research capacities will be incorporated into the new product lines currently under discussion within CIAT. Water productivity issues will be of strategic importance for our future work in the region.

Our activities in Haiti, however, were drastically reduced to two small projects on cassava, beans, and capacity building. With Heifer International, we are preparing a new proposal for forage work on the island and are exploring further funding opportunities with different donors to continue our work on research for development.

Apart from fund-raising activities and the implementation of strategic reductions, Regional Coordination-Central America concentrated on fostering partnerships. We succeeded in establishing new partnerships (e.g., Heifer International) while strengthening existing strategic alliances (e.g., ETH-ZIL). After changes in government in Honduras and Nicaragua, the safeguarding of our collaborative work plans had highest priority. We further developed the idea of a strategic alliance between CAC-SICTA and the CGIAR Center Alliance to develop and implement a regional research agenda that capitalizes on the joint expertise and research capacities of all CGIAR Centers channeled through CIAT. The proposal was approved by CAC-SICTA and is now being further explored with the Center Alliance. A general agreement is being prepared.

With Heifer International, we are preparing a new proposal for forage work on the island and are exploring further funding opportunities with different donors to continue our work on research for development.

ROBERTO PORRO

Timber from lowland Amazon waiting for processing by a logging company near Santarém, Pará, Brazil.

Amazon

In 2007, the National Institute of Agrarian and Food Research and Technology (INIA) in Spain renewed and increased its support for the institutional development of the Amazon Initiative (AI) through a 3-year, 1-million-dollar project.

The Amazon Initiative (AI), the International Consortium for the Conservation and Sustainable Use of Natural Resources in the Amazon, is composed of the national agricultural research institutes of Bolivia, Brazil, Colombia, Ecuador, Peru, Suriname, and Venezuela; four CGIAR Centers (CIAT, ICRAF, CIFOR, and Bioversity International); and other national and international associate institutions. In September 2007, these institutions signed their second cooperation agreement and launched an additional 3-year term of the consortium.

The AI Secretariat is hosted by EMBRAPA in Belém, Brazil. The Initiative fosters in-country collaboration and influence on policy development and implementation processes, and aims to enhance livelihoods in the Amazon by promoting regional collaborative research activities that focus on sustainable land use systems. Being aware of the strong linkage between environmental issues and local livelihoods in the Amazon, the thematic focus of the AI's agenda includes socioeconomic research on (i) climate change mitigation and adaptation, (ii) sustainable production on degraded and/or deforested land, (iii) enhanced benefits from forests, and (iv) value-chain development for Amazonian products.

A revised proposal to establish an Amazon Initiative System-Wide Ecoregional Program within the CGIAR structure included these four research thrusts, and was submitted to the Science Council in June 2007.

In 2007, the National Institute of Agrarian and Food Research and Technology (INIA) in Spain renewed and increased its support for the institutional development of the AI through a 3-year, 1-million-dollar project.

In January 2007, Dr Jan Börner started his appointment as the AI environmental services expert hired by CIAT. Funding came from CIM of Germany.

The first of the five AI international training events on sustainable agroforestry techniques, funded by JICA, was successfully carried out by EMBRAPA in February 2007.

Extension agents from six countries participating in a training event on agroforestry systems; it was held by the Amazon Initiative (AI) in southern Pará, Brazil, February 2007.

Roberto Porro

The World Bank's Institutional Development Fund approved a grant of US$487,000 to the AI to develop a comparative study on Amazonian livelihoods and natural resources in 15 sites across the region. An inventory and shared database on sustainable Amazonian land use systems will also be developed.

In 2007, EMBRAPA released the second round of funds earmarked for use on AI activities, after four collaborative projects were implemented in 2006.

Finally, in May 2007, the British Natural Environment Research Council and DFID have appointed the AI as a coordination institution for a situation analysis on environmental services and poverty alleviation. The 7-month US$500,000 grant started this August and includes CIAT, TNC, WWF, Kings College of London, and the Universidad Nacional de Colombia.

The AI website is now available both in Spanish and Portuguese. *Ida y Vuelta*, the AI electronic newsletter has been published since March 2006, while the quarterly *NoticIA* began printing in May 2007. The 11 thematic networks formed in the domain of the AI have been interacting through an open source software for collaboration and knowledge management.

Small grants have been approved for the first three network projects; these are Agroforestry Germplasm, Integrated Forest Management, and Sustainable Pasture Management.

In collaboration with Association of Amazonian Universities (UNAMAZ), the AI has supported 34 students enrolled in Amazonian universities through short-term internships in research projects carried out in NARS and CGIAR Centers.

In May 2007, the British Natural Environment Research Council and the Department for International Development (DFID) have appointed the Amazon Initiative (AI) as a coordination institution for a situation analysis on environmental services and poverty alleviation.

Julio César Martínez

Agronatura Science Park

Agronatura's vision is to be recognized as a science park that brings together private and public research institutions of international and national character and which share CIAT's mission. Together, they would constitute a dynamic research community working in agriculture and natural resource management. The focus would be to generate effective and pertinent innovations that result in high returns for poor farmers in the tropics.

www.ciat.cgiar.org/agronatura/index_eng.htm

The Park provides an optimal environment and location to promote and develop such international partnerships and alliances. Current themes include the generation of high-value alternatives, involving agroenterprise; the support of collaborative research in such areas as biotechnology, integrated pest-and-disease management, soil management, and GIS; and training.

At present, 14 members make up the Park. They are:

- CIAT
- Two CGIAR Centers: Bioversity International and CIMMYT
- Other international institutions: CIRAD and IRD
- Colombian institutions: Corporación BIOTEC, CENICAÑA, FIDAR, INVEMAR, Humboldt Institute (IAvH), and ICA
- Alliances: CLAYUCA, FLAR, and FLIPA

This year, a new member was welcomed: the Latin American Fund for Oil Palm Innovation (FLIPA), which was established in March, along the lines of its sister member alliances, CLAYUCA and FLAR. Its mission is to contribute towards attaining sustainability of the oil-palm agroindustry in tropical Latin America. It conducts R&D activities such that the palm-growing sector remains competitive, profitable, and efficient according to parameters for protecting the environment. It thereby captures potential economic and social benefits arising from effective participation in national and international markets with products for both consumption by humans and other uses. In August, the Fund held its first technical meeting to prioritize initial areas of work, which are genetic resources, plant health, improved cultural practices, and technology transfer.

The Corporación BIOTEC–CIAT Collaboration at Agronatura Science Park

http://biotec.univalle.edu.co

- To contribute to technological innovation in agriculture, BIOTEC has led, since 2004, a group of organizations in the Program *Site-Specific Agriculture as Applied to Fruit Crops: On-Farm Technology Developed for Each Farm*. CIAT is represented by its Land Use and Tropical Fruit Crops groups, and the Pathology Group for Tropical Fruit Crops and Cassava. The Program's scientific director is also a CIAT scientist.

- BIOTEC is conducting research on the soursop production chain, following an I&D+IT model that would allow BIOTEC to become a center of reference for soursop. Within this framework, the following project is being carried out: *Selection of Soursop (*Annona muricata *L.) under Diverse Environmental Conditions, Characterization of Selection Sites, and the Promotion of Crop Establishment in Specific Sites*. Participants in this Project are Biotechnology for Production Chains of Promising Fruit Crops (a BIOTEC group recognized by COLCIENCIAS), PROFRUTALES Ltda. (an elite nursery), and CIAT's Land Use and Tropical Fruit Crops groups.

- For these projects, we also receive the collaboration of the Humboldt Institute (IAvH), also a member of Agronatura.

- BIOTEC participated in the Feria Compartir Conocimiento (*Knowledge Sharing Fair*), organized by CIAT within the framework of the EPMR visit. We took the opportunity to present our results and experiences, and demonstrate the cyclical micrografting of elite soursop plants, a technology for which the Corporation and CIAT received an invention patent (Resolution No. 17204 of 29 June 2006).

- Since March 2006, BIOTEC has been executing the project *Strengthening the Capacity of Corporación BIOTEC Laboratories to Ensure the Food Safety of Regional and National Fruit Cultivation*. This Project includes the modernization and amplification of laboratory infrastructure at the Agronatura Science Park, with the goal of being registered with ICA in the capacity of offering analytical services on pesticide residues (using gas chromatography), physico-chemical analyses for determining fruit maturity and quality, and microbiological analyses. This laboratory will become part of a network of laboratories that includes those of CIAT and the Universidad del Valle, serving the Valle del Cauca Bioregion.

An Overview of CIAT

Mission, Vision, and Values

Mission

To reduce hunger and poverty in the tropics through collaborative research that improves agricultural productivity and natural resources management.

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

- **Excellence**
  High quality outputs are achieved through efficient work processes.
- **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.
- **Impact orientation**
  Research and related activities are demand driven, and are monitored and evaluated for social and environmental impact and relevance.
- **Teamwork and partnership**
  Internal and external teams are proactively built and strengthened through collaborative activities.

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Agropolis

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CIAT

Moisés Wasserman (ex-officio), Colombia
Rector
National University

Claudio Wernli, Chile
Executive Director
Millennium Science Initiative
Ministry of Planning and Cooperation

Term ended in the reporting period:

Jenchyn Luh, USA
Chief Operation Officer
C.M. Capital Corporation

Victoria Tauli-Corpuz, Philippines
Founder and Executive Director
Tebtebba Foundation

Donors

CIAT receives funds through the CGIAR or under specific projects from the countries and organizations listed below. We gratefully acknowledge their commitment and contributions. CIAT also receives funds for research and development services provided under contract to a growing number of institutional clients.

Asian Development Bank (ADB)
Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)
Australia
- Australian Agency for International Development (AusAID)
- Australian Centre for International Agricultural Research (ACIAR)

Austria
- Austrian Development Agency (ADA)
- Federal Ministry of Finance (BMF)

Belgium
- General Administration for Development Co-operation (AGCD)

Bill and Melinda Gates Foundation
Brazil
- Brazilian Agricultural Research Corporation (EMBRAPA)

Canada
- Canadian International Development Agency (CIDA)
- International Development Research Centre (IDRC)

Colombia
- Colombian Corporation of Agricultural Research (CORPOICA)
- Colombian Institute for the Development of Science and Technology (COLCIENCIAS)
- Ministry of Agriculture and Rural Development (MADR)

Common Fund for Commodities (CFC)
Denmark
- Danish International Development Assistance (of the Royal Danish Ministry of Foreign Affairs) (DANIDA)

European Commission (EC)
Food and Agriculture Organization (FAO) of the United Nations
Forum for Agricultural Research in Africa (FARA)
France
- French Agricultural Research Centre for International Development (CIRAD)
- GENOPLANTE
- Institute of Research for Development (IRD)
- Ministry of Foreign Affairs

Germany
- Federal Ministry for Economic Cooperation and Development (BMZ)

Global Environment Facility (GEF)
Inter-American Development Bank (IDB)
Inter-American Institute for Cooperation on Agriculture (IICA)
International Fertilizer Development Center (IFDC)
International Fund for Agricultural Development (IFAD)
Italy
- Ministry of Foreign Affairs

Japan
- Ministry of Foreign Affairs
- The Nippon Foundation

Latin American and Caribbean Consortium to Support Cassava Research and Development (CLAYUCA)
Latin American Fund for Irrigated Rice (FLAR)
Mexico
- Grupo Papalotla

Netherlands
- Directorate-General for International Cooperation (DGIS)
- Ministry of Foreign Affairs

New Zealand
- New Zealand Agency for International Development (NZAID)

Norway
- Norwegian Agency for Development Cooperation (NORAD)
- Royal Ministry of Foreign Affairs

Peru
- National Institute for Agricultural Extension and Research (INIA)

Regional Fund for Agricultural Technology (FONTAGRO)

Spain
- National Institute of Agrarian and Food Research and Technology (INIA)

Sweden
- International Programme in the Chemical Sciences (IPICS) of Uppsala University
- Stockholm Environment Institute (SEI)
- Swedish International Development Cooperation Agency (SIDA)

Switzerland
- Swiss Agency for Development and Cooperation (SDC)
- Swiss Centre for International Agriculture (ZIL)
- Swiss Federal Institute of Technology Zürich (ETH)

Technical Centre for Agricultural and Rural Cooperation (CTA)

United Kingdom
- Department for International Development (DFID)
- Natural Resources Institute (NRI)

United Nations Environment Programme (UNEP)

United States of America
- The Rockefeller Foundation
- United States Agency for International Development (USAID)
- United States Department of Agriculture (USDA)
- W.K. Kellogg Foundation
- World Vision

World Bank

Financial Results

In recent years, operating deficits were occurring largely because of declining unrestricted core funding and the strengthening Colombian peso. To reverse these losses and increase reserves to the CGIAR-recommended level, CIAT began adjusting its programmatic, organizational, and financial structure in January 2006. The Center adopted across-the-board spending cuts, and strategic reductions in research projects and support and administrative services, thereby reducing unrestricted expenditures by US$3.9 million. Several international and national staff positions were also eliminated.

Overall financial results showed that total revenues decreased by 8%, from US$41.5 million in 2005 to $38 million in 2006. Operational expenditures also decreased by 8%, from $42.4 million in 2005 to $39.1 million in 2006, before phase-out costs. The net operational deficit was $1 million, compared with a deficit of $0.9 million in 2005. When phase-out costs of $2.8 million were included, the total deficit was $3.9 million and the level of reserves had declined to $1.8 million. The Board and Management Team had projected the level of unrestricted net assets (reserves) at the end of 2006 to be $3.3 million, representing 32 days of operating expenditures.

Unfortunately, in late December, a late funding cut from a major donor was confirmed, representing an income loss of US$1.6 million for CIAT. A second late cut from another donor resulted in a further $0.2 million reduction. However, a contribution of $0.4 million from the World Bank partly offset these losses.

In 2007, restructuring will continue and additional measures implemented. Yearly surpluses for the next 3 years are being estimated to achieve financial targets for 2009. The Board and Management Team are working together to implement a Business Plan. With continued support from the donor community, we feel CIAT will successfully emerge from this difficult financial period.

CIAT Statement of Financial Position
(in thousands of US$, at 31 December for years 2006 and 2005)

	2006	2005
Assets		
Current Assets		
Cash and cash equivalents	18,514	14,559
Accounts receivable		
Donors	5,244	7,181
Employees	366	357
CGIAR Centers	195	57
Others	2,754	1,489
Inventories	430	348
Prepaid expenses	97	176
Total Current Assets	27,600	24,167
Non-Current Assets		
Property and equipment	9,525	10,021
Other assets	6	6
Total Non-Current Assets	9,531	10,027
Total Assets	37,131	34,194
Liabilities and Net Assets		
Current Liabilities		
Accounts payable		
Donors	13,399	8,551
Employees	776	774
Others	3,766	2,356
Support to partner Challenge Programs	2,852	3,620
Funds in trust	2,775	1,950
Accruals and provisions	304	145
Total Current Liabilities	23,872	17,396
Non-Current Liabilities		
Others	477	514
Accruals and provisions	1,441	1,091
Total Non-Current Liabilities	1,918	1,605
Total Liabilities	25,790	19,001
Net Assets, Unrestricted		
Designated	10,260	11,125
Undesignated	1,081	4,068
Total Net Assets	11,341	15,193
Total Liabilities and Net Assets	37,131	34,194

CIAT Statement of Activities
(in thousands of US$, at 31 December for years 2006 and 2005)

	Unrestricted	Restricted		Total 2006	Total 2005
		Temporary	Challenge Programs		
Revenue and Gains					
Grants	11,776	21,030	3,800	36,606	40,216
Other revenues and gains	1,411			1,411	1,248
Total revenues and gains	13,187	21,030	3,800	38,017	41,464
Expenses and Losses					
Program-related expenses	10,412	20,729	3,620	34,761	37,312
Management and general expenses	6,002	301	180	6,483	7,645
Other expenses	530	-	-	530	198
Subtotal expenses and losses	16,944	21,030	3,800	41,774	45,155
Indirect cost recovery	(2,719)	-	-	(2,719)	(2,797)
Total expenses and losses	14,225	21,030	3,800	39,055	42,358
Net Surplus (Deficit) from Activities	(1,038)	-	-	(1,038)	(894)
Extraordinary Items:					
Reorganization/Phase-out costs	(2,814)	-	-	(2,814)	-
NET SURPLUS (DEFICIT)	(3,852)	-	-	(3,852)	(894)
Operating expenses by natural classification					
Personnel costs	11,331	6,895	855	19,081	20,639
Supplies and services	1,113	7,812	1,662	10,587	10,432
Collaborators/Partnerships costs	-	3,823	574	4,397	5,797
Operational travel	877	2,199	529	3,605	3,592
Depreciation of fixed assets	904	301	180	1,385	1,898
Total operating expenses, net	14,225	21,030	3,800	39,055	42,358

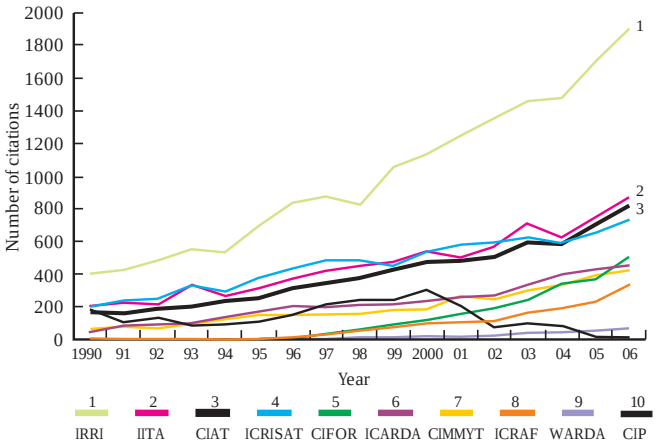
Institutional Performance

The CGIAR implemented a Performance Measurement System in 2004 on a pilot scale, executing it in full in 2005. The idea is to measure and compare the CGIAR Centers in terms of results, potential for future accomplishments, and performance as perceived by stakeholders. Measurement is therefore based on these three "dimensions", which can be further subdivided into six performance elements, as follows:

Results	Potential to perform	Stakeholder perceptions
Outputs	Quality and relevance of current research	(surveyed every 3 years)
Outcome	Institutional health	
Impact	Financial health	

According to this evaluation system CIAT's greatest strengths, as with other Centers, lie in its research, regional focus, and especially partnerships. It is also strong in documenting the impact of its research, although more focus is needed on the communication and dissemination of research findings.

According to the EPMR Panel, CIAT ranks highly among CGIAR Centers in publications and citations and has an impressive array of germplasm products. The Panel referred to three specific indicators (see table and figure, this page): (1) a broad measure of output of published research, including many types of publications; (2) publications in top journals, thus considering quality as well as quantity of published output; and (3) total citations, which indicates quality and impact of scientific output. Articles that are frequently cited are influential in furthering science, and often-cited authors are recognized as leaders in their profession. All three measures rank CIAT as a top CGIAR Center in terms of quantity and quality of science.



Total citations for ten CGIAR Centers, 1990–2006 (from Thomson Scientific/Web of Science®).

SOURCE: EPMR Report, August 2007.

CIAT's ranking among CGIAR Centers for publications and citations, 2004–2006.

Indicator	2004[a]		2005		2006	
	Number	Rank	Number	Rank	Number	Rank
1. Number of all publications per scientist in peer-reviewed journals, books, monographs, and book chapters (15 Centers)	2.63	7	3.05	2	2.67	2
2. Number of peer-reviewed publications per scientist in journals listed in Thomson Scientific (15 Centers)	n.a.	n.a.	1.14	2	1.13	4
3. Total citations in publications included in Thomson Scientific (10 Centers)	589	3	707	3	821	3

a. n.a. = Information not available.

SOURCE: EPMR Report, August 2007, based on CGIAR Performance Measurement System, various years.

In terms of institutional health, good governance, supported by an effective policy framework, is critical to CIAT's performance, together with a positive culture of learning and change. This culture should be monitored to understand staff needs, levels of satisfaction, and opportunities for advancement. According to the EPMR report, more work is needed in these areas.

Information on financial health over the CGIAR's reporting period indicates that, of the 15 Centers, CIAT has:

- The lowest short-term solvency or liquidity (36 days; target is 90–120 days).
- The least long-term financial stability or reserves (18 days; target is 75–90 days).
- An average level of efficiency of operations (20%, measured as an indirect cost ratio, with a range of 13% to 28%).
- Its index for cash management of restricted operations is 0.35 (range is 0.13 to 2.03).

The 2004–2006 figures show deterioration in the principal financial indicators.

Finally, stakeholder satisfaction with CIAT may have declined over the reporting period as a result of the Center's financial difficulties, downsizing, and continued restructuring of its research agenda.

Awards

2007

- Best Research Scientist in College of Agriculture and Veterinary Sciences, Award granted by the University of Nairobi (Kenya) to **Paul Kimani**.
- CIAT-Outstanding Principal Staff Achievement Award (OPSA), granted to **Segenet Kelemu**.
- CIAT-Outstanding Young Scientist-of-the-Year Award (OYSYA), granted to **Marcela Quintero**.
- CIAT-Outstanding Research Publication Award (ORPA), granted to Elizabeth Balyejusa Kizito, Linley Chiwona-Karltun, Thomas Egwang, **Martin Fregene**, and Anna Westerbergh.
- CIAT-Outstanding Employee of the Year Award (OEYA), granted to **Girlena Aricapa**.
- CIAT-Outstanding Support Staff Contribution Award (OSSCA), granted to **Paula Ximena Hurtado**.
- CIAT-Outstanding Team of the Year Award (OTYA), granted to the **Motor Pool team**.

2006

- Recognition for scientific contribution in rice, Award granted by "General Saavedra" Municipal Council, Bolivia, to the **CIAT Rice Project** (**Lee Calvert** and **Marc Châtel**).
- First Prize at the GFAR-2006 Poster Competition, Award granted by the Global Forum on Agricultural Research (GFAR) to **Jonas Chianu**, **Peter Okoth**, **Omo Ohiokpehai**, **Kristina Roing**, **Bernard Vanlauwe**, **Nteranya Sanginga,** Pat Naido, Akin Adesina, and Joyce Opondo.
- Third Innovation Marketplace Award, high-level recognition, granted by the CGIAR at AGM 2006 to **CIAT-FLAR**.
- Humber Prize, granted by the University of Nottingham, UK, to **Jean-Claude Rubyogo**.
- The CGIAR Science Award for Outstanding Partnership at AGM 2006, granted to the **CGIAR Genebank Community.**

- The CGIAR Science Award for Outstanding Scientific Support Team at AGM 2006, granted to the **CGIAR Information Managers/Librarians Community.**

- 2006 Semilleros ADN Prize for Best Agricultural Biotechnology Research Project, granted by Agro-Bio to **Jesús Alonso Beltrán** (undergraduate thesis directed by Paul Chavarriaga and supervised by Joe Tohme).

- 2006 Semilleros ADN Prize Third Place, granted by Agro-Bio to **Luz Elena Romero**, **Iván Lozano Potes**, and **Natalia Villareal** (undergraduate thesis supervised by Lee Calvert).

- International Service in Agronomy Award, granted by the American Society of Agronomy (ASA) to the "Cassava Team" (**Reinhardt Howeler**, Watana Watananonta, and Tran Ngoc Ngoan).

- Poster finalist, Kellogg's Latin American Award to Research on Food and Human Nutrition, granted by the Latin American Nutritional Society to **Helena Pachón**.

- The Order of the Seed, Gold Category, granted by INPROARROZ Rice Industry to the **CIAT Rice Project**.

- One of the Best Learning Experiences of Africa Forum 2006 of Dual Epidemics of HIV and Food Security, granted by the Project Concern International to **Jonas Chianu**, Brenda Kingolla, **Omo Ohiokpehai**, **Nteranya Sanginga**, and **Bernard Vanlauwe**.

- Friendship Award, granted by the State Administration of Foreign Experts Affairs, State Council of People's Republic of China to **Segenet Kelemu**.

- The Order of Australia for services to primary industry through research and the development of sustainable tropical pasture technology to increase food production, rural incomes, and scientific knowledge in Asia, Central and Southern America, and Australia, granted to **Bert Grof** (former CIAT scientist).

- Award to the best poster presented during the XXXIII Congress at the Colombian Society of Entomology to **Claudia Marcela Ospina**, **Daniel C. Peck**, and **Jairo Rodríguez Chalarca**.

- Third Class of the "Most Exalted Order for the White Elephant", granted by the Thai Government to **Reinhardt Howeler**.

- Poster Award granted by the Global Health Council to **Helena Pachón**.

- Scholarship to undertake graduate studies, granted by the Universidad Nacional de Colombia to **Germán Alonso Plata**.

Staff*

Management Team

Joachim Voss, Director General
Jesús Cuéllar, Administrative Director**
Albin Hübscher, Deputy Director General for Corporate Services
Douglas Pachico, Deputy Director General for Research
Luis Roberto Sanint, Director for Public–Private Partnerships and Agronatura Science Park**

Regional Coordination

Robin Buruchara, Plant Pathologist; Coordinator for Sub-Saharan Africa, Uganda
Rod Lefroy, Upland Systems Specialist; Coordinator for Asia, Lao PDR
Axel Schmidt, Agronomist; Coordinator for Central America and the Caribbean, Nicaragua

Sharing the Benefits of Agrobiodiversity

Joseph Tohme, Plant Breeder and Geneticist; Leader, Research for Development Challenge: Sharing the Benefits of Agrobiodiversity
Elizabeth Álvarez, Plant Pathologist
Bernardo Arias, Agricultural Engineer
Stephen Beebe, Bean Breeder; Leader, Outcome Line: Improved Beans for the Developing World
Anthony Bellotti, Entomologist**
Luis Eduardo Berrío, Agronomist, FLAR
Mathew Blair, Bean Germplasm Specialist and Breeder
Hernán Ceballos, Cassava Breeder; Leader, Outcome Line: Cassava for the Developing World
Fernando Correa, Plant Pathologist; Leader, Outcome Line: Improved Rice for Latin America and the Caribbean
Edgar Alfredo Corredor, Agronomist, FLAR
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Acronyms and Abbreviations

AARESA: Alliance for Agricultural Research in Eastern and Southern Africa (now Regional Plan for Collective Action in Eastern and Southern Africa, of the CGIAR)

ACIAR: Australian Centre for International Agricultural Research

ADA: Austrian Development Agency

ADB: Asian Development Bank

AfNet: African Network for Soil Biology and Fertility (of TSBF-CIAT)

AGCD: General Administration for Development Co-operation, Belgium

AGM: annual general meeting

AI: Amazon Initiative, the International Consortium for the Conservation and Sustainable Use of Natural Resources in the Amazon

AMA: Accra Metropolitan Assembly, Ghana

ARI: Agricultural Research Institute, Tanzania

ASA: American Society of Agronomy

ASARECA: Association for Strengthening Agricultural Research in Eastern and Central Africa

ATDT: Agricultural Technology Development and Transfer Project, Rwanda

AusAID: Australian Agency for International Development

BCMNV: bean common mosaic necrosis virus

BCMV: bean common mosaic virus

BFPs: basin focal projects

BGYMV: bean golden-yellow mosaic virus

BI: Bioversity International

BIOTEC, *also* Corporación BIOTEC: Corporación para el Desarrollo de la Biotecnología *(Corporation for the Development of Biotechnology)*, Colombia

BMF: Bundesministerium für Finanzen *(Federal Ministry of Finance)*, Austria

BMZ: Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung *(Federal Ministry for Economic Cooperation and Development)*, Germany

BOKU: Universität für Bodenkultur Wien *(University of Natural Resources and Applied Life Sciences)*, Austria

C&W: Communities and Watersheds Project (of CIAT)

CAADP: Comprehensive Africa Agriculture Development Programme (of NEPAD)

CAC: Consejo Agrícola Centroamericano *(Central American Agricultural Council)* (of SICTA)

CCC: Corporate Communications and Capacity Strengthening Unit (of CIAT)

CCER: Center-Commissioned External Review (of the CGIAR)

CENICAÑA: Centro de Investigación de la Caña de Azúcar de Colombia *(Colombian Sugarcane Research Center)*

CFC: Common Fund for Commodities (of the United Nations)

CGIAR: Consultative Group on International Agricultural Research

CIAT: Centro Internacional de Agricultura Tropical *(International Center for Tropical Agriculture)*

CIDA: Canadian International Development Agency

CIFOR: Center for International Forestry Research

CIM: Centrum für Internationale Migration und Entwicklung *(Centre for International Migration and Development)*, Germany

CIMMYT: Centro Internacional de Mejoramiento de Maíz y Trigo *(International Maize and Wheat Improvement Center)*

CIP: Centro Internacional de la Papa *(International Potato Center)*

CIRAD: Centre de coopération internationale en recherche agronomique pour le développement *(French Agricultural Research Centre for International Development)*, France

CLAYUCA: Consorcio Latinoamericano y del Caribe de Apoyo a la Investigación y Desarrollo de la Yuca *(Latin American and Caribbean Consortium to Support Cassava Research and Development)*

CMD: cassava mosaic disease (a viral disease transmitted by whitefly)

CODEPO: Consejo de Población para el Desarrollo Sostenible *(Council for Population for Sustainable Development)*, Bolivia

COLCIENCIAS: Instituto Colombiano para el Desarrollo de la Ciencia y la Tecnología "Francisco José de Caldas" *(the Francisco Jose de Caldas Colombian Institute for the Development of Science and Technology)*, Colombia

CORPOICA: Corporación Colombiana de Investigación Agropecuaria *(Colombian Corporation of Agricultural Research)*

CP: Challenge Program (of the CGIAR)

CPWF: CGIAR Challenge Program on Water & Food

CRS: Catholic Relief Services, USA

CSO: civil society organization

CTA: Centre technique de coopération agricole et rurale *(Technical Centre for Agricultural and Rural Cooperation)* (of the European Union)

CTAA: Centro de Ciencia e Tecnologia Agroindústria de Alimentos *(Center for Agrifood Technology)* (now Embrapa Agroindústria de Alimentos or *EMBRAPA—Food Agroindustry*), Brazil

cv.: cultivar

DALYs: disability-adjusted life years (statistical health model)

DANIDA: Danish International Development Assistance (of the Royal Danish Ministry of Foreign Affairs), Denmark

DFID: Department for International Development, UK

DGIS: Directoraat-Generaal Internationale Samenwerking *(Directorate-General for International Cooperation)*, Netherlands

DNA: deoxyribonucleic acid

DREB: dehydration-responsive element binding gene

EC: European Commission

ECABREN: East and Central Africa Bean Research Network

EMBRAPA: Empresa Brasileira de Pesquisa Agropecuária *(Brazilian Agricultural Research Corporation)*

EPMR: External Program and Management Review (of the CGIAR)

ERI: Enabling Rural Innovation (of CIAT)

ETH: Eidgenössische Technische Hochschule-Zürich *(Swiss Federal Institute of Technology Zürich)*

EULACIAS: European-Latin American Co-Innovation of Agricultural Systems

F_2: second filial generation

FAO: Food and Agriculture Organization of the United Nations

FARA: Forum for Agricultural Research in Africa

FCRI: Field Crops Research Institute, Thailand

FIDAR: Fundación para la Investigación y Desarrollo Agrícola *(Foundation for Agricultural Research and Development)*, Colombia

FLAR: Fondo Latinoamericano para Arroz de Riego *(Latin American Fund for Irrigated Rice)*

FLIPA: Fondo Latinoamericano de Innovación en Palma de Aceite *(Latin American Fund for Oil Palm Innovation)*

FONTAGRO: Fondo Regional de Tecnología Agropecuaria *(Regional Fund for Agricultural Technology)* (a consortium coordinated by IDB)

GCP: Generation Challenge Programme (of the CGIAR)

GEF: Global Environment Facility

GFAR: Global Forum on Agricultural Research

GIS: geographic information system

GRU: Genetic Resources Unit (of CIAT)

HIV/AIDS: human immunodeficiency virus/acquired immunodeficiency syndrome

I&D+IT: investigación, desarrollo e innovación tecnológica *(technological research, development, and innovation)*

IAASTD: International Assessment of Agricultural Science and Technology for Development

IAR4D: integrated agricultural research for development

IAvH; *also* Humboldt Institute: Instituto de Investigación de Recursos Biológicos Alexander von Humboldt *(Alexander von Humboldt Institute of Research in Biological Resources)*, Colombia

ICA: Instituto Colombiano Agropecuario *(Colombian Institute of Agriculture and Livestock)*

ICARDA: International Center for Agricultural Research in the Dry Areas

ICRAF: International Centre for Research in Agroforestry (now World Agroforestry Centre)

ICRISAT: International Crops Research Institute for the Semi-Arid Tropics

ICT-KM: Information and Communications Technology and Knowledge Management Program (of the CGIAR)

IDB: Inter-American Development Bank

IDRC: International Development Research Centre

IFAD: International Fund for Agricultural Development

IFDC: International Fertilizer Development Center

IICA: Instituto Interamericano de Cooperación para la Agricultura *(Inter-American Institute for Cooperation on Agriculture)*

ILRI: International Livestock Research Institute

INIA: Instituto Nacional de Investigación y Extensión Agraria *(National Institute for Agricultural Extension and Research)*, Peru

INIA: Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria *(National Institute of Agrarian and Food Research and Technology)*, Spain

INIVIT: Instituto Nacional de Investigaciones en Viandas Tropicales *(National Institute for Research on Tropical Roots and Tubers)*, Cuba

iNRM: integrated natural resources management

INTA: Instituto Nicaragüense de Tecnología Agropecuaria *(Nicaraguan Institute of Agricultural Technology)*

INVEMAR: Instituto de Investigaciones Marinas y Costeras José Benito Vives De Andréis *(José Benito Vives De Andréis Marine and Coastal Research Institute)*, Colombia

IPG: international public good

IPGRI: International Plant Genetic Resources Institute (now Bioversity International)

IPICS: International Programme in the Chemical Sciences (of Uppsala University), Sweden

IPM: integrated pest management

IPMS: Improving Productivity and Market Success of Ethiopian Farmers (of ILRI)

IPRA; *also* IPRA Project: Investigación Participativa en Agricultura *(Participatory Research in Agriculture)* (of CIAT)

IRD: Institut de recherche pour le développement *(Institute of Research for Development)*, France

ISFM: integrated soil fertility management

IWMI: International Water Management Institute

JICA: Japan International Cooperation Agency

JIRCAS: Japan International Research Center for Agricultural Sciences

LAC: Latin America and the Caribbean

Lao PDR: Lao People's Democratic Republic

LKPLS: Lake Kivu pilot learning site (of CIAT-Africa)

LLC: limited liability company

Ma: millions of years ago

MADR: Ministerio de Agricultura y Desarrollo Rural *(Ministry of Agriculture and Rural Development)*, Colombia

MAFF: Ministry of Agriculture, Forestry and Fisheries, Japan

MAS: marker-assisted selection (a germplasm improvement technique)

MIS: Manejo Integrado de Suelos *(Integrated Soil Management)*, Central America

MOFA: Ministry of Food and Agriculture, Ghana

MSEC: Management of Soil Erosion Consortium (of the CGIAR)

MTP: medium-term plan

N: nitrogen

NARES: national agricultural research and extension system

NARS: national agricultural research system

NEPAD: New Partnership for Africa's Development

NGO: nongovernmental organization

NIRS: near-infrared spectroscopy

NORAD: Norwegian Agency for Development Cooperation

NR: natural resources

NRCRI: National Root Crops Research Institute, Nigeria

NRI: Natural Resources Institute, UK

NRM: natural resources management

NuMaSS: Nutrient Management Support System (of the global Soil Management Collaborative Research Support Program)

NZAID: New Zealand Agency for International Development

OEYA: Outstanding Employee of the Year Award (of CIAT)

OPSA: Outstanding Principal Staff Achievement Award (of CIAT)

ORPA: Outstanding Research Publication Award (of CIAT)

OSSCA: Outstanding Support Staff Contribution Award (of CIAT)

OTYA: Outstanding Team of the Year Award (of CIAT)

OYSYA: Outstanding Young Scientist-of-the-Year Award (of CIAT)

P: phosphorus

P&A: People and Agroecosystems (an RDC at CIAT)

PABRA: Pan-Africa Bean Research Alliance

PCI: participatory crop improvement

PCR: polymerase chain reaction

PES: payment for environmental services

pH: pouvoir hydrogène *(hydrogen power)*

PIPA: Participatory Impact Pathways Analysis

PLS: pilot learning site

PPB: participatory plant breeding

PPD: postharvest physiological deterioration (of cassava roots)

PRDU: Participatory Research for Development in the Uplands, Southeast Asia

PRGA: CGIAR Systemwide Program on Participatory Research and Gender Analysis

PROFRUTALES: Propagación de Frutales Ltda., Colombia

QPM: quality-protein maize

QSMAS: Quesungual slash-and-mulch agroforestry system

QTL: quantitative trait locus

R&D: research and development

R4D: research for development

RDC: Research for Development Challenge (of CIAT)

Red SICTA: Proyecto Red de Innovación Agrícola *(Network of Agricultural Innovation Project)*, Central America

SABRN: Southern Africa Bean Research Network

SADC: Southern African Development Community

SADU: Small-scale Agroenterprises Development in the Uplands of Lao PDR and Vietnam (of SDC)

SBA: Sharing the Benefits of Agrobiodiversity (an RDC at CIAT)

SDC: Swiss Agency for Development and Cooperation

SDS-PAGE: sodium dodecyl sulfate-polyacrylamide gel electrophoresis

SE: southeast

SEI: Stockholm Environment Institute, Sweden

SICTA: Sistema de Integración Centroamericana de Tecnología Agrícola *(Central American System for Integration on Agricultural Technology)*

SIDA: Swedish International Development Cooperation Agency

SLM: sustainable land management

SRTM: Shuttle Radar Topography Mission

SSA CP: Sub-Saharan Africa Challenge Program (of the CGIAR)

SSR: simple sequence repeat (molecular markers)

SSSEA: Soil Science Society of East Africa

T-shaped: referring to those people who have disciplinary depth in one field (leg of the "T") and are also able to reach out (arms of the "T") to other disciplines. Not to be confused with "jack of all trades"

TILLING: Targeting Induced Local Lesions in Genomes (a molecular approach to crop improvement)

TNC: The Nature Conservancy, USA

TSBF Institute: Tropical Soil Biology and Fertility Institute (of CIAT)

UNAMAZ: Associação de Universidades Amazônicas *(Association of Amazonian Universities)*, Brazil

UNEP: United Nations Environment Programme

USAID: United States Agency for International Development

USDA: United States Department of Agriculture

WWF: World Wide Fund for Nature

ZIL: *Swiss Centre for International Agriculture* (of ETH)

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