Annual Report Project SB-2

2005

Summary

Conservation and Use of Tropical Genetic Resources

April, 2006

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PROJECT SB 2 CONSERVATION AND USE OF TROPICAL GENETIC RESOURCES

ANNUAL REPORT 2005

SUMMARY

PROJECT SB 2 CONSERVATION AND USE OF TROPICAL GENETIC RESOURCES

A Project Overview

Project Description

Goal To contribute to the sustainable increase of productivity and nutrition of mandated and other priority crops and the conservation of agrobiodiversity

Objective Integrate genomics and cellular technologies with breeding and the conservation of genetic resources to 1) Conserve characterize and enhance the genetic diversity base needed for future development 2) improve the nutritional quality of crops achieve and sustain a continuous yield increase to meet the food needs of a rapidly growing population and 3) improve the livelihood of the rural poor who have not benefited so far from the technological advances

Important Assumptions Pro active participation of CIAT NARS and NGOs agricultural scientists biologists and development personnel

Target Ecoregion Worldwide service but special focus in developing countries of Latin America and Sub Saharan Africa

Beneficiaries and End Users Small farmers of Latin America Sub Saharan Africa and Southeast Asia will use dozens of germplasm accessions conserved by the gene bank as such or after improvement through biotechnology tools Sources of disease and pest resistance will be identified for current and future efforts in germplasm enhancement and plant breeding National programs will have their national collections restored

Collaborators

Africa NARS
DRC Mvuazi Research Center (INERA) **Ghana** Crop Research Institute (CRI) Kumasi **Kenya** University of Nairobi **Malawi** Chitedze Research Station Malawi **Nigeria** National Root Crops Research Institute (NRCRI) Institute for Agricultural Research and Training (IAR&T) Ibadan **Rwanda** ISAR **Tanzania** Agricultural Research Institute (ARI) **Uganda** Namunlonge Agricultural and Animal Research Institute Kampala Medical Biotech Laboratories Kampala

Latin American NARS and Universities

Bolivia CFP Centro Fitogenetico Pairumani **Brazil** Embrapa Cenargen Embrapa CTA Embrapa CNPAF Embrapa CNPMF University of Campinas **Colombia** Cenicana Cenicafe Universidad Javeriana CIB COLCIENCIAS Colombian Ministry Agriculture and Rural Development Corpoica Corporacion Biotech Colombian National Biosafety Council FEDARROZ ICA Instituto Humboldt UniAndes UniValle Universidad Nacional at Palmira and Bogota Universidad del Tolima **Chile** INIA REDBIO **Costa Rica** University of Costa Rica **Cuba** INIVIT **Dominican Republic** IDIAF National Bean Programs of the (INIAF) **Ecuador** INIAP Universidad Catolica **Honduras** Zamorano **Mexico** Universidad Autonoma de Mexico INIFAP **Nicaragua** Ministerio de Agricultura **Peru** INIA **Venezuela** Centro Tecnologico Polar Simon Bolivar University

Colombia NGOs

CEGA FIDAR PBA REDBIO Colombia Latin America Small Farmers from Pescador and Tierradentro Cauca Cauca farmers association Parque del Software Cali

Colombia private sector

Corn product Barranquilla Agrobios Bogota LIMSYS Cali DATABIO Cali Syngenta Cali

Asia NARS

China Academy of Agricultural Sciences (CAAS) SCIB **India** Central Tuber Crops Research Institute (CTCRI) Thiruvananthapuram Kerala **Thailand** Rayong Field Research Center

Biodiversity Institutes

Colombia Instituto Humboldt **Costa Rica** Inbio **Mexico** Conabio **US** Smithsonian Museum of Natural History

Advanced Research Institutes

Australia Center for Applied Molecular Biology in International Agriculture (CAMBIA) ***Europe*** **Belgium** University of Ghent **Denmark** University of Aarhus **France** CIRAD Genoplants IRD INRA Universite de Perpignan **Germany** University of Freiburg University of Hanover University of Hohenheim Federal Biological Research Centre for Agriculture and Forestry (BBA) **Netherlands** PRI Wageningen **Sweden** USLU Uppsala **Switzerland** Universite de Geneve ETH **UK** University of Bath **Japan** JIRCA Tsukuba **United States** Clemson University Cornell University Danforth Center Kansas Sate University Louisiana State University Michigan State University National Center for Genome Research (NCGR) Ohio State University Penn State University Rutgers University Smithsonian Molecular Systematic Lab University of Nebraska University of Puerto Rico University of Chicago USDA Plant Soils and Nutrition Lab at Cornell University USDA at Children Hospital Baylor University USDA Soybean Genomics at Beltsville Yale University

Regional networks
ASARECA SACCAR AfNet ECABREN and SABRN (Africa) SIGTTA (Central America) REDBIO (Latin America) CATIE and EAP Zamorano (Central America) Cassava Biotechnology Network (CBN LAC) FLAR CLAYUCA

CGIAR and International organizations
CIP CIMMYT FAO IAEA ICARDA ICRISAT IFPRI IITA IPGRI IRRI TSBF WARDA

CGIAR Challenge Programs
HarvestPlus Generation Challenge Program

CGIAR system linkages Saving Biodiversity (40%) Enhancement & Breeding (40%) Training (15%) Information (5%)

CIAT project linkages *Inputs to SB 2* Germplasm accessions from the gene bank project Segregating populations from crop productivity projects Characterized insect and pathogen strains and populations from crop protection projects GIS services from the Land Use Project *Outputs from SB 2* Management of Designated Collections (gene banks) genetic and molecular techniques for the gene bank crop productivity and soils (microbial) projects Identified genes and gene combinations for crop productivity and protection projects Propagation and conservation methods and techniques for gene banks and crop productivity projects Interspecific hybrids and transgenic stocks for crop productivity and IPM projects

Explanation of any Project changes (with respect to previous MTPs) The project takes into account the recent changes introduced by the International Treaty on Plant Genetic Resources for Food and Agriculture New collection efforts may now be possible for cassava and beans with agreement with the countries Tropical forages do not however enjoy facilitated access status so distribution and conservation of forage genetic resources requires bilateral negotiations on a country by country basis

B Project Funding

Budgeting 2004 2008

Year	2004	2005	2006	2007	2008
US Dollars (millions)	6 081	6 909	6 854	6 891	6 729

ACTUAL EXPENDITURES 2005

Project SB 2 Conservation and Use of Tropical Genetic Resources

Source	Amount US$	Proportion (%)
Unrestricted Core	335 933	4%
Restricted Core Colombia	29 719	0%
European Commission	963 606	12%
Sub total	1 329 258	17%
Special Projects	6 024 038	76%
Generation Challenge Program	603 704	8%
Total Project	**7 957 000***	**100%**

* Include Funds to National Programs in Partners

ACTUAL EXPENDITURES 2005

Harvest Plus Challenge Program

SOURCE	AMOUNT US$	PROPORTION (%)
Unrestricted Core	0	0%
Restricted Core	0	0%
	0	0%
Sub total	**0**	**0 /**
Restricted Projects 1	2 047 731	100%
Total Project	**2 047 731**	**100%**

1 Includes only funds implemented by CIAT

C CIAT SB2 Project Log Frame (2006 2008)

CIAT Project SB 2 Conservation and Use of Tropical Genetic Resources (2006 2008)

	Outputs	Intended User	Outcome	Impact
OUTPUT 1	Genomes of wild and cultivated species of mandated and non mandated crops and of associated organisms are characterized	Breeders agronomists and other crop scientists working on/ using these crops and associated organisms	Production or breeding methods are more efficient as compared to previous years Varieties with improved or novel traits are produced and adopted	Farmers livelihoods are improved by increased crop productivity by producing new crops for niche markets or by using varieties that require less pesticides or costly inputs
Output Targets 2006	Genome wide PCR base d markers (SNPs CAPs) developed for beans and cassava Scaling up of marker assisted established for rice bean and cassava Marker assisted selection for multiple traits implemented in beans rice and cassava Target genes for drought identified and tested in beans Useful genes and genes combination identified and mapped for high iron and zinc bean lines Introgression lines from rice interspecific crosses developed Places of bean domestication and races/ genepools identified	ARIs and NARS in Latin America and Africa with capacity for market work	Better understanding of genetic structure of diversity of specific crop gene pools Identification of molecular markers for marker assisted selection	

	Outputs	Intended User	Outcome	Impact
	Lab Information Management System (LIMS) implemented for MAS and molecular biology activities			
Output Targets 2007	Allele mining in *ex situ/ in situ* collections of wild relatives of beans and cassava for genes of traits of economic importance	Breeders and crop geneticists and conservationists dealing with these crops and their wild relatives	Breeders and crop geneticists and conservationists dealing with these crops and their wild relatives are better informed about allelic richness and its possible economic significance	
Output Targets 2008	Bioinformatics tools developed for data mining in relation to gene functions for traits of economic importance	Breeders and crop geneticists	Breeders and geneticists can use sequence data generated on traits of economic importance in beans cassava rice and *Brachiaria*	
OUTPUT 2	Genomes modified genes and gene combinations used to broaden the genetic base of crops (bean rice and cassava) and forage species (*Brachiaria*)	Breeders and crop geneticists worldwide working on these crops and relatives	Breeders and crop geneticists have access to improved lines and genetic stocks and benefit from increased knowledge about gene function/ regulation	Better varieties requiring less expensive inputs are made available to NARS and farmers resulting in gains of productivity environmental sustainability and in social benefits
Output Targets 2006	Efficiencies for genetic transformation for beans and cassava improved Genes constructs for traits related to plant disease –	Rice geneticists and breeders around the world but particularly in ARIs	Rice geneticists and breeders have a better understanding of regulation of genes responsible for yield and plant architecture	

	Outputs	Intended User	Outcome	Impact
	insect resistance plant stress and nutritional traits obtained for transformation in beans rice and cassava T DNA rice 10 000 mutant collections characterized under field conditions			
Output Targets 2007	Transgenic events tested under green house biosafety conditions Gene flows in rice and beans documented in farmers fields in parts of Latin America	ARI and molecular biologists breeders Biosafety authorities of Latin America	Biosafety authorities have technical information about risk of gene flow (intensity location persistence) for better decision making	
Output Targets 2008	Transgenic lines of mandated crops generated with different constructs against biotic (e g Bt) and abiotic (e g DREB) stresses	Cassava and rice breeders at CIAT and in partner countries	Cassava and forage breeders at CIAT and in partner countries have access to materials with novel genetic diversity to start new breeding activities	
OUTPUT 3	Increased efficiency of NARS breeding programmes by using biotech tools	Breeding programs biodiversity institutions concerned by biosafety issues extensionists rural health centers	Breeding programs biodiversity institutions concerned by biosafety issues extensionists rural health centers make a wider use of biotech tools developed/ improved by CIAT	Improved varieties raise agricultural productivity and reduce environmental impacts sooner than otherwise would have occurred

	Outputs	Intended User	Outcome	Impact
Output Targets 2006	Low cost rapid propagation systems implemented at small scale and commercial levels of cassava and other high value crops Improved capacity of Colombian NARS to deal with biosafety	Breeding programs in Latin America and East Africa and biodiversity institutions concerned by biosafety issues	Colombian institutions concerned by biosafety issues consider data and technical information generated by CIAT and partners	
Output Targets 2007	Training on MAS has been provided to several country partners in Latin America and Africa	Breeders and breeding programs in developing countries	Breeders and breeding programs in developing countries adopt MAS techniques used/ improved by CIAT	
Output Targets 2008	Information package delivered to NARS in Latin America and Africa about biofortified crops	Breeders extensionists rural health centers	Breeders extensionists and rural health centers take into account the biofortified crops produced by the Biofortification CP	
OUTPUT 4	Bean cassava and forage germplasm collections multiplied and thus available restored and safely duplicated Germplasm conservation methods improved	CIAT commodity project and external users around the world namely in Africa can have access to characterized and viable samples at any time	Partners and any other public or private institutions use CIAT designated germplasm in own research and development	Increased and more stable agricultural productivity with less negative environmental impacts
Output Targets 2006	25 / of CIAT designated germplasm has been regenerated recently 30 / of germplasm requests are handled through a user friendly	CIAT projects in Latin America and East Africa and external users have access to a wider set of diversity foi further studies	Partners namely in Africa increase the material scope of their research conservation and development work	

	Outputs	Intended User	Outcome	Impact
	interface at CIAT website *Slow growth in vitro* protocol developed for palms and fruits of economic importance			
Output Targets 2007	25 / of designated germplasm is documented at CIAT website 5 / of designated germplasm included in the DNA bank	CIAT projects and external users have direct immediate access to germplasm information for use and research	Wider use of designated germplasm because of its web based documentation	
Output Targets 2008	Bean and forage collections *safely duplicated at* CIMMYT and cassava at CIP	(security backups are not intended for use)	Other national genebanks are also making security backups of their collections	
OUTPUT 5	NARS strengthened in the conservation and utilization of sets of agrobiodiversity	National genebanks botanic gardens biodiversity institutes university departments working in conservation/ utilization of agrobiodiversity	NARS and national genebanks adopted new conservation methods and make greater use of genetic resources for crop improvement	Increased agricultural productivity and reduced environmental impacts
Output Targets 2006	Genebank handbook produced in *English and* Spanish	National genebanks botanic gardens biodiversity institutes university departments running some *ex situ* conservation facility	NARS and national genebanks across Latin America and Africa use the handbook	
Output Targets 2007	Public awareness products for institutions working in *ex situ* conservation	National genebanks botanic gardens	National genebanks botanic gardens have material to explain their work	

	Outputs	Intended User	Outcome	Impact
Output Targets 2008	Distance education presential courses run	NARS dealing with aspects of conservation/ utilization of germplasm collections	Personnel trained and/ or updated in conservation methods (e g DNA bank)	
OUTPUT 6	Strengthening Stressed Seed Systems during Emergency and Recovery	NGOs and UN Agencies involved in crisis response	Personal involved in making assessments related to seed security assessment and interventions have clear set of tools to improve practice	Strengthening (rather than undermining) of seed systems—during crisis periods and hence enhanced contribution to food security
Output Target 2006	Development of Seed System Security Assessment (SSSA) Tools	NGOs and UN Agencies involved in crisis response	Targeting of emergency agricultural aid to meet real user needs	
Output Target 2007	Clarification of the effects on Longer term Seed Aid Assistance—so as to guide chronic stress response (model country Ethiopia)	NARS and UN Agencies involved in both emergency and developmental response	Identification of better seed systems development options for most vulnerable populations (i e those receiving aid on repeated basis)	
Output Target 2008	Application of more effective response options in both acute and chronic stress seed system scenarios	NARS NGOs and UN Agencies involved in Agricultural Reconstruction and Development	Matching of seed system support to problem identification in variety of stressed seed system contexts	

D Current SB 2 Investigators Discipline position and time fraction

Name	Discipline	Time dedication%
Beebe Steve	***Bean Breeding***	30
Bellotti Anthony	Cassava Entomology	20
Blair Mathew	Bean Genetics and breeding	70
Ceballos Hernan	Cassava Breeding	40
Chavarriaga Paul	Transgenesis Cassava	100
Debouck Daniel	Head Genetic Resources Botany	20
Fregene Martin	Cassava Genetics and breeding	60
Ishitani Manabu	Molecular Biologist	100
Lentini Zaida	Transformation of rice and tropical fruits Biology/Genetics	80
Lorieux Mathias	Rice Genetics and Biotechnology	50
Martinez Cesar	Breeding	49
Mejia Alvaro	Cell Biology	100
Alonso Gonzalez	Tropical fruits	100
Sperling Louise	Seed Systems	20
Tohme Joe	Genomics Project manager	100

E Highligts of outputs

Staff Changes

To reinforce CIAT activities in biofortification the project hired **Dr Helena Pachon** as a nutritionist working as part of AgroSalud the CIDA funded project on biofortification in Latin America Dr Pachon has a PhD in nutrition from Cornell University with a wide experience in public health intervention in Central America and Peru Dr Pachon will bring a unique public health and nutrition perspective to CIAT activities Dr Pachon will join CIAT in April 2006 Dr Pachonis a US citizen

Dr Alex Garcia was hired in Nov 2005 as a post doc in bioinformatics for one year to assist the team in this strategic area Dr Garica is a Colombia citezen

Team member received the following awards

Aranzalez E Thesis awarded as meritorious by the Universidad Francisco de Paula Santander Cucuta Colombia for the degree of Engineer of Biotechnological Production

Arcia Moreno Kiliany Andrea B Sc Tesis Evaluacion del flujo de genes desde una linea transgenica de arroz (*Oryza sativa* l) resistente al virus de la hoja blanca hacia seis biotipos de arroz rojo (*Oryza sativa f spontanea*) Universidad del Tolima Programa de Biologia Ibague 2005 **Tesis Meritoria**

Beltran Jesus Alonso 2005 BSc Evaluacion Molecular de Plantas Transgenicas de Yuca *Manihot esculenta* (Crantz) Mediante Reaccion en Cadena de la Polimerasa (PCR) en Tiempo Real Universidad del Tolima Colombia **Tesis Laureada**

Florez Varon Juan Carlos B Sc Tesis Evaluacion del flujo de genes desde la variedad purpura de arroz (*Oryza sativa* L) hacia seis biotipos de arroz rojo (*Oryza sativa f spontanea*) Universidad del Tolima programa de biologia Ibague 2005 **Tesis Meritoria**

González R I and the SB 01/02 Project Gene flow for assessing the safety of bioengineered crops Outstanding Team Year Award for 2004 at CIAT

González Torres R I O Toro M Carvajal & D G Debouck 2005 Presencia de complejos Silvestre Malez Cultivo de *Phaseolus vulgaris* L en Costa Rica y Bolivia utilizando marcadores de ADN nuclear y cloroplastico V SIRGEALC Simposio de Recursos Geneticos para America Latina y el Caribe November 23 25 Montevideo Uruguay Best Poster Award

Pineda Rosana M Sc Thesis Flujo de genes desde arroz transgenico al arroz maleza Universidad Nacional Sede Medellin Abril 2005 **Tesis Meritoria**

Tofino A P & C Ocampo Award at the Professional level for the research work Introgresion del acervo mesoamericano en el germoplasma de la habichuela *Phaseolus vulgaris* L cultivada en los centros secundarios de domesticacion IX Congreso de la Asociacion Colombiana de Fitomejoramiento y Produccion de Cultivos Palmira Colombia 11 May 2005

F Overall view of the SB 2 project

The project has continued its effort in fund raising and has lead successfully several projects in the areas of abiotic stress and biofortification Overall the project has pursued all three outputs outlined in the MTP

Output 1 Genomes of wild and cultivated species of mandated and non mandated crops \associated organisms characterized

Output 2 Genes and genes combination made available for broadening the base of mandated and non mandated crops

Output 3 Collaboration with public and private partners enhanced

Only the following achievement for 2005 are summarized

Race structure in common beans determined with microsatellite markers

The microsatellite markers we have developed at CIAT have given us the opportunity to dissect genetic diversity in common bean on a larger scale and to a finer degree than has ever been possible before The most polymorphic and reliable SSR loci have been identified based on a micro core of 44 CIAT parents and evaluation of 150 microsatellite markers A manuscript was prepared on the discrimination power and allelic diversity values for all these microsatellite markers and ws accepted in Theoretical and Applied Genetics The research was the basis for marker selection in additional diversity studies carried out or finished during the year Two notable studies that were part of MSc degrees at the Univ Nacional extended the evaluation of the loci by testing the reliability of 30 to 50 microsatellite markers in detecting race structure in common beans In these studies a total of 120 genotypes were selected to represent the three races present in each of the gene pools of common bean (Andean and Mesoamerican) and race structure analysis showed that commercial seed class was a good predictor of race structure and was better than morphological differences at distinguishing races As a result the principal divisions in common bean can be described as Durango Jalisco Mesoamerica Nueva Granada and Peru Races Chile and Guatemala appear to be admixtures of new alleles perhaps from wild bean introgression Another interesting result was the finding that for microsatellite markers allelic diversity is higher in the Andean gene pool than in the Mesoamerican gene pool a reversal from previous studies with other types of markers which will allow the use of microsatellites to a greater degree to investigate trait inheritance in the Andean gene pool In parallel with the work on race structure we are analyzing data for the microsatellite evaluations of the Andean and Mesoamerican core collections (350 genotypes each) and the national or CIAT collections for Bolivia Brazil China Colombia and Cuba which were conducted as part of the Generation Challenge Program A publication on the Colombian collection has been published and a mansucript has been prepared for the Mesoamerican races We hope to use this information for association mapping studies and to guide evaluation of other national collections especially in secondary centers of diversity such as Africa and Asia

New genetic markers for marker assisted selection of common beans at CIAT

Marker assisted selection is a priority in the bean breeding program because of the large number of segregants screened and the diverse array of biotic and abiotic limitations being tackled Until recently all marker assisted selection in common beans was done with SCAR markers In this year s annual report we describe the development of CAPS (Cleaved Amplified Polymorphic Sequence) markers for *Apion godmani* resistance and the screening of microsatellites for selecting geminivirus resistance genes In addition we evaluated COS (Conserved Orthologous Sequence) markers for use in mapping of drought QTLs This builds on experience with low phosphorus tolerance which is a trait we have completed a series of QTL studies for and which have been published in three consecutive articles in Plant and Soil Journal of Functional Biology (2004) and Crop

Science (2005) While diversifying the types of markers in use at CIAT we continue to validate SCAR markers in practical real life plant breeding situations Notable for this year was the collaboration with Univ Nacional where we have introgressed the *bc* 3 resistance gene for BCMV and the *Co 4*^{2} and *Co 5* resistance genes for anthracnose into large red seeded climbing beans for the Colombian market The combination of markers was found to work well for climbing beans especially for a shuttle breeding program between CIAT and Univ Nacional that is part of a Colciencias funded project In this project marker assisted selection and phenotypic screening in both field and greenhouse sites is proving to be complementary and efficient Two MS c students have been trained from the Univ Nacional as part of this project and are forming part of a cadre of local practicioners of marker assisted selection both within the academic and public sectors building on work we did in the previous two years with CORPOICA

Evaluation of nutritional quality traits in common bean

This year we report on methodologies we have developed for evaluating two anti nutrients (tannins and phytates) in common beans from different commercial seed classes and among parents of QTL mapping populations In the case of tannins we developed separate calibration curves for tannins isolated from each commercial seed class We then applied the calibration curves to evaluate genotype x environment interaction of total soluble and insoluble condensed tannins in Andean breeding lines grown at three locations in Colombia While location effects were found location x genotype interactions were not significant Furthermore genotypic differences in average total condensed seed coat tannins seemed not to be due to the genotype s seed color with red mottled and large red seeded varieties having similar variability for tannin Fortunately breeding for higher minerals in the NUA high mineral Andean lines seems not to have increased tannin levels This is important since these red mottled genotypes have been promoted and widely tested in Colombia Bolivia and Eastern and Southern Africa The NUA lines are also the basis for a bioefficacy trial with Univ del Valle where they will be given to pre school children in a feeding program in Cali As part of this project we have increased the amount of NUA seed to approximately 1 ton of grain both for distribution and for the feeding trial In terms of seed phytates evaluated for a set of mapping parents grown under high medium and low soil phosphorus the highest accumulating genotypes were the P inefficient genotypes such s DOR364 while the lowest phytate content were found in seed of the P efficient genotypes G2333 and G19839 This has been observed previously in studies of low P tolerance where under low P conditions efficient genotypes produce a larger amount of grain for a given amount of soil P In this study the same genotypic differentiation was observed under both medium high and even low soil P levels especially for the genotype DOR364 although interestingly G19839 had higher phytate content in the medium P than in high P unlike G2333 that had higher phytate content in high P compared to the medium P treatment Our final goal with the tannin and phytate information is to better understand how to breed common bean for better nutritional quality So far breeding has been with the goal of higher mineral accumulation (see this year s annual report section on the development of the NUA lines) but in the future we may try to reduce anti nutrient content However

the results presented this year indicate some of the difficulties that may be found with reduction of tannin or phytate levels

Efficient protocol for isolation of microspores in cassava developed

Cassava is one of the most important calorie carbohydrate sources in the tropics adapted to a broad range of environments including tolerance to drought and acidic soils This important staple food for subsistence farming is also becoming an important raw source for industrial applications worldwide Cassava breeding is cumbersome and inefficient compared to other crops Efficient breeding is needed to maintain cassava s competitiveness respect to other commodities The inefficiency in cassava breeding is mainly due to its highly heterozygous nature and inbreeding depression affecting the selection of early generations of breeding materials in replicated field trials The *in vitro* production of doubled haploids (DHs homozygous) lines would serve as a baseline for the development of populations allowing the identification of valuable recessive traits and providing the opportunity for the incorporation of molecular tools This project seeks the development of an *in vitro* protocol for the generation of doubled haploids from cultured anthers or microspores via androgenesis establishing a suitable model system for different ecotypes of cassava This initiative is being financed by the Rockefeller Foundation New York ZIL Switzerland and CIAT Results and detailed information are found in SB2 Reports from 2004 and 2005 Suitable genotypes for the development and standardization of a protocol to generate doubled haploids in cassava were identified after a pre selection/ evaluation of 45 genotypes representing broad environmental adaptation according to the CIAT breeding program One of the main bottlenecks affecting microspore culture in cassava was elucidated which includes obtaining high yielding homogenous microspore suspensions allowing culture at 10^5 cells/ml A methodology for viability monitoring during microspore isolation and the standardization of protocols for selecting optimal plant donor and tissue within the plant were established Low temperature has been proven to be a crucial factor for keeping viability of cassava microspores during the flower bud harvest and isolation process Factors were identified allowing an effective flower bud shipment for collaboration abroad Microspore separation using Percoll gradient 30 40 50% allowed a cleaner and better separation of microspores by size and developmental stages than a 50 60 70% gradient Results corroborated last year results indicating putative cell divisions from pre chilled tetrads cultured at 10^4 cell/ ml in B5 liquid medium at 26 C in the darkness Histological analysis of cassava microsporogenesis was initiated in September 2005 Improvements of the protocols were introduced and information generated will be used to better design a reproducible responsive microspore culture protocol Current work focuses on tailored conditions for culturing microspore suspension rich in selected type of stage of development The progress attained and report herein is pioneer in the establishment of a reproducible protocol for the generation of doubled haploids in cassava

Phyhylogenetic Patterns In The Genus *Manihot* Mill (Euphorbiaceae) Biogeography And Comparative Ecology Of Mesoamerican And Southamerican Species

Evolutionary relationships among wild *Manihot* species are still uncertain Current studies have emphasized on the origin of cassava (*Manihot esculenta* subsp *esculenta*) one of the most important crops in tropical countries without regarding the rest of species In order to quantify inter specific genetic variability among wild *Manihot* species and to establish a molecular phylogeny of the genus three plastid (*accD psaI* spacer *trn*L F spacer and *trn*L intron) and three nuclear DNA regions (*G3pdh CAM1* and *CAM2*) were sequenced *Cnidoscolus* was included as outgroup Tree topology and geographical distribution of species were used to infer a biogeographic hypothesis of the genus The age of the different nodes was estimated by means of a molecular clock calibration Ecological data obtained from the last monograph of *Manihot* was also used to infer the adaptation process of the species to their current habitats Nuclear *G3pdh* was chosen to infer the evolutionary relationships of the species due to the lack of variation of the chloroplast genome the possibility of gene duplications in the *CAM1* region and the positive effect of natural selection on the *CAM2* region The phylogeny shows a Central American clade sister to the South American species The diversification of the last clade began in Brazil during the Pleistocene followed by migration of species towards other parts of the South American continent Glacial and interglacial periods could play an important role modulating the adaptation to dry habitats The predominance of shrub forms could occur early in the evolution of *Manihot* species although a better sampling of species is needed

Molecular marker assisted selection (MAS) for the improvement of local cassava germplasm in Tanzania for pest and disease resistance

The low adoption of improved cassava genotypes coming from centralized breeding programs in many African countries have led to the proposal of a decentralized breeding scheme involving molecular marker assisted selection (MAS) and participatory plant breeding (PPB) to accelerate the improvement of local farmer preferred varieties for pest and disease resistance Improved introductions of cassava from CIAT having resistance to the cassava mosaic disease (CMD) and the cassava green mite (CGM) were evaluated in the field and 80 genotypes selected Simultaneously 27 and 24 varieties were selected from local varieties collected from the Southern and Eastern zones respectively From the CIAT introductions and local varieties were established in a controlled and polycross crossing block at Chambezi experimental station situated about 60km North west of Dar es Salaam To date over 20 000 crosses have been made and at least 40 000 sexual seeds assuming an average of 2 sexual seeds per cross are expected Pollination is still on going to achieve a target of 60 000 sexual seeds in total The seeds will be planted in January 2006 and molecular markers will be used to identify disease and pest resistant genotypes for transfer to the single row trial stage

Simple sequence marker (SSR) evaluation of global germplasm resources in cassava

Part of the activities of sub programme 1 of the Generation Challenge Program (GCP) is the characterization of global crop genetic resources to define the genetic structure of germplasm collections as a first step to looking for new genes and alleles that contribute to solving the challenges of modern agriculture A decision was made to analyze 3000 cassava accessions 1500 accessions from CIAT s world germplasm collection 1000 accessions from IITA s African collection and 500 accessions from EMBRAPA national cassava gene bank with 36 SSR markers Data analysis includes assessment of genetic structure using principal coordinate analysis (PCoA) and multidimensional scaling (MDS) based on individuals cluster analysis based on country samples and an estimation of genetic diversity and allelic richness Results obtained so far are the SSR characterization of 2 575 genotypes with 30 SSR markers A cluster analysis based on country of origin reveal a clear separation between accessions from Africa and the rest of the world confirming findings from previous studies that shows that global cassava germplasm diversity is structured by region Sources of this genetic differentiation could be selection for adaptation to agro ecologies particularly diseases Other results include the identification of a separation of some accessions from Ghana Nigeria and Central America The source of the observed structure could be selection in the African accessions and introgression from wild relatives as well as independent domestication events for the Central American accessions

Development of physiological and genomics technologies to trait gene discovery

The molecular biology section is focusing on three research areas which are 1) environmentally friendly technology development 2) abiotic stress tolerance and 3) high value crops The first area is directly related to the Nitrification Inhibition (NI) Project IWe have started refining the bioassay system as part of a collaboration with JIRCAS in Japan to measure NI activity and the assay system is being used for screening Brachiaria and rice genotypes A new NI project will be launched by JIRCAS from April 2006 for 5 years and the planned activities in this project will enhance understanding of biological NI toward genetic improvement of this trait in Brachiaria and other crops in collaboration with JIRCAS

The second research area is mainly related to drought/water saving technology For the Generation CP and DREB project we lack expertise in crop physiology for drought particularly in rice Some efforts were made this year on this aspect and we will develop a more strategic plan to build the expertise at CIAT We have made some progress on understanding physiological and molecular aspects of aluminum tolerance in *Brachiaria*

With regard to high value crops the main focus is the utilization of full length cDNA clones for cassava genetic improvement which was developed in collaboration with RIKEN in Japan About 20 000 cDNA clones will be sequenced by RIKEN by March and the resultant genomic resources can be shared by both institutes to identify trait gene(s) of interest Discussion is underway to develop collaborative work between Asia (Thailand) Japan and CIAT

Molecular analysis of a BC3F2 population from the cross Lemont x *O barthii*

Wild rice species represents valuable genetic resources to broaden the genetic base of cultivated rice Two rice samples collected in Salahondita Pacific Coast and Santa Rosa Villavicencio Meta were shown to be a tetraploid species (CCDD) belonging to *O latifolia* After several backcrosses to O sativa it was possible to recover fertile plants having introgressed traits from the wild progenitor some plants presented additional chromosomes These hybrid plants represent a very valuable genetic resource for genetic and breeding purposes The presence of bivalents at diakinesis in F1 plants could be indications of recombination between genomes of different species Chromosome behavior was abnormal in F1 BC2 and BC3 progenies which causes high plant sterility Polymorphic markers were identified which could be used to assess introgressions from the wild progenitor Preliminary results showed that *O latifolia* is resistant to rice blast rice hoja blanca virus and *Tagosodes oryzicola* This finding has very important positive implications for our breeding program since new alleles become available for further breeding work

***In vitro* Propagation and Regeneration of Solanum quitoense (Lulo) Plants and their Use as Elite Clones by Resource Farmers –**

A four year project (2001 2005) on the development of *in vitro* approaches for lulo funded by the Colombian Ministry of Agriculture and CIAT was accomplished The objective of this work was to develop *in vitro* protocols that facilitate *(a)* the conservation of germplasm *(b)* the multiplication and distribution of healthy elite clones selected by farmers *(c)* the evaluation of *in vitro* propagated plants vs sexual seeds propagated plants in farmer s fields and *d)* the high efficient plant regeneration as a first step for setting the basis and development of gene transfer technology to this tropical fruit species *Solanum quitoense* also known as lulo in Colombia and naranjilla in other countries has great potential to become a premium product for local and export markets Recently lulo evolved from being a fruit for local fresh consumption to become an industrial high value crop as ingredient of juices yogurt flavoring and processed food increasing its market value Various diseases and pests affect its production and plant breeding is at a young stage A major constraint for the rapid adoption of lulo by the local farmers is the limited availability of elite clonally propagated germplasm free of pathogens Rapid clonal multiplication of high quality planting materials is of paramount importance to obtain uniform elite plants Genetic transformation could also facilitate splicing in genes for traits of interest Results showed (detailed information are found in SB2 Reports from 2001 to 2005) the establishment of an efficient reproducible true type *in vitro* propagation protocol of elite clones and field grown clones selected by farmers It was also demonstrated a stepwise progress for the scale up use of the technology from the laboratory to the greenhouse small scale experimental field to larger scale farmers field With the participation of farmers a process was initiated to evaluate the advantages/ disadvantages of using *in vitro* propagated plants as planting materials to establish new crops Thousand of *in vitro* propagated lulo plants were generated from selected commercial clones by experienced resource farmers and evaluated in the field using

participatory research approaches in two commercial zones in Colombia (Pescador Cauca and Tierradentro Huila) with the aim of comparing in the field the performance of the *in vitro* plants with those conventionally propagated materials through seeds The potential advantage of the *in vitro* source is the supply of pathogen free homogenous plants maintaining the selected traits of the elite materials According to the farmers the *in vitro* generated plants showed higher vigor earlier development and rooting respect to seed propagated plants which was corroborated by the statistical analyses *In vitro* propagated plants flowered and fructified earlier than seed derived plants It was also found that one of the *in vitro* material derived from a selected in Cauca (clone JY E1) showed the highest productivity This clone was selected by farmers from Tierradentro Cauca and then was evaluated in a different location (Pescador Cauca) This project had set a pilot experience that now with funding from the Ministry of Agriculture competitive grant is allowing expanding these findings to other lulo growing regions in Colombia including Valle del Cauca Caldas and Risaralda as well as germplasm exchange between farmers from different regions and a vehicle to canalized advanced breeding lulo material from Corpoica It is also giving the ground for a regional new initiative under formulation seeking funding from Fontagro that includes Ecuador

G Problems encountered and their solutions

Budget allocation and internal charges

As acknowledged by all the SB 2 staff has managed in the past decade to raise CIAT profile with the research community and was successful to secure funds from a wide range of donors by participating in some very competitive grants As the results of the team efforts SB 2 has been able to contribute significantly to the economic health of the center However the disproportionate percentage on overhead and internal charges imposed on SB 2 projects have stretched SB 2 staff capacity The concerns of the team are the current situation where SB 2 staff have a far larger burden than any other projects to contribute to the non core funding of the center will result in a reduced CIAT capacity to delivery on previous commitments made to donors Such situation has affecting the efforts of the team to improve the infrastructure of the labs or to hire needed post docs budgeted in some special projects Discussions with management are on going to seek a solution to such problem

Bioinformatics

The issue was raised in 2002 To respond to the need of the project the director of research allocated from CIAT strategic resources funds to cover part of the salary of a post doc The rest of the needed funds came from a small grant from the Generation Challenge Program However the allocation is for one year and is a temporary measure to address an expanding need of the team for such expertise While the team has prepared several proposals trained junior staff in bioinformatics and established alliance both in Colombia and with ARI the team is not getting the needed support The only immediate solution is to have a post doc for an additional two years with full funding from the central strategic funds

Need for physiology support

Sb 2 staff have been quite successful in the past three years in raising funds for project on abiotic stress The projects involve the integration of breeding molecular biology and physiology Such success has put a heavy burden on Dr Rao the only plant physiologist currently based a headquarters A proposal made by senior management in 2004 to hire a post doc to work with Dr Rao never materialized To address such limitation the team has expanded its collaboration with plant physiologist working at IVIC in Venezuela and prepared a proposal that included plant physiologists from CIRAD Still CIAT management needs to address such strategic issue at the Center level and not a project level

Lack of structured phenotypic databases

One the major strength of the international centers is the wealth of phenotypic information on germplasm and breeding lines accumulated over the years Such unique sets of data are becoming key to gene discovery when integrated with CIAT molecular markers work Due to historic reasons several of the data taken on beans cassava and forages are not completely deposited in structured databases that can be quickly queried The only viable solution to addressed this issue is to have management imposed on the researcher a strict deadlines to incorporate the data

Recurring problems raised in 2002 2004

- **Space** the team needs more space for visiting researchers and lab areas
- **Maintenance of major equipment** the central fund allocated during the past ten years has been drastically reduced Several of the major equipment such as the sequencer and microarray spotter are now without a proper maintenance for the past two years The lack of preventive maintenance for other piece of equipment are also generating serious problems
- **Salary of national recruited staff** Some of the major issues raised in 2004 were resolved in collaboration with Human resources However the is an

urgent need to formulate a long term strategy for promotion and salary increase and for the allocation of funds to ensure equity across the Center Right now some of the promotion of assistants is linked availability of funds and to merit creating serious inequity among the national recruited staff

Plan for next year

Biofortification The bean and cassava team members will continue their involvement in the HarvestPlus challenge program Based on HarvestPlus recommendations the cassava transgenic work will be increased in collaboration with The University of Freiburg

As part of the AgroSalud – CIDA biofortification project for LA the bean and rice team members will increase their activities that include breeding and marker assisted selection for key genes related to iron and zinc The team will also interact with the partners of AgroSalud at CIP CIMMYT CLAYUCA and EMBRAPA to develop a diet based strategies for deployment of biofortified crops The project will interact with HarvestPlus and will demonstrate the capacity of CIAT to lead a project that can be considered as an example of collective action between CG and NARS institutions
Abiotic stress Generation Challenge Program Team members will implement the three projects (two Cassava and one on rice) funded by the Generation Challenge Program as part of the competitive grant system The team members will also expand the work on gene discovery for drought as part of collaboration between the molecular biology section and several collaborator in ARI and NARS

Biosafety SB 2 staff will be submitting to the World Bank GEF a regional project to assist National Programs in the technical implementation of the Cartagena protocol The World Bank had approved fund in 2005 to prepare the project The countries involved include Colombia Brazil Peru Mexico and Costa Rica In addition SB 2 staff will continue their support to NARS by conduction capacity building workshop

Characterization of wild relatives of crops in Central America and Colombia The World Bank has approved funds for CIAT and IICA to develop a proposal the Conservation and Sustainable Use of Neotropical Native Crops and Wild Relatives of Crops Project Team member will be preparing the full proposal in 2006 for submission to the GEF The project will involve among others the main biodiversity institutes in Central America and Colombia, the Museum of Natural history of the Smithsonian and several other research institutions from the US Mexico Central America and Colombia

Tools development Teams members will increase their activities in the uses of gene expression Real Time PCR and Single Nucleotide Polymorphism as part of the gene discovery and marker assisted selection projects

Targeted sequencing of cassava bean and Brachiaria EST and full length cDNA will be pursued with partners coupled by in house annotation and when needed with the processing of microarray chips

In addition to the Lab Information Management System the team will complete the development of several bioinformatics tools related to gene annotations SNP discovery Metabolic pathway searches and structured ontologies searches

Project indicators

Publication

- Refereed Journals Published 19
- Refereed Journals Submitted 15
- Book Chapters 5

Technologies and tools

- More than 10 genes and QTLs indetified in rice bean cassava and Brachiaria
- Full length cDNA libraries were developed for cassava and Brachiaria
- Several root promoters were identified in cassava
- BAC library for Barchiaria developed at Clemson University
- SNP primers developed for beans and rice for mapping and tagging projects

H Strengthening NARS

The project concentrated its efforts this year on strengthening NARS through a series of events either at CIAT headquarters or at NARS facilities More than 500 persons from national and national institutions visited and or received training with SB 2 Project Staff or participated in SB 2 events

- Implementation Planning Workshop for PDF BConservation and Sustainable use of Neotropical Native Crops and Wild Relatives of Crops January 17 19 2005 **(8 participants)**
- Workshop of Molecular Biology Bases and Data Base Information February 4 5 2006 **(19 participants)**
- HarvestPlus consultancy for CIDA Latin American Biofortification Project August 7 11 2005 **(25 participants)**
- Workshop on Bean Breeding for Nutritional value and Tolerance to the drought August 15 19 2005 **(33 participants)**
- How can the poor benefit from the growing markets for high value agricultural products? October 3 5 2005 **(37 participants)**

- Biosafety in Centers of Biodiversity Building Technical Capacity in Latin America for Safe Deployment of Transgenic Crops (a multy country approach for Brazil Colombia Costa Rica Mexico and Peru) October 24 26 2005 **(42 participants)**

- HarvestPlus Sixth Project Advisory Committee (PAC) Meeting November 7 8 2005 **(28 participants)**

- Detection of Genetically Modified Plants October 5 6 2005 **(27 participants)**

- Senators of the Republic attended Workshop on Biotechnology and Genetic Modification crops CIAT October 27 2005 **(15 participants)**

I Strengthening the technical capacities of CIAT SB 2 Assistant

As part of a long term strategy the project has managed to increase the technical capacity and expertise of the SB 2 assistants and associate Without having access to additional funds the project took advantage of several opportunities to achieve such training 1) Specific courses were identified and assistants were encouraged to apply to fellowships provided by certain courses 2) training components were build in collaborative projects 3) targeted funding from special project to needed training in key areas As mentioned in previous reports SB 2 assistants managed again in 2005 to get accepted to one of the highly competitive courses at the Cold Spring Harbor where attendance is usually restricted to a max of 20 participants In total in the past 5 years 6 SB 2 assistants were accepted at courses at the Cold Spring Harbor In addition several assistants are engaged in graduate studies at the Master or PhD level with full support of the respective supervisor

1 Soto Mauricio Universite de Perpignan (Perpignan France) February 05 2005 to april 16 2005 Working with Microarray analysis and Gene expression analysis using Real Time PCR technology

2 Soto Mauricio Work on Molecular Biology in Rice and Yuca IRD France February 5 March 24 2005

3 Soto Mauricio University of Wisconsin Madison June 27 28 2005 USA Connecting Underrepresented High School Students with Genomics Workshop

4 Duque Myriam Cristina Mixed models course CATIE Costa Rica March 13 19 2005

5 Chavarriaga Paul Updating on Genetic Modification of Cassava Danforth Plant Science Center March 2 7 2005

6 Soto Mauricio Rodriguez Fausto and Galindo Leonardo attended Latin American workshop of bioinformatica Cartagena June 20 24 2005

7 Rojas Fernando IPGRI Rome June 2005 Participation in the Generation Challenge Program (GCP) Web Services Workshop

8 Rojas Fernando ICARDA – SYRIA February 2005 Participation in the Singer Workshop

9 Rojas Fernando Feb 2005 Participation in the ICIS Workshop as part of the Generation Challenge program

10 Chavarriaga Paul Statistic Course on data interpretation Tecnologica de Pereira Julio 29 2005

11 Chavez Lucia Carotens Analysis Brazil Sao Paulo EMBRAPA CNPMF Salvador Brazil August 20 2005

12 Arango Jacobo Training on PCR Real Time Freigburg University Alemania October November 2005

13 Rodriguez Fausto Advanced Bioinformatics Course Cold Spring Harbor USA October 11 – November 04 2005

14 Bernal Diana Microarray design and data analysis training course at the TIGR Wash DC

Strengthening the technical capacities of NARS

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7 Staff SB 2 organized and conducted in collaboration with national research institutions Rice biofortification planning meeting with the Instituto de Investigaciones del Arroz en La Habana Cuba

8 SB 2 staff co organized the Herramientas moleculares para el mejoramiento de la tolerancia al stress abiotico en plantas coordinated by IVIC Venezuela Around 30 35 participants from Colombia Venezuela Cuba Nicaragua Dominican Republic Bolivia Chile Brazil and Argentina were trained in each workshop 2005

9 Staff SB 2 organized the II National Course on Hybridization and analysis of DNA Microarrays December 5 7 2005 Around 25 participants from Colombia and CIAT

10 Biosafety Workshop offered to Ministry of Agricultural December 2005 (22 participants)

11 Implementation Planning Workshop for Conservation and Sustainable Use of Neotropical Native Crops and Wild Relatives of Crops To prepare for the World Bank a proposal for Agrobiodiversity CIAT January 17 19 2005 (8 participants)

J Current Graduate Students

PhD 12

- MSc 13
- Undergraduate 36
- Complete Thesis 22

K Resource Mobilization

Project approved or on going

- BMZ Germany Bean genomics for improved drought tolerance in Latin America

- Colciencias – Obtencion de nuevas variedades de frijol comun con atributos de rendimiento y potencial para nuevos mercados utilizando seleccion convencional y asistida por marcadores moleculares Universidad Nacional with CIAT

- Generation Challenge Program TILLING mutagenesis and drought gene analysis

- Harvest Plus Challenge Program – Biofortified crops for human nutrition Harvest Plust challenge program various donors 300 000 USD/yr (2003 2008)

- USAID – Breeding staple crops for improved micronutrient value 400 000 USD (2002 2004)

- EcoFondo – Manejo del germoplasma local y aumento de la agrobidodiversidad de frijol y maiz con variedades biofortificadas para mejorar la nutricion en comunidades rurales del departamento de Narino – FIDAR with CIAT –

- Fontagro – Mejoramiento de la nutricion humana en comunidades pobres de America Latina utilizando maiz (QPM) y frijol comun biofortificados con micronutrientes

- BioCassava Plus a project to develop new cassava cultivars with improved nutritional status for sub Saharan Africa Gates Foundation US$260 000 for 5 years

- Development of Low Cost Technologies for Pyramiding Useful Genes From Wild Relatives of Cassava into Elite Progenitors GCP US$894 420 for 3 years

- Identifying the physiological and genetic traits that make cassava one of the most drought tolerant crops GCP US$78 806 for 3 years

- Development of Molecular Markers Associated with Genes for Useful and Unique Traits in Wild Progenitors of Cassava for Marker Aided Introgression into Elite Cassava Cultivars SIDA FORMAS SEK494 000 for 2 years

- Identification of Genes Controlling Starch Accumulation and Quality in Cassava (*Manihot esculenta* Crantz) Towards the Development of Varieties with Novel

Quality and High Content of Starch (High Value Cassava) SIDA FORMAS SEK495 000 for 2 years

- Graduate Level (M Sc) Training in Plant Breeding for NARs Scientists from Mozambique Rockefeller Foundation US$144 000 for 2 years

- A One Month Intensive Course in Cassava Breeding for NARs Cassava Breeders from Uganda Kenya Tanzania and Mozambique Rockefeller Foundation US$44 000 for 1 year

- Improvement of the nutritional value of cassava high storage protein content and zero cyanide cassava DANIDA US$120 000 for 3 years

- Proof of Concept Molecular Breeding Communities of Practice GCP commissioned grants US$30 000 for 2 years

- A dataset on allele diversity at orthologous candidate genes in GCP crops (ADOC) GCP Commissioned grants US$30 000 for 2 years

- A Public Private Partnership to Commercialize High Protein and Beta Carotene Rich Cassava Varieties for the Animal Feed Flour and Cassava Chip Markets The Government of Nigeria US$14million for 4 years

- CIDA Canada Agrosalud High iron and zinc rice lines US$235 000

- GCP Unlocking genetic diversity SP1 and SP2 US&4 500

- GCP Evaluation of T DNA mutants to drought stress US$ 3 000

- GCP Exploring natural genetic variation developing genomic resources and introgression lines for four AA genome rice relatives US$ 4 500

- CIAT Yale Univ Consortium Screenhouse and field evaluation of Ac/Ds mutants USDA US$ 4 000

- HP Rice crop Identification and expression analysis of genes important for iron translocation to the rice grain US$200 000 Two years project starting in 2006 PI Dr Janette Palma Frett Universidade Rio Grande do Soul Porto Alegre Brazil

- Assisting Disaster affected and chronically stressed communities in East and Central Africa USAID/OFDA 8 case studies 7 countries Full volume published March 2002 March 2005 Total Amount USD305 650

- Seed Aid & Germplasm restoration in disaster situations IDRC Shows that CGIAR not involved in Germ Restoration in acute stress June 2003 March 2005 (ext to August) Total Amount 198 000 CAD (126 000 USD)

- Long term seed Aid in Ethiopia IDRC Addresses chronic stress areas and extreme poverty June 2005 May 2007 Total Amount 232 000 USD

- Getting high yielding and adapted bean varieties into the hand and fields of seed stressed farmers USAID High impact 73% of farmers reached had never been reached with new bean varieties prior October 2003 February 2005 Total Amount 150 000 USD

- Systematic evaluation of rice mutant collections for conditional phenotypes with emphasis on stress tolerance Generation CP 40 000 US$/2005

- Crop gene expression profiles and stress gene arrays Generation CP 23 000 US$ 2005

- Evaluation and deployment of transgenic drought tolerant varieties Generation CP 33 479 US$/ 2005 2006

- Bean genomics for improved drought tolerance in Central America BMZ 16 000 US$/2005

Projects funded and their Donors (Oct 2004 – Sept 2005)

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- Delivery of Transgenic Rice Cultivars to Seed Producers and Farmers in Tropical America US$ 300 075 (2001 2005) Donor The Rockefeller Foundation

- Development and use of inbred lines in cassava breeding Donor The Rockefeller Foundation USD 1 008 800 (2003 2006)

- Development of an *In Vitro* Protocol for the Production of Cassava Doubled Haploids and its Use in Breeding CIAT – ETH (Switzerland) SCIB (China) Donor ZIL
- Switzerland CHF 229 258 (2004 2007) Approved October 2004

- FLOWERS FRUITS AND ROOTS MODIFICATION OF FLOWERING TO IMPROVE TRAITS OF AGRICULTURAL IMPORTANCE CIAT MAX PLANCK INSTITUTE GERMANY DONOR THE ROCKEFELLER FOUNDATION USD 410 640 (2004 2008)

- Gene Flow Analysis for Environmental safety in the Tropics CIAT – University of Costa Rica – Hannover University and BBA Germany Donor EURO 450 000 (2005 2006)

- Development and evaluation of drought tolerant rice transgenic plants GCP SB3 USD 70 000 (2005 2006)

- Lulo (*Solanum quitoense* naranjilla) with added value New alternatives for the small farmer CIAT CORPOICA Col $ 499 million (2006 2008)

- Biosafety in centers of biodiversity Building technical capacity in Latin America for safe deployment of transgenic crops GEF World Bank USD 5 million PDF B (pre proposal) approved August 2005 USD 260 000 (November 2005 July 31 2006)

- Development and evaluation of drought tolerant rice transgenic plants GCP SB3 USD 70 000 (submitted March 2005)

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