Executive Summary

Project IP-4. Improved Rice Germplasm for Latin America and the Caribbean

Project Description

Objectives: To increase rice genetic diversity and enhance gene pools for higher, more stable yields with lower unit production coats and which proportion lower prices to consumers and reduce environmental hazards.

Outputs:
1. Enhancing Gene Pools
2. Integrated Pest And Disease Management
3. Rice Cultivation as a Vehicle to Alleviate Poverty

Gains: Broader genetic base available and germplasm better characterized. New sources of resistance to diseases, viruses, and insects incorporated and made available. Higher yielding, advanced, rice lines. Variability and stability of progenitors and of advanced materials made available to increase breeding efforts. Rational pesticide use with fewer environmental hazards. Lower unit costs conductive to higher profits and lower rice prices to consumers.

Milestones:
2002 Molecular markers associated with blast resistance genes identified and used in marker-assisted selection. Sources of blast resistance distributed to national breeding programs. Improved rice populations with broader genetic base developed by recurrent selection and distributed to national programs in LAC. Rice cultivars released for savannas, lowland and highlands ecosystems. Participatory breeding strategies began to be implemented. Epidemiological studies for the control of RHBV and its vector, *T. orizicolus* completed. Potential use of transgenic plants with resistance to RHBV evaluated in the field. Rice germplasm with improved grain quality and milling developed together with FLAR. National scientists from LAC trained in new technologies used at CIAT.
2003 Improved rice cultivars using wild rice genes and recurrent selection populations. Introgression of new plant type (IRRI) into LAC's gene pools. Evaluation and selection of improved rice populations with broader genetic base by national programs in LAC. Characterization of rice blast pathogen populations in LAC. Identification of relevant blast resistance genes for LAC blast populations. Promotion of IPM strategies for controlling RHBV and *T. orizicolus.* RHBV-viral genes from transgenic plant introgressed into commercial rice cultivars. Rice germplasm with improved grain quality and milling developed together with FLAR. Selection of rice lines with tolerance to submergence for an improved weed control strategy. Functional genomics is being started in collaboration with GENOPLANTE.
2004 Genetic progress and gains in recurrent selection for different traits will be assessed in several LAC countries. Near-isogenic lines with QTLs associated with yield developed for use in LAC breeding programs. Genetic gains for yield derived from interspecific crosses will be evaluated after introgression of wild genes into cultivated LAC rice varieties. Implementation of breeding methods for durable blast resistance in LAC based on population dynamics of pathogen populations and partial resistance. Molecular and virulence characterization of other rice pathogens. Management of RHBV and its vector based on epidemiological studies. Commercial rice cultivars with transgenes for RHBV tested in LAC. Participatory rice selection and breeding will be producing new rice varieties for resource poor farmers.

Users: Breeders throughout Latin America and available elsewhere. Ultimate beneficiaries are poor urban consumers and rice farmers.

Collaborators: CIRAD, IRD, FLAR (Fund for Latin American and Caribbean Irrigated Rice), IRRI, WARDA. NARS (e.g., EMBRAPA, CORPOICA, IDIAF, INIAP, INIA, IIA), U.S. Universities (Cornell, Purdue, LSU, Arkansas, Texas A&M, California, Florida State, Yale), JIRCAS, GENOPLANTE.

CGIAR system linkages: Enhancement and Breeding (50%); Crop Systems (5)%; Protecting the Environment (15%); Saving Biodiversity (20%); Strengthening NARS (10%). Linked to IRRI global rice research and WARDA interspecific crosses.

CIAT project linkages: Germplasm conservation SB-1, genomics SB-2, participatory research SW-3 for upland in hillsides PE-3 and cropping systems SW-2 for the savannahs. Provide improved germplasm to PE-1 and PE-2.

Project IP-4 Log-Frame 2002.
Improved Rice Germplasm for Latin America and the Caribbean

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
Goal To add to the well being of the rice sector with emphasis on the resource poor rice farmers by increasing genetic diversity and the stability of high yielding varieties.	Increased rice production with farmers having more access to improved germplasm and information, and markets.	National production statistics	
Purpose To produce robust high yielding rice varieties requiring lower inputs, we will provide well-characterized progenitors and advanced materials with an ample genetic base as well as training to our partners.	Monitoring of yields of new varieties that were developed using our improved germplasm. Reductions in pesticide use and lower costs of production due to adoption of ICM practices leading to stable production and a cleaner environment.	Project, CIAT, FLAR and NARS annual reports. Publications. Impact assessment reports	Stability (internal and external) National policies favor adoption of new technology.
OUTPUT 1. Enhancing Gene Pools	Rice populations with improved tolerance to biotic and abiotic stresses with good grain quality and physiological traits. Number populations and lines selected as well as the distribution of these for line development. Number of double haploid produced and used.	Project, CIAT, FLAR and NARS annual reports. Publications. Improved varieties released by partners.	Continued donor support. Maintaining multidisciplinary team
OUTPUT 2. Integrated Pest and Disease Management	Understanding components of resistance and virulence of rice blast, rhizoctonia, hoja blanca, crinkling disease, and other selected pathogens. Molecular markers associated and number of resistance genes for rice pathogens and pests. Crop management components developed. Using novel genes resistance to rice pathogens including hoja blanca and rhizoctonia.	Project, CIAT, FLAR and NARS annual reports. Publications. Pest and disease resistant varieties released by partners.	Continued donor support. Maintaining multidisciplinary team
OUTPUT 3. Education and Rice Cultivation as a Vehicle to Alleviate Poverty	Number of communities participating New varieties and small equipment for rice Number of workshops and scientists trained. Published reports of courses. Development of web pages	Project, CIAT, FLAR and NARS annual reports. Publications. Impact assessment reports CIAT's Rice Web page	Continued donor support. Maintaining multidisciplinary team

Project IP-4: Improved Rice Germplasm for Latin America and the Caribbean

Summary of Annual Report 2002

Inputs

Principal Staff	**Allocation of time**	**Affiliations**	**Work Location**
Dr. Lee Calvert	60%	CIAT	CIAT HQ
Dr. Marc Chatel	100%	CIRAD/CIAT	CIAT HQ
Dr. Fernando Correa	100%	CIAT	CIAT HQ
Dr. Zaida Lentini	20%	CIAT	CIAT HQ
Dr. Mathias Lorieux	50%	IRD/CIAT	CIAT HQ
Dr. César Martínez	51%	CIAT	CIAT HQ
Dr. Rafael Meneses	50%	IIA Cuba/CIAT	CIAT/Cuba
Dr. Gilles Trouche	50%	CIRAD/CIAT	Managua, Nicaragua
Dr. Michel Valès	100%	CIRAD/CIAT	CIAT HQ
Total	5.81 Principal Staff positions		
Dr. Carlos Bruzzone works as a consultant	50%	CIAT	Chiclayo, Peru

There are 14 associates or assistants, 3 visiting scientists and 28 technical and support staff.

Principal Cooperators by Organization
U. of Tucumán & U. La Plata Argentina, CIAT Santa Cruz Bolivia, EMBRAPA Brazil, INIA Chile, FEDEARROZ & CORPOICA Colombia, IIA Cuba, IDIAF Dominican Republic, CIRAD & IRD France, DICTA Honduras, JIRCAS, Japan, INTA Nicaragua, INIA Peru, INIA Uruguay, Cornell, UC at Davis, KSU & LSU, Texas A&M USA, INIA & DANAC Venezuela, IRRI, and WARDA, and FLAR.

Highlights

Rice, a crop with impact
In output 1A, there is the section "Impact in Latin America of CIRAD's Rice Genetic Resources". This documents the successful use of these genetic resources as the parents of varieties. Over 90% of the approximately 40 upland varieties released in the last 20 years have at least one CIRAD parent. Germplasm that has been developed by CIAT has also been crucial as parents, and often the crosses for these varieties were made at CIAT. For the last decade, CIRAD and CIAT have had a strategic alliance that has worked synergistically by bring the critical human capital, resources and infrastructure together to help serve the Latin American and Caribbean rice sectors. The effectiveness of this alliance depends on our national partners. An excellent example, where CIAT, CIRAD, CORPOICA, and FEDEARROZ worked together, is documented in the impact study "Un negocio de amplios horizontes para el Llano". It is

estimated that the economic impact of CIAT rice projects contribution is $450 million between 1994-2001. The strategic alliance of CIRAD/CIAT with many local partners will continue to have lasting impact in the Llanos of Colombia and throughout Latin America.

The first rice variety that was developed using recurrent selection in Latin America

Using recurrent selection for rice breeding has been somewhat controversial. Nevertheless, the alliance of CIAT and CIRAD continues to promote this method. The EMBRAPA and CIRAD collaborative project in Brazil is now bearing fruit. In the State of St. Catarina Brazil, a new variety named Tio Taka was released in 2002, and it was produced using recurrent selection. There are currently populations that have been developed using recurrent selection in eleven countries, and there are many advanced lines that could soon be selected as new varieties. We expect that Tio Taka will be the first of many varieties that have their origins in recurrent selection populations, and this shows the importance of maintaining a consistent effort over a sufficient period of time.

Using wild rice species to improve cultivated rice in Latin America

The genera Oryza possess very high genetic diversity and 21 wild rice and two cultivated species are known. After 6,000 years of continuous selection by man and intensive breeding efforts during the last 100 years, the genetic base of the crop is narrower than ever. Modern rice varieties that ushered in the green revolution brought about dramatic increases in rice production worldwide, but a narrower genetic base. There are many reports of rice production in farmers' fields reaching a yield plateau, and the narrow base is contributing to instability of rice yields caused by biotic and abiotic factors. The Oryza wild species represent a potential source of new alleles for improving the yield, quality and stress resistance of cultivated rice. Results presented in this report and generated in collaboration with key partners provide further evidence that certain regions in *O. rufipogon* and *O. glaberrima* harbor alleles of interest for the genetic improvement of cultivated rice. In the interspecific cross of Bg90/*O. rufipogon*, selected progeny yield better than either parent suggest the greater yields can be achieve through the introgression of alleles from wild species. Even more surprising is despite the poor grain quality of both parents Bg90-2 and *O. rufipogon*, through positive transgressive segregation, we were able to select advanced lines with long and slender, translucent grains. The results for disease resistance are also impressive. Using high disease pressure, advanced breeding lines with resistance to several fungal diseases particularly to *Rhizoctonia solani* were derived from the interspecific crosses of Oryzica3/*O. rufipogon*. High level of resistance to the rice stripe necrosis virus was found in *O. glaberrima*, and this resistance has been transferred through interspecific crosses to Bg90-2 and Caiapo. Advanced interspecific lines that have been tested in farmer's fields confirm that *O. rufipogon* and *O. glaberrima* possess alleles with positive effects on yield, stress resistance and grain quality. Molecular markers are being used to map QTLs associated with these traits and near isogenic lines are being developed for use in breeding programs. We are using the wild species to increase genetic diversity while developing varieties with high and stable yields.

The long road to developing durable rice blast resistance

There are voices of pessimism that lament the lack of progress on developing rice with durable resistance to rice blast. There is no doubt that the fungus has a chimerical ability to breakdown resistance and to remain the most important disease of rice. There are molecular studies that are identifying the resistant genes, and others that are bringing order to the many races of the fungi. These studies will be the basis to develop a durable resistance in a systematic manner that targets specific combinations of genes. Even as this research is progressing, there is a tendency to produce varieties that remain resistant to rice blast for longer periods of time. For example, the variety Fedearroz 50 is widely grown in Colombia and has remained highly resistant to rice blast for over three years. The genetic resistance profile of Fedearroz 50 is similar to that of Oryzica Llanos 5, which has remained resistant to rice blast for over 12 years. This contrasts with many varieties that start to have problems one to two years after their release. Much work remains before we can declare that we have the knowledge and methods to consistently develop rice with durable resistance, but there is evidence that step-by-step, we are making progress.

The new rice hoja blanca resistant varieties are better than their parents

Developing rice varieties with resistance to rice hoja blanca virus (RHBV) has been a research objective even before the CIAT came into existence. For many years, it seems like there was only marginal progress and most commercial varieties are not resistant to hoja blanca disease. Also there was only one source of resistance was widely used in breeding programs. In the mid-1990s when it appeared as if a new epidemic was imminent, CIAT with the collaboration of Fedearroz in Colombia and Danac in Venezuela, starting working intensively on developing resistant varieties. In addition to the mass screen method that has been in place since the mid 1980's, we introduced an evaluation scheme using different levels of disease pressure. Since the capacity is more limited, only selected advanced lines can be evaluated by intensive screening. Nevertheless, this has led to the liberation of five varieties with resistance to hoja blanca disease in Venezuela and Colombia. Two varieties, Fedearroz 2000 and Fedearroz Victoria 1 have resistance to hoja blanca disease that is superior to any of their parents including the principal source of resistance Colombia 1. Fedearroz 2000 is the most resistant variety and is now considered the standard for high resistant to hoja blanca disease. The release of these varieties confirms the success of the two-step breeding strategy, and these new commercial varieties are recommended as parental sources for hoja blanca resistance.

Are the small rice farmers doomed to subsistence living?

In Latin America, rice is considered by many to be a crop for the large farmer. It takes lots of infrastructure such as irrigation and leveled fields, while the price is relatively low, therefore the small rice farmer cannot make a decent living. The highly mechanized farms are only one part of the rice sector in Latin America. Most rice farmers are small and grow rice in favored upland conditions, and they do need help if they are going to get out of the poverty trap. The CIAT/CIRAD alliance shares a vision to help these farmers by producing varieties that produce higher yields in upland conditions. This year, we expanded our activities in Central America. For several years, we have been working in Colombia and these efforts are beginning to have impact with the development of the first varieties of the new type Rice for Hillsides with Cold tolerance "RHICO". Also the rice sector on the Pacific coast is being reactivated with the introduction of seeds from commercial varieties and an effort to develop varieties that are specifically adapted to the local conditions. To be successful, the local farmers need high yields and a way to market their surplus rice. We also need to develop a strategy that generates additional employment both for small farm equipment as well as the processing and marketing of rice. Further, rice should be a stable component in the cropping system that allows these small farmers the ability to take risks with higher value crops. Rice can be a motor that drives these small farmers into a more prosperous life. We need the vision to help them make it a reality.

Plans for next year

- The breeder's workshop for irrigated rice will be held in the Dominican Republic and for upland rice in Colombia.
- The launching of International observational nurseries (CIAT-ION) for irrigated and upland rice.
- Developing an alliance with the Rural Innovation Institute of CIAT to develop participatory projects on the chain of rice production in agricultural systems.
- The use of anther culture, transgenics, and molecular markers as advanced breeding tools for rice
- Continuing to find and incorporate better resistance for major pests and diseases into CIAT populations and advanced lines.
- Incorporating additional traits from wild relatives of rice.
- Developing more drought resistant upland rice with partners in CIRAD, IRD, EMBRAPA and WARDA.

Project Performance Indicators

1. Technologies, Methods and Tools

1.1 Released Varieties

The crosses for most of these varieties were made at CIAT. Details on the date and parents of the crosses are available upon request.

Bolivia	Tacuú by CIAT-SC	2002
Brazil	BRS Talento by EMBRAPA	2002
	BRS Jaqiaru by EMBRAPA	2002
	Tio Taka by EPAGRI	2002
Dominican Republic	INIAP-1 by INIAP	2002
Nicaragua	INTA 2000 by INTA	2002
Venezuela	D-Sativa by DANAC	2002

1.2 Genetic Materials Distributed

- Breeding nurseries made up of advanced lines derived from interspecific crosses were sent to partners in Colombia, Argentina, Uruguay, Venezuela, Suriname, Nicaragua, and Peru
- 400 progenitors of CIRAD-Centre Francais du riz (CFR) were provided to FEDEARROZ (Colombia), CIAT-Bolivia, and DANAC (Venezuela)
- 323 CIAT progenies from CIAT/Peru program and from interspecific crosses *Oryza sativa* x *O. glaberrima*, *O. sativa x O. barthii* and *O. sativa* x *O. rufipogon* for lowland irrigated conditions or favorable aerobic conditions (from Cesar Martinez program)
- 24 CIAT-CIRAD progenies derived from PCT-4 population for aerobic upland conditions (from Marc Châtel program)
- 5 CIAT-CIRAD varieties for upland conditions: CIRAD 409, 446, 447, ORYZICA Sabana 6, ORYZICA Sabana 10
- 6 CIAT varieties for irrigated conditions: Fedearroz 50, Fedearroz 2000, Bg90-2, Oryzica 1, Selecta 320 and Oryzica 3

Participatory Breeding

- PCT-18: narrow genetic base population adapted for upland conditions for rice blast resistance and grain quality (from Michel Vales program)
- PCT-17: narrow genetic base population adapted for high altitude hillsides upland conditions for rice blast resistance, cold tolerance and grain quality (from Michel Vales program)

1.3 Elite Materials Developed

- Advanced lines with tolerance to Rhizoctonia solani and the rice stripe necrosis virus have been developed.
- The first upland varieties for hillsides with tolerance to drought and to cold, and with high level of partial resistance to rice blast disease are nominated as a results of a participatory evaluation: CIRAD 446 and CIRAD 447. They are the first

varieties of RHICO type (Rice for Hillsides with Cold tolerance) in Latin America.
- The upland savanna line CT10069-27-3-1-4 (CIRAD/CIAT 445) is adapted to inter-cropping with young coffee plantations in Colombia, and the CIAT upland line CT13226-11-1-M-BR1 will be released in 2003 in Brazil.
- An elite upland line (PCT-4\SA\1\1>975-M-2-M-3) developed in Colombia from recurrent selection breeding

Participatory Varietal Selection
- 14 advanced lines and varieties from INTA Rice Program for upland and lowland conditions
- 9 CIRAD varieties from collaborative program in Ivory Coast, Brazil and Madagascar for less favorable upland conditions
- 14 CIAT-CIRAD advanced lines for high altitude hillsides

1.4 Genetic Mechanisms Understood
There is a strong correlation between RHBV titer in the propagative vector *T. orizicolus* and its ability to transmit the virus.

1.5 Sources Identified
Oryza rufipogon (IRGC105491) has been showed to have a good level of tolerance to *Rhizoctonia solani* under greenhouse and field conditions.

2. Publications

2.1 Referred Journals

Published
Two articles were published and one article has been accepted for publication.

Submitted
One article has been submitted for publication.

2.2 Books

Book Chapters
Three book chapters were published.

Published Proceedings
Four articles were published in Proceedings.

Scientific Meetings or Publications
Ten abstracts were published and presented at scientific meetings.

3. Strengthening NARs and NGOs

3.1 Individual Training

The rice project worked with 9 scientists for intensive specialized training.

3.2 PhDs, MS & BS

The rice project is involved in the thesis with 7 Bachelor of Sciences, 10 Masters of Science and 1 PhD students.

3.3 Workshop and Meetings

The rice project sponsored or participated in 10 workshops that had over 300 participants.

3.4 Technical Assistance

CIAT provided technical assistant to FLAR in the areas of rice blast screening in the southern cone.

Technical assistance was given to many programs on breeding activities.

3.5 Advanced Research Organizations Research Partnerships

The CIAT rice project maintains research partnerships with CIRAD and IRD in France, JIRCAS in Japan, and with Cornell, UC at Davis, Kansas State, Louisiana State, and Texas A&M in the USA. We also collaborate with WARDA and IRRI.

4. Impact Monitored

An impact study for the Convenio Colombia-CIAT was made. It is titled "Un negocio de amplios horizontes para el Llano". It estimated that the new rice varieties that were developed in collaboration with the rice project have had an impact of $450 million in just the Llanos of Colombia during 1994-2001.

The section 1A of the Annual Report IP-4 2002, documents use of CIRAD germplasm in upland rice. Of the 40 varieties released in the past 20 years, more than 90% had CIRAD parents in their background.

Improved Rice Germplasm for Latin America and the Caribbean

Recognitions received during 2002

Brazil

Brazil's Rice Production Chain made a public recognition of the contributions made by CIAT's Rice Project toward the development of irrigated and upland rice cultivars in that country over the past 20 years. The award was presented during the inauguration ceremony of the First Brazilian Rice Production Chain Congress, held between 20 and 23 August 2002, at the Convention Hall in Florianópolis (Santa Catarina, Brazil).

Dominican Republic

On 7 July 2002, the National Cereal Grains Program of the Dominican Agricultural and Forest Research Institute, IDIAF, presented a plaque of recognition to César Martínez, CIAT Rice Project Breeder, within the framework of the release of a new rice variety, IDIAF 1, and the celebration of the 40th anniversary of the Juma Experiment Station, events that were attended by the President of Dominican Republic, Hipólito Mejía.

César Moquete, Head of the National Cereal Grains Program, stated that this recognition was given for the valuable contributions made by Martínez to the genetic improvement of rice in Latin America, enabling the expansion of the genetic base of this grain, and his contribution to the training of many of the region's rice researchers.

Bolivia

Within the framework of the 4th National Rice Day, held in Santa Cruz, Bolivia, rice breeder Marc Chatel from CIRAD/CIAT received a plaque from Bolivia's Tropical Agricultural Research Center in recognition of "his support and collaboration in training, germplasm supply, breeding methodologies, and unconditional friendship to CIAT-Bolivia and the Santa Cruz rice sector", signed by the San Juan Japanese Colony on 9 March 2002.