PROJECT IP3

IMPROVED CASSAVA FOR THE DEVELOPING WORLD

Executive Summary – Annual Report 2004

CIAT IP-3 Project LogFrame (2004-2006)

Project: Improved cassava for the developing world

Project Manager: Hernán Ceballos

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
Goal To improve the livelihoods of rural populations in Latin America, Africa and Asia by increasing cassava productivity, while protecting the environment and enhancing the value of products derived from this crop.	Increased productivity of cassava clones. Widened uses for cassava. Increasing the area planted to the crop.	National statistics of different countries where projects have been implemented. Recognition of private sector (processing)	
Purpose To develop methods and tools that will make the genetic improvement of cassava more efficient and to identify valuable germplasm for the breeding project. Eventually a technology package involving germplasm, cultural practices and processing alternatives will be made available to rural communities.	By the end of year 2006, the project has consolidated the technology packages for alternative industrial uses of cassava as well as strengthened the reliability and sustainability of the crop as a source of food security for subsistence farming.	Reports and project documents of our partner institutions. Reports from the processing sector. Scientific publications	Political and institutional support for sustainable rural and agricultural development at the reference sites and targeted countries is maintained. Natural disasters and civil strife do not impede progress toward contributing to the project's goal. Absence of drastic changes in the price of maize as a commodity that greatly affects cassava competitiveness.
Output 1 Genetic base of cassava and related Manihot species evaluated and available for cassava improvement.	True retention of carotenes after processing determined (2004) and published (2005). Method for storage/shipment of roots determined (2004) and published (2005). Effect of carotene content on PPD determined (2004) and published (2005). Number of new clones and self-pollinations produced and evaluated combining high carotene content and desirable agronomic traits (2004-2007).	Articles published. Annual reports and project proposals. Clones developed to take advantage of findings from this output.	Natural disasters or civil strife do not impede progress toward achieving the project's goal. Cassava germplasm bank is maintained in the field.

Narrative Summary	**Measurable Indicators**	**Means of Verification**	**Important Assumptions**
	Confirmation of stability of carotene, Fe and Zn contents in roots from selected clones determined (2004) and published (2005). Knowledge on the possibility of further increasing levels of carotenes through self-pollinations or specific crosses (2006). New generation of clones with higher carotenes or better agronomic performance (2007).		
Output 2 Genetic stocks improved gene pools developed and transferred to national programs**.**	Protein content in selected clones from Central America confirmed (2005). High and low amylose content in roots from selected clones confirmed (2005). notypes induced for mutation (2004) production of self-pollinated seed (2005). Evaluation for starch quality (2006) and implementation of TILLING.	Project home page. Annual reports and working documents. Scientific publications. Shipment of germplasm to collaborators in different countries.	Natural disasters or civil strife do not impede progress toward achieving the project's goal. Adequate funding for research activities.
Output 3 New methods for cassava breeding developed	Number of S_1, S_2 and S_3 seed produced and planted in the field (2004-2007). Six articles on inheritance of quantitative traits submitted for publication (2004-2005). Two scientific articles on cassava breeding submitted for publication (2004-2005). Analysis of the impact of the new evaluation/ selection scheme conducted (2004) and published (2005). Search of useful recessive traits in partially inbred germplasm incorporated as routine in the breeding project (2004-2007**).**	Case studies published. Annual reports and working documents. Submission of joint research proposals. Support from private sector	Natural disasters or civil strife do not impede progress toward achieving the project's goal. Willingness of IITA to continue the collaboration we have had.
Output 4 Research on the industrial uses of cassava and elite germplasm produced	Number of germplasm produced and evaluated (2004-2007). Performance of elite germplasm identified (2004-2007). Number of officially released varieties. Area planted to cassava germplasm developed totally/partially by CIAT (2007). Number of *"Trapiches Yuqueros"* consolidated	Project proposals and reports. Accessions planted and maintained in the field. Introduction of new accessions	Natural disasters or civil strife do not impede progress toward achieving the project's goal.

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
	(2005). Information of alternative uses of cassava products developed by CLAYUCA from roots and foliage (2005). Progress to introduce artificial drying processes in other countries from Latin America (2007). Number of clones (vitroplants) or new genotypes shared with collaborating NARs and IITA (on a yearly base 2004-2007).		
Output 5 Breeding for insect and other arthropods and disease resistance and development of alternative methods for their control.	Number of germplasm evaluated for their reaction to insects and arthropods with emphasis in white flies and mites (2004-2007). Number of germplasm evaluated for their reaction to diseases with emphasis in bacterial blight, root rot and super elongation disease (2004-2007). Results of field studies to determine how and who transmits the frog skin disease (2007). Identification of the etiology of frog skin disease (2007). Number of crosses with wild relatives evaluated every year in search of resistance to pests and diseases (2005-2007)	Annual reports and working documents. Scientific publications. Development of commercial products for biological control of pests in cassava.	Natural disasters or civil strife do not impede progress toward achieving the project's goal. Adequate funding for research activities.
OUTPUT 6 Development and use of biotechnology tools for cassava improvement	More than 700 CMD resistant hybrids (10 plants per genotype) shipped to Africa (Tanzania, Nigeria, Uganda, and South Africa) and India. (2005). About 300 CMD resistant hybrids (10 plants per genotype) shipped to Tanzania, hardened and transferred to the field. Latin American germplasm transferred to the field in Ghana and Nigeria and evaluated for high protein content and resistance to pest and diseases. Field results on starch quality from a transgenic clone with waxy starch developed with anti-sense technology (2005-2006). Molecular markers for resistance to mites developed (2005) and validated with field data		Natural disasters or civil strife do not impede progress toward achieving the project's goal. Adequate funding for research activities.

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
	(2007). Molecular markers for beta-carotene (2005) developed and validated with field data (2007). Molecular markers for resistance to dry matter content (2005) developed and validated with field data (2007).		
Output 7 Integrated cassava-based cropping systems in Asia. Widespread adoption of farming practices that enhance sustainability	Research partnerships established in Laos and Cambodia (2005). Number of trials introducing new germplasm/ technologies established (2006). Number of communities adopting new germplasm/technologies in Laos and Cambodia (2006).		

2. PROJECT INPUTS

2.1 Staff

Table 1. Internationally and nationally recruited staff associated with the cassava-breeding project. Underlined are the women associated with the project.

Name	Degree	Capacity Area	Name	Degree	Capacity Area
International Staff Directly Involved in Cassava Breeding Project IP3					
Alvarez, E.	Ph.D.	Pathology	Fregene, M.	Ph.D.	Genetics
Bellotti, A.C.	Ph.D.	Entomology	Howeler, R.	Ph.D.	Agronomy
Ceballos, H.	Ph.D.	Breeding	Ospina, B.	M.Sc.	Processing
National Staff Directly Involved in Cassava Breeding Project IP3					
Name	**Degree**	**Capacity Area**	**Name**	**Degree**	**Capacity Area**
Alzate, A.	I.A.	Genetics	Loke, J.B.	I.A.	Pathology
Arias, B.	M.Sc.	Entomology	Marin, J.A.	Biol.	Genetics
Barrera, E.	Biol.	Genetics	Mejía, J.F.	I.A.	Pathology
Bohorquez, A.	Biol.	Entomology	Moreno, J.Z.	Biol.	Genetics
Buitrago, C.	I.A.	Genetics	Moreno, X.	Zootec	Breeding
Calle, F	I.A.	Breeding	Montaña, V.S.	I.A.	Breeding
Carabalí, A.	I.A.	Entomology	Morante, N.	Biol.	Breeding
Castelblanco, W.	Biol.	Genetics	Múnera, D.F.	I.A.	Entomology
Guerrero. J.M.	I.A.	Entomology	Ortega, E.	I.A.	Breeding
Guitérrez, J.P.	Biol.	Genetics	Ospina, C.A.	I.A.	Genetics
Herrera, C.J.	I.A.	Entomology	Perez, J.C.	Ph.D.	Breeding
Holguín, C.M.	I.A.	Entomology	Puentes, G.J.	I.A.	Genetics
Hurtado, P.X.	Biol.	Genetics	Sánchez, R.	I.A.	Breeding
Jaramillo, G.	I.A.	Breeding	Sánchez, T.	Chem.	Breeding
Lenis, J.I.	I.A.	Breeding	Santos, L.G.	I.A.	Genetics
Llano, G.	M.Sc.	Pathology	Zamora, Z.	B.S.	Pathology
López, J.	I.A.	Breeding			

2.2 List of partners

Table 2. Institutions with which personnel of the cassava breeding project maintains collaborative activities

Partner	Country	Partner	Country
University of Adelaide	Australia	Central Institute for Food Crops, Bogor	Indonesia
EMBRAPA - CNPMF	Brazil	Res. Inst. for Legumes & Tuber Crops, Malang	Indonesia
EMBRAPA - CENARGEN	Brazil	Soil Research Institute, Bogor	Indonesia
EMBRAPA - CTA	Brazil	KARI	Kenya
IAC - Sao Paulo	Brazil	NAFRI	Laos
Universidade de Campinas – Sao Paulo	Brazil	Bvumbwe Agricultural Research Station	Malawi
Chinese Acad. Trop. Agric. Sciences, Hainan	China	Crop and Food Research Institute,	New Zealand
Animal Husbandry Station, Mengzhe, Yunnan	China	IITA	Nigeria
Guangxi Subtrop. Crops Res. Inst., Nanning	China	National Root Crops Research Institute	Nigeria
CARDI	Cambodia	FIAFOR	Panamá
Corp. Des. Sostenible del N y O Amazónico	Colombia	CIP	Peru

Table 2 cont.

CORPOICA	Colombia	IDIAF	Rep.Dominc.
Consejo Regional Indígena del Vaupés (Mitú)	Colombia	Uppsala University	Sweden
ICA	Colombia	ETH - Zurich	Switzerland
Magro S. A.	Colombia	ARI	Tanzania
Secretaría de Agricultura del Vaupés	Colombia	Kasetsart University	Thailand
Special - La Tebaida	Colombia	Land Development Department	Thailand
UMATAs	Colombia	TTDI	Thailand
Universidad de Caldas—Manizales	Colombia	DOAE	Thailand
Universidad de los Andes—Bogotá	Colombia	Field Crops Res. Station- Banmai Samrong	Thailand
Universidad del Valle—Cali	Colombia	Field Crops Research Center- Khon Kaen	Thailand
Universidad Nacional de Colombia—Palmira	Colombia	Field Crops Research Center- Rayong	Thailand
12 Trapiches Yuqueros	Colombia	Field Crops Research Center- Bangkok	Thailand
FENAVI	Colombia	NAARI	Uganda
INYUCAL	Colombia	University of Florida, Gainesville, USA	USA
Corn Products	Colombia	Systematic laboratory in Livingston, Montana	USA
MADR	Colombia	National Starch and Chemical Co.	USA
Universidad Nacional de Colombia—Bogotá	Colombia	United States Department of Agriculture,	USA
CENICAFE - Chinchiná	Colombia	Cornell University	USA
BIOTROPICAL S.A., Medellín	Colombia	ILTAB – Danforth Center	USA
INIVIT	Cuba	Ohio State University	USA
KVL University	Denmark	INIA - Maracay	Venezuela
MAFF	East Timor	INIA - Anzoátegui	Venezuela
IRD	France	IDEA – Universidad Simón Bolivar	Venezuela
Council for Scientific and Industrial Research	Ghana	Agropecuaria Mandioca	Venezuela
Plant Genetic Resources Centre	Ghana	Thu Duc Univ. of Agric. and Forestry, HCM	Vietnam
Ministry of Agriculture	Haiti	Hung Loc Agric. Res. Center, IAS, Dong Nai	Vietnam
World Vision	Haiti	Hue Univ. of Agriculture and Forestry, Hue	Vietnam
AVEBE	Holland	Root Crops Research Center, VASI, Hanoi	Vietnam
Wageningen University	Holland	National Inst. of Soils and Fertilizers, Hanoi	Vietnam
CTCRI	India	Thai Nguyen University, Thai Nguyen	Vietnam
Brawijaya University-Malang	Indonesia		

2.3 Budget

Table 3. Core and special project budgets from the cassava breeding project activities for Africa, America and Asia.

SOURCE	AMERICA/AFRICA		ASIA		TOTAL	
	(US$)	%	(US$)	%	(US$)	%
Unrestricted Core	0	0%	0	0	0	0%
Restricted Core: Col - EC	369,011	16%	0	0	369,011	14.6%
Carry over from 2003	14,690	1%	0	0	14,690	0.6%
Sub-total	**383,701**	**16%**	**0**	**0**	**383,701**	**15.2%**
Special Projects	1,843,086	78%	154,000	100%	1,997.086	78.9%
Generation Challenge Program	150,000	6%	0	0	150,000	5.9%
Total Project	**2,376,787**	**100%**	**154,000**	**100%**	**2,376,787**	**100%**

3. RESARCH HIGHLIGHTS 2004.

3.1 Two separate studies assessing the extent of adoption of new cassava varieties and improved technologies resulting from the successfully ended Nippon Foundation Project in Thailand and Vietnam completed in 2004. Adoption of improved varieties as well as the use of chemical fertilizers is now widespread in both Thailand and Vietnam.

3.2 A new Nippon Foundation-funded cassava project entitled "Improving the Livelihoods of Smallholder Upland Farmers in Lao PDR and Cambodia through Improved and Integrated Cassava-based Cropping and Livestock Systems" started in April, 2004. The new Nippon Foundation (NF) funded cassava project is working in close collaboration with the National Agric. and Forestry Research Institute (NAFRI) and with CIAT's Participatory Research for Development in the Uplands (PRDU) project in Lao PDR, while a similar collaborative arrangement has been established with the Cambodian Agric. Research and Development Institute (CARDI) in Cambodia.

3.3 An important change in the direction of the cassava-breeding project at CIAT is rapidly taking place. An increased emphasis will be given to the development of "high-value cassava". In addition to the ongoing activity to increase the nutritional value (pro-vitamin A, Fe and Zn) of cassava roots financed by HarvestPlus, significant progress was achieved in confirming the natural occurrence of higher tan average (> 5%) levels of proteins in cassava roots in the *Manihot esculenta* geen pool. This finding comes to strengthen the activities already going on to introgress the high-protein trait from wild relatives. Finally a major step has been given to create the conditions for the production, identification and exploitation of cassava germplasm with novel starch types. Several approaches ranging from traditional recurrent selection to the implementation of the TILLING molecular approach for the identification of specific mutations started to be implemented. Resources for the creation of a high-capacity starch quality laboratory have been obtained to analyze as many as 15,000 starch samples per year. The relevance of these strategies is difficult to over-emphasize. In addition to the benefits of a higher nutritional quality in cassava roots for the human populations that depend on this crop, the same traits will also increase the commercial value of the roots when used for animal feed. An increase as large as 30% in the income of farmers is not unreasonable. A similar increase could be expected if cassava roots with an amylose-free (waxy) starch could be developed and identified.

3.4 A large number of scientific publications in refereed journal have been accepted for publication (15 articles), are currently in under review (11 articles) or will be submitted before the end of the year (6 articles). In addition five chapters in books have also been published by personnel from the project.

3.5 Many important projects have begun during the year. In addition to the HarvestPlus project, the Doubled-Haploids project also began during 2004. Two important proposals were short listed within the Generation Challenge Program in collaboration with EMBRAPA and Cornell University. These proposals involve several research disciplines within CIAT (Entomology, Pathology, Breeding, Physiology and Molecular Biology).

3.6 The trend for the consolidation of many "*Trapiches Yuqueros*" continued during the year 2004. The technical requirement that industrial cassava varieties developed by CIAT surpassed the 20 t/ha of fresh roots has been widely confirmed and accepted in many different regions in Colombia. This situation has consolidated the credibility of CIAT as a source of technology and has prompted the Ministry of Agriculture to continue supporting our breeding activities.

3.7 Growing interest in different regions of the world for the production of alcohol as carburant for vehicles. In Thailand two processing plants are under construction and a law was introduced in Colombia promoting this idea. As a result several projects (involving CLAYUCA and CIAT) are in the development stage to be submitted to donor agencies.

4. PROBLEMS ENCOUNTERED AND THEIR SOLUTION.

4.1 One of the problems that need to be properly solved is the technical tuning of the artificial drying plants. This is a key issue for the success of the Trapiches Yuqueros. CLAYUCA has vigorously addressed this issue by implementing a one-week long workshop to discuss about the technical considerations affecting the artificial drying plants. The workshop was attended by 35 people.

4.2 Frog skin disease has proven to be a very elusive and frustrating problem for the project. We have failed to definitely identify the causal organism(s) and its vector(s). The disease is endemic in the region and affects particularly the breeding and evaluation activities at CIAT's Experimental Station in Palmira. As a result several activities had to be cancelled or moved to other areas with increases in their costs. In addition it represents a potential risk because CIAT can be blamed responsible for the propagation of the disease through the different activities related to seed multiplication and distribution. During 2004 research to identify the pathogen(s) responsible for the disease continued. Important progress has been achieved regarding the potential role played by a virus and/or a phytoplasm. Scientists at CIAT feel that within a year or two the pathogen will have been properly identified and diagnostic tools developed.

4.3 As a result of the changes that had occurred during the last decade public investment in agriculture research in general has drastically been reduced. Project IP3 frequently has trouble identifying an adequate partner in different countries with whom to collaborate. Other crops such as maize offer the alternative of interacting with the private sector (frequently multinational seed companies). But cassava has no such promoting interests either.

4.4 Two strategies have been used to deal with this problem in a rather successful way. One is by approaching the processing sector (i.e. poultry producers in Peru and Ecuador, or a starch factory in Venezuela). These processing industries have been willing to fill the vacuum left by the official agriculture research institutions. The other approach has been through CLAYUCA. The consortium has proven to be an excellent vehicle for the transference of technologies developed by CIAT to its participating countries. During 2004, CLAYUCA started working in Nicaragua and CIAT's varieties were introduced and multiplied in the country.

4.5 Cassava is typically grown in areas with little development, away from urban centers and, in the case of Colombia, affected by social and security problems. The personnel working for the project IP3 has been required to modify its activities and sites where they are carried out to minimize the probabilities of undesirable events. So far these measures have proven to be effective.

4.6 The presence of CIAT in Africa in the area of cassava research has frequently been complex. IITA expects that CIAT's technologies and products are introduced into Africa through IITA. There are some justifications for CIAT and IITA to proceed this way but also some problems. One of them has been the issue of recognition, because once the technologies moved to IITA they became IITA's assets. CIAT has difficulty, therefore, documenting its significant contributions to Africa. Also there have been objections that CIAT searches for resources for cassava research in Africa. The approach that CIAT has taken is to search for a productive and open dialog with IITA but results need to be seen.

5. INDICATORS: LIST TECHNOLOGIES, METHODS & TOOLS

5.1 Varietal releases

CORPOICA- Tai. Adapted to sub-humid conditions in Colombia. Susceptible to diseases but with excellent dry matter productivity. Is has been already widely adopted by farmers in different regions of Colombia, and performs well as progenitor.

CORPOICA- Verónica. Adapted to the northern Coast of Colombia (Córdoba and Sucre Departments). Originally known with the Code CM 4919-1. Excellent plant type, roots are uniform with yellow parenchyma, and performs well as progenitor.

CORPOICA- Ginés. Adapted to the northern Coast of Colombia (Córdoba and Sucre Departments). Originally known with the Code CM 4843-1. Although this variety does not have a particularly nice plant type, it has excellent tolerance to prevalent diseases, good yield stability, and performs well as progenitor.

5.2 Germplasm distributed

A considerable fraction of the seed produced by the project has been transferred to National Programs in different regions of the world. As shown in Table 4, more than 110,000 recombinant seeds were produced between June 2003 and October 2004 and about 30% of that seed (34366) has been shipped to our collaborators (Table 4). Since the retirement of our cassava breeder stationed in Thailand in 1998 an increasing number of recombinant seed originated in CIAT-HQ has been shipped to Asia. In the future, we foresee that the flux of improved germplasm between CIAT-HQ, and the Thai and other Asian breeding programs will continue, and it will be through CIAT that other National Programs will receive progenies involving the latest selections of elite germplasm from Asia.

Table 4. Shipments of germplasm (recombinant seed and in vitro clones) produced within the project from September 2003 through September 2004.

Continents	Genotypes in-vitro	Crosses (families)	Plants (in-vitro)	Seeds in the shipment
Latin America				
In-vitro	52		476	
Hybrid seed		75		17043
Asia				
In-vitro	275		649	
Hybrid seed		100		15323
Europe + USA				
In-vitro	242		266	
Hybrid seed		10		2000
Total				
In-vitro	569		1391	
Hybrid seed		185		34366

In addition to recombinant botanical seed a total of 1391 vitroplants, representing 569 genotypes were shipped during the past year.

5.3 Other methods & tools

Quantitative genetics formula for estimating epistasis and the standard error of the estimate from a large diallel studies with 9 or 10 progenitors. The within-family analysis allows obtaining information on the relative importance of epistatic effects. In the absence of epistasis the equation:

$$\text{Espistasis Test} = \sigma^2_{c/F1} - 3 \text{ Cov FS} + 4 \text{ Cov HS} \approx 0$$

The variance to estimate standard error for this test was developed by the project as follows:

$$\text{Var (Test “n” Locations)} = \text{Var}(\sigma^2_{c/F1}) + 9\,\text{Var}(\sigma^2_{SCA}) + 4\,\text{Var}(\sigma^2_{GCA}) - 12\,[2/(r^2a^2k^2(p-2)]*[\,(MS_{sca})^2/(df+2)+(MS_{sca\ x\ Env.})^2/(df+2)]$$

$$\text{Var [Test one Location]} = \text{Var}(\sigma^2_{c/F1}) + 9\,\text{Var}(\sigma^2_{SCA}) + 4\,\text{Var}(\sigma^2_{GCA}) - 12\,[2/(r^2a^2k^2(p-2)]*[(MS_{sca})^2/(df+2)]$$

The development of this formula, although it may seem simple took about a year for development and constant consultation with quantitative genetics experts.

6. INDICATORS: PUBLICATION LIST.

6.1 Publications: journal articles.

<u>*Published or accepted for publication:*</u>

1. Ceballos, H., C.A. Iglesias, J. C. Pérez, & A.G.O. Dixon, 2004. Cassava breeding: opportunities and challenges. **Plant Molecular Biology** (in press).
2. Fregene M. , Okogbenin E., Marin J., Moreno I., Ariyo O., Akinwale O., Barrera E., Ceballos H., and Dixon A. (2004). Molecular Marker Assisted Selection (MAS) of Resistance to the Cassava Mosaic Disease (CMD). **Molecular Breeding** (in press)
3. Holguín, C.M.; Bellotti, A.C. 2004. Efecto de la aplicación de insecticidas químicos en el control de la mosca blanca *Aleurotrachelus socialis* (Homoptera: Aleyrodidae) en el cultivo de yuca *Manihot esculenta* Crantz. **Revista Colombiana de Entomología** 30(1):37-42.
4. Hurtado PX; Alvarez E; Fregene M; Llano GA. Detección de marcadores microsatélites asociados con la resistencia a *Xanthomonas axonopodis* pv. *manihotis* en una familia de yuca (bc1). **Rev Fitopatol Colomb.** (In press.)
5. Hurtado PX; Alvarez E. Búsqueda de genes análogos de resistencia asociados con la resistencia al añublo bacterial de la yuca. **Fitopatol Colomb** 27(2):59–64.
6. Jaramillo, G., N. Morante, J.C. Perez, F. Calle, H. Ceballos*, B. Arias and A.C. Bellotti. 2004. Diallel analysis in cassava (*Manihot esculenta* Crantz) adapted to the mid-altitude valleys environment. **Crop Science** (in press)
7. Kelemu, S., Mahuku, G., Fregene, M., Pachico, P., Johnson, N., Calvert, L., Rao, I., Buruchara, R., Amede, T., Kimani, P., Kirkby, P., Kaaria, S., and Ampofo, K. (2004). Harmonizing the agricultural biotechnology debate for the benefit of African farmers. **African Journal of Biotechnology** 2(11):394-416.
8. Llano GA; Alvarez E; Muñoz JE; Fregene M. Identificación de genes análogos de resistencia a enfermedades en yuca (*Manihot esculenta* Crantz), y su relación con la resistencia a tres especies de *Phytophthora*. **Acta Agron** 53(1/2). (In press.)
9. Lenis, J.I., F. Calle, G. Jaramillo, J.C. Perez, H.Ceballos, and J.H. Cock. 2004. The effect of leaf retention in cassava productivity. (Submitted to **Field Crops Research** and accepted for publication after minor changes).
10. Loke JB; Alvarez E; Vallejo FA; Marín J; Fregene M; Rivera S; Llano GA. Análisis de QTLs de la resistencia a pudrición de raíz causada por *Phytophthora tropicalis* en una población segregante de yuca (*Manihot esculenta* Crantz). **Acta Agron.** (In press.)
11. Okogbenin E., Marin J., and Fregene M. (2004). An SSR-based molecular genetic map of cassava and QTL analysis for early yield in a Pseudo F_2 population. **Crop Science** (In Press)
12. Riis, L.; Bellotti, A.C.; Bonierbale, M.; O'brien, G. 2003. Cyanogenic potential in cassava and its influence on a generalist insect herbivore *Cyrtomenus bergi* (Hemiptera:Cydnidae). **Journal of Economic Entomology** 96(6):1905-1914.
13. Riis, L., Esbjerg, P; Bellotti, A.C. Influence of temperature and soil moisture on some population growth parameters of the subterranean burrower bug *Cyrtomenus bergi* (Hemiptera: Cydnidae). **Florida Entomologist** (In press)
14. Trujillo, H.; Arias, B.; Guerrero, J.; Hernández, P.; Bellotti, A.; Peña, J.E. Survey for parasitoids of whiteflies in cassava growing regions of Colombia and Ecuador. **Florida Entomologist**, 87:268-273.

15. Xia L., Peng K., Yang S., Wenzl P., de Vicente M.C., Fregene M., and Kilian A. (2004) DArT for high-throughput genotyping of cassava (*Manihot esculenta*) and its wild relatives. **Theoretical and Applied Genetics** (In Press)

<u>*Submitted for publication:*</u>

1. Cach, N.T., J.I. Lenis, J.C. Perez, N. Morante, F. Calle and H. Ceballos. 2004. Inheritance of relevant traits in cassava (*Manihot esculenta* Crantz) for sub-humid conditions. (Submitted to **Plant Breeding**).
2. Calle, F., J.C. Perez, W. Gaitán, N. Morante, H. Ceballos, G.Llano & E.Alvarez. Genetics of relevant traits in cassava (*Manihot esculenta* Crantz) adapted to acid-soil savannas. (Submitted to **Euphytica**).
3. Carabalí, A.; Bellotti, A.C.; Montoya, J.; Cuellar, M.E. Adaptation of Biotype B of *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae) to cassava. **Crop Protection**.
4. Ceballos, H, T. Sánchez, A.L. Chávez, C. Iglesias, D.Debouck, G. Mafla, and J. Tohme. 2004. Variation in crude protein content in cassava (*Manihot esculenta* Crantz) roots. (Submitted to **Journal of Food Composition and Analysis**).
5. Chávez, A.L., T. Sánchez, G. Jaramillo, J. M.l Bedoya, J. Echeverry, E. A. Bolaños , H. Ceballos, & C.A. Iglesias. 2004. Variation of quality traits in cassava roots evaluated in landraces and improved clones. (Submitted to **Euphytica** and accepted for publication after minor changes).
6. Morante, N., X. Moreno, J.C. Perez, F. Calle, J.I. Lenis, E. Ortega, G.Jaramillo and H. Ceballos. 2004. Precision of selection in early stages of cassava genetic improvement. (Submitted to **Crop Science**).
7. Nguyen Thi Cach, JC Perez, JI Lenis, F Calle, N Morante and H. Ceballos. 2004. Epistasis in the expression of relevant traits in cassava (*Manihot esculenta* Crantz) for sub-humid conditions (Submitted to **Journal of Heredity**).
8. Perez, J.C., H. Ceballos, F.Calle, W. Gaitán, N. Morante, G.Llano & E.Alvarez. Additive, dominance and epistatic effects of relevant traits in cassava (*Manihot esculenta* Crantz) adapted to acid-soil savannas. (Submitted to **Theoretical and Applied Genetic**s).
9. Perez, J.C., H. Ceballos, Jaramillo, G., N. Morante, F. Calle, B. Arias and A.C. Bellotti. 2004. Analysis of the relative importance of epistasis in cassava (*Manihot esculenta* Crantz) adapted to the mid-altitude valleys environment. (Submitted to **Crop Science**).
10. Perez Velázquez, J.C. C.L. Souza Jr. L.A. Narro, S. Pandey, and C. De León. Genetic effects for maize traits under acid and non-acid soils. (Submitted to **Euphytica**)
11. Sánchez, T., A.L. Chávez, H. Ceballos, D.B. Rodriguez-Amaya, P. Nestel and M. Ishitami. 2004. Reduction or delay of post-harvest physiological deterioration in high-carotene cassava roots. (Submitted to **Journal of the Science of Food and Agriculture**).

6.2 Publications: book chapters and books.

1. Bellotti, A.; Peña, J.; Arias, B.; Guerrero, J.M.; Trujillo, H.; Holguín, C.; Ortega, A. 2004. Biological Control of Whiteflies by Indigenous Natural Enemies for Major Food Crops in the Neotropics. ***In:*** Whiteflies and whitefly-borne viruses in the tropics: building a knowledge base for global action.
2. Bellotti, A.; Tohme, J.; Dunbier, M.; Timmerman, G. 2004. Sustainable Integrated Management of Whiteflies through Host Plant Resistance. ***In:*** Whiteflies and whitefly-borne virases in the tropics: building a knowledge base for global action.

3. Howeler, R. 2004. Cassava in Asia: Present situation and its future potential in agro-industry. *In:* K. Fuglie (Ed.). Roots crops for Agro-Industry. Proc. International Workshop, Bogor, Indonesia.
4. Reddy, BVS, AF Rangel, B. Ramaiah and R. Ortiz. A research amd network strategy for sustainable sorghum production systems for Latin America. 2004. In MCS Bantilan, UK Deb, CLL Gowda, BVS Reddy, AB Obilana and RE Evenson (Eds.) Sorghum Genetic Enhancement: research process, dissemination and impacts. ICRISAT, Patancheru 502 324, Andhra Pradesh, India pp. 139-148.
5. Suyamto and R.H. Howeler. 2004. Cultural practices for soil erosion control in cassava-based systems in Indonesia. *In:* D.H. Barker, A. Watson, S. Sombatpanit, B. Northcult and A.R. Maglinao (Eds.). Ground and Water Bioengineering for the Asia-Pacific Region. 2001 Intern. Erosion Control Assoc. Science Publishers Inc., Enfield, NH, USA. (in press)

6.3 Publications: workshop and conference papers, presentations and posters.

<u>*Posters*</u>

1. Arias, B.; Bellotti, A.C.; Vargas, H.L. 2004. Nataima-31, a cassava (*Manihot esculenta)* variety resistant to the whitefly, *Aleurotrachelus socialis.* Sixth International Scientific Meeting of the Cassava Biotechnology Network. 8-14 March 2004, CIAT, Cali, Colombia.
2. Ariety resistant to the whitefly, *Aleurotrachelus socialis.* Sixth International Scientific Meeting of the Cassava Biotechnology Network. 8-14 March 2004, CIAT, Cali, Colombia.
3. Bellotti, A.C.; Bohórquez, A.; Arias, B.; Vargas, J.; Vargas, H.L.; Mba, Ch.; Duque, M.C.; Tohme, J. 2004. Recent advances in host plant resistance to whiteflies in cassava. Sixth International Scientific Meeting of the Cassava Biotechnology Network. 8-14 March 2004, CIAT, Cali, Colombia.
4. Carabalí, A.; Bellotti, A.C.; Montoya-Lerma, J. 2004. Adaptation of Biotype "B" of *Bemisia tabaci* to cassava. Sixth International Scientific Meeting of the Cassava Biotechnology Network. 8-14 March 2004, CIAT, Cali, Colombia.
5. Carabalí, A.; Bellotti, A.C.; Montoya, J. 2004. Comparación de la adaptabilidad del biotipo B de *Bemisia tabaci* (Homoptera: Aleyrodiade) a yuca comercial *Manihot esculenta* (Crantz) Mcol 2063 y silvestre *M. Carthaginensis***.** Resúmenes XXXI Congreso Sociedad Colombiana de Entomología, SOCOLEN. July 28-30, Bogotá, Colombia. p. 130.
6. Caicedo, A.M.; Trujillo, H.; Quintero, M.P.; Calatayud, P-A.; Bellotti, A.C. 2004. Reconocimiento de nematodos entomopatógenos asociados a *Cyrtomenus bergi* en tres localidades de Colombia**.** Resúmenes XXXI Congreso Sociedad Colombiana de Entomología, SOCOLEN. July 28-30, Bogotá, Colombia. p. 138.
7. Ceballos H; Perez J.C.; Calle F.; Morante N.; Lenis J.I. and Jaramillo G. Alternative for estimating general combining ability in cassava beeding. Sixth International Scientific Meeting of the Cassava Biotechnology Network. Cali, Colombia March 8-14, 2004.
8. Ceballos H.; Lentini Z.; Perez J.C. and Fregene M. Introduction of inbreeding in cassava through the production of doubled haploids. Sixth International Scientific Meeting of the Cassava Biotechnology Network. Cali, Colombia March 8-14, 2004.

9. Ceballos H; Perez J.C.; Jaramillo G.; Morante N.; Calle F. and Lenis J.I. Inheritance of agronomically relevant traits in cassava. Sixth International Scientific Meeting of the Cassava Biotechnology Network. Cali, Colombia March 8-14, 2004.
10. Ceballos H.; Fregene M.; Mejía S.; Castelblanco W.; and Morante N. Mutagenesis of cassava (*Manihot esculenta* Crantz) for the generation, identification and molecular analysis of novel traits. First FAO/IAEA Research Coordination Meeting on "Effects of mutagenic agents on the DNA sequence in plants" Vienna, Austria, 1-5 March 2004.
11. Chavarriaga, P.; Prieto, S.; Herrera, C.J.; Lopez, D.; Bellotti, A.C.; Tohme, J. 2004. Screening Transgenics Unveils Apparent Resistance to Hornworm (*E. ello*) in the non-Transgenic, African Cassava Clone 60444. Sixth International Scientific Meeting of the Cassava Biotechnology Network. 8-14 March 2004, CIAT, Cali, Colombia.
12. Chavez A. L.; Sánchez T.; Tohme J.; Ishitani M. and Ceballos H. Sampling variability in cassava roots for total carotene content. Sixth International Scientific Meeting of the Cassava Biotechnology Network. Cali, Colombia March 8-14, 2004.
13. Chavez A. L.; Sánchez T.; Tohme J.; Ishitani M. and Ceballos H. Effect of processing on B-carotene content of cassava roots. Sixth International Scientific Meeting of the Cassava Biotechnology Network. Cali, Colombia March 8-14, 2004.
14. Egesi C.; Castelblanco, W.; Morante N.; Mba C.; Ceballos H. and Fregene M. Identification of naturally occurring and irradiation-induced mutant GBSSI alleles of cassava in a heterozygous genetic background. Sixth International Scientific Meeting of the Cassava Biotechnology Network. Cali, Colombia March 8-14, 2004.
15. Herrera, C.J.; Prieto, S.; Chavarriaga, P.; Bellotti, A.C.; Tohme, J. 2004. Indicios de resistencia en plantas transgénicas de un clon africano de yuca, al gusano cachón, *Erinnyis ello* (Lepidoptera: Sphingidae)**.** Resúmenes XXXI Congreso Sociedad Colombiana de Entomología, SOCOLEN. July 28-30, Bogotá, Colombia. p. 131.
16. Holguin, C.M.; Mendoza, C.E.; Tauber, C.A.; Bellotti, A.C. 2004. Especies de la familia *Chrysopidae* asociadas al cultivo de yuca *Manihot esculenta* Crantz**.** Resúmenes XXXI Congreso Sociedad Colombiana de Entomología, SOCOLEN. July 28-30, Bogotá, Colombia. p. 137.
17. Howeler, R.H. 2004. Working with farmers in Asia: Spreading new varieties, improved practices and… new hope. Paper presented at VI Cassava Biotechnology Network (CBN) International Scientific Meeting, held in Cali, Colombia, March 8-14, 2004.
18. Kullaya A.; Mtunda K.; Kulembeka H.; Ferguson M.; Marin J.; Ospina C.; Barrera E.; Jarvis A.; Morante M.; Ceballos H.; Tohme J. and Fregene M. Molecular marker-assisted and farmer participatory improvement of cassava germplasm for farmer/market preferred traits in Tanzania. Sixth International Scientific Meeting of the Cassava Biotechnology Network. Cali, Colombia March 8-14, 2004.
19. Llano GA; Alvarez E; Fregene M; Muñoz JE. Identification of resistance-gene analogs in cassava (*Manihot esculenta*), and their relationship to three *Phytophthora* species. Poster presented at the Sixth International Scientific Meeting of the Cassava Biotechnology Network, Cali, Colombia. Page 121.
20. Loke J.B.; Alvarez E.; Corredor J. A.; Folgueras M.; Jaramillo G. and Ceballos H. Preliminary evidence of correlation between foliar and root resistance to root rot caused by Phytophtthora tropicalis in cassava. Sixth International Scientific Meeting of the Cassava Biotechnology Network. Cali, Colombia March 8-14, 2004.
21. Loke JB; Alvarez E; Fregene M; Marín J; Rivera S; Llano GA; Mejía JF. QTL mapping for resistance to root rot caused by *Phytophthora tropicalis* in cassava. Poster presented at the Sixth International Scientific Meeting of the Cassava Biotechnology Network, Cali, Colombia. Page 158.

22. Perez J.C.; Ceballos H; Lenis J.I.; Ortega E.; Calle F. and Morante N. Stability and genotype by environment analysis in cassava. Sixth International Scientific Meeting of the Cassava Biotechnology Network. Cali, Colombia March 8-14, 2004.
23. Perez J.C.; Ceballos H; Lenis J.I.; Ortega E.; and Morante N. Heritability of agronomically relevant traits in cassava. Sixth International Scientific Meeting of the Cassava Biotechnology Network. Cali, Colombia March 8-14, 2004.
24. Perez J.C.; Ceballos H; Ortega E.; Lenis J.I.; Calle F. and Morante N. Phenotypic and genetic correlations among agronomically relevant traits in cassava. Sixth International Scientific Meeting of the Cassava Biotechnology Network. Cali, Colombia March 8-14, 2004.
25. Perez J.C.; Ceballos H; Ortega E. and Lenis J.I. Analysis of genotype by environment interactions in cassava using the AMMI model. Sixth International Scientific Meeting of the Cassava Biotechnology Network. Cali, Colombia March 8-14, 2004.
26. Morante N.; Sánchez T.; Marin J.; Ospina C.; Gutiérrez J.; Barrera E.; Ceballos H.; Alzate A.; Moreno S. and Fregene M. Mining the primary gene pool of cassava: introgression of resistance to the cassava green mite and high root protein from accessions of *Manihot esculenta* sub spp flabellifolia and Manihot tristis into cassava. Sixth International Scientific Meeting of the Cassava Biotechnology Network. Cali, Colombia March 8-14, 2004.

Conferences

1. Alvarez E; Mejía JF; Llano GA; Loke JB. Detección de un fitoplasma asociado a Cuero de sapo de yuca (*Manihot esculenta* Crantz) en Colombia. Paper presented at the XXV ASCOLFI Congress, Cali.
2. Bellotti, A.C. 2003. Integrated Management of Cassava Arthropod Pests. Success Stories: Present and Future Research. Annual Review, PE-1. 9-12 December 2003. CIAT, Cali, Colombia.
3. Bellotti, A.C. 2004. Recent Advances in Whitefly (*Aleurotrachelus socialis* Bondar; Homoptera: Aleyrodidae) Resistance in Cassava (*Manihot esculenta* Crantz). SP-IPM Inter-Institutional Working Group (IIWG) Meeting, 22-26 February 2004, CIMMYT, Mexico.
4. Bellotti, A.C. 2004. Integrated Management of Cassava Arthropod Pests. Success Stories: Present and Future Research. Sixth International Scientific Meeting of the Cassava Biotechnology Network-CBN. 8-14 March 2004, CIAT, Cali, Colombia.
5. Bellotti, A.C. 2004. Control Biológico en los Neotrópicos. Una Revisión Selectiva con Énfasis en Yuca. I Seminario Internacional y II Nacional de Control Biológico de Plagas y Enfermedades en los Cultivos, April 28-30 2004, Sangolquí, Ecuador.
6. Bellotti, A.C. 2004. Recent Advances in Whitefly (*Aleurotrachelus socialis*) Resistance in Cassava. 15th International Plant Protection Congress – Beijing International Convention Centre, May 11-16, 2004, Beijing, China.
7. Bellotti, A.C. 2004. Integrated Management of Cassava Arthropod Pests. University of Florida, Gainesville, FL, USA. June 3, 2004.
8. Bellotti, A.C. 2004. Integrated Management of Cassava Arthropod Pests. University of Florida, Homestead, FL, USA. June 4, 2004.
9. Bellotti, A.C. 2004. Recent Advances in Whitefly Resistance in Cassava. Florida Entomology Society, Fort Lauderdale, FL, USA. July 25-27, 2004.
10. Ceballos, H., A.L. Chávez, and T. Sánchez. 2004. Improving cassava nutritional value through the Harvest Plus Challenge Program. IVACG Meeting. Lima, Peru. November 15-17, 2004.

11. Ceballos, H.; Fregene, M.;Sánchez, T.; Pérez J.C.; and Lentini, Z. Approaches for modifications of starch quality traits in cassava through conventional breeding. Workshop on starch biosynthesis and cassava biotechnology. Chulalongkorn University. Bangkok, Thailand. May 10-12, 2004.
12. Ceballos, H., J.C. Perez, A.L. Chávez, T. Sánchez, F. Calle, N. Morante, G. Jaramillo. 2004. Cassava research and nutrition value. ECHO Agricultural Missions Conference. Fort Myers, Florida, USA. November 8-10, 2004.
13. Howeler, R. H. 2004 A participatory and inter-institutional project to enhance the sustainability of cassava production in Thailand, Vietnam, and China: Its impact on soil erosion and farmers' income. Paper presented at the International Conference on Interdisciplinary Curriculum and Research Management in Sustainable Land Use and Natural Resource Management, held in Bangkok, Thailand. Aug 17-19, 2004.
14. Howeler, R.H., B. Palmer, K. Hartojo and C. Piggin. 2003. Evaluation of cassava and bean germplasm in East Timor. *In*: H. da Costa, C. Piggin, C.J. da Cruz and J.J. Fox (Eds.). Agriculture: New Directions for a New Nation East Timor (Timor-Leste). Proc. Workshop held in Dili, East Timor. Oct 1-3, 2002. pp. 95-101.
15. Howeler, R. H., W. Watananonta, W. Vongkasem and K. Klakhaeng. 2004 Working with farmers: The challenge of achieving adoption of more sustainable cassava production practices on sloping land in Asia. Paper presented at the Sustainable Soil and Water Management (SSWM) International Conference, held in Chiangmai, Thailand. Sept 5-9, 2004.
16. Jaramillo, G., J.I. Lenis, F.Calle, N. Morante, E. Ortega, J.C. Perez and H. Ceballos. 2004. Relationship between traits measured at different stages of the selection process in cassava. ISTRC-African Branch. ISTRC-African Branch. Nairobi, Kenya. November 1-5, 2004.
17. Loke JB; Pérez JC; Alvarez E; Cuervo M; Mejía JF; Llano G.; Pineda B. Cuero de Sapo: *Una Enfermedad de la Yuca* -Once Preguntas Muy Interesantes de Agricultores-. Poster presented during the release of new cassava varieties. Montería, Córdoba.
18. Maziya-Dixon, B., A. G. O. Dixon, R. Asiedu, R. Kapinga, M. Andrade, M. Bonierbale, and H. Ceballos. 2004. Biofortification of Root and Tuber Crops: A Novel Approach. ISTRC-African Branch. Nairobi, Kenya. November 1-5, 2004.
19. Morante, N., T. Sanchez, J. Marin, C. Ospina, J. Gutierrez, E. Barrera, H. Ceballos, A. Alzate, S. Moreno, M. Fregene. 2004. High Root Protein Content in Accessions of Wild Manihot species and *Manihot esculenta* land races from Guatemala. ISTRC-African Branch. ISTRC-African Branch. Nairobi, Kenya. November 1-5, 2004.
20. Rao, I., Ayarza, M., Trouche, G., Ceballos, H., Alves, A., Miles, J., Argel, P., Schmidt, A., Peters, M., Holman, F., Lundy, M., Quirós, C., Rondon, M., Monneveux, P., and Córdoba, H. Improving crop and forage adaptation to dry conditions of Central America. Climate Change Workshop. Catie, Costa Rica. March 16-18, 2004.
21. Watananonta, W., S. Charoenrath, S. Tangsakul, S. Nual-On, W. Vongkasem, K. Klakhaeng, B. Vankaew and R.H. Howeler. 2004. The use of a farmer participatory approach in the development of technologies to control erosion for sustainable cassava production. Paper presented at 5th Scientific Meeting of Maejai University, held in Chiangmai, Thailand. May 20-21, 2004. (Thai and English abstract).
22. Watananonta, W., S. Tangsakul, P. Phetpraphai and R.H. Howeler, 2004. The effect of application of micronutrients on the root yields of two cassava varieties. Paper presented at 42nd Scientific Meeting of Kasetsart University, held in Bangkok, Thailand. Feb 5, 2004. (in Thai)

6.4 Publications: extension bulletins and brochures

1. W. Watananonta. 2004. Farmer Participatory Research in Cassava Production. Scientific paper submitted to DOA, Thailand. 84 p. (in Thai).

7. INDICATORS: TRAINING

7.1 Courses and workshops organized or supported with scientific capacity from the project.

Table 5. List of courses and workshops organized or supported with scientific capacity from the project.

COURSE TITLE	# Participants
Conference and field day. MIP in whitefly and Cassava Frogskin (CFS)	70
Conference and field day (MIP on Cassava whitefly) in an International Course about Modern Systems of Production, Processing and Utilization of Cassava	40
Integrated Pest Management in Cassava in the Coffee-growing Region	28
Integrated Management of arthropod pests.	9
Sixth International Scientific Meeting of the Cassava Biotechnology Network.	150
Censo de Plantas Procesadoras de Yuca para Uso Industrial	35

7.2 Training through research thesis of undergraduate and graduate students.

Table 6. List of undergraduate and graduate students enrolled during the year 2004 with the cassava breeding project.

Area of Research	Undergraduate		Graduate	
	Female	Male	Female	Male
Breeding	6	1	5	2
Pathology	4	0	0	0
Entomology	0	1	0	1
Genetics	3	0	2	2

7.3 Training through research thesis of undergraduate and graduate students.

Table 7. Number of visiting scientists that have spent more than two weeks in collaborative activities with the cassava breeding project during the year 2004.

Area of Research	Visiting Scientists
Breeding	5
Pathology	5
Entomology	0
Genetics	4

7.4 Training of farmers through field days, visits to their farms, fairs and workshops.
It is difficult to maintain a careful accounting of the number of farmers that have benefited from the technical capacity of personnel working in the project. It is fair to say that no less that 500 farmers have been exposed through the kind of activities such as field days, visits to their farms, fairs and workshops

8. INDICATORS: RESOURCE MOBILIZATION LIST

8.1 List of proposals funded in 2004; dollar value of contract & donor

1. Modification of Flowering in cassava and Mango using cloned flower gene from Arabidopsis. Rockefeller foundation US$280,000 for 4 years.
2. Development of a High Capacity Starch Laboratory Analysis. Colociencias/Corn Products. US$ 118,000 for three years.
3. Introduction of inbreeding in cassava. Rockefeller Foundation. US$ 1,000,000 for three years.
4. HarvestPlus Challenge Program. US$238,221/year (renewable every year depending on the delivery of results).
5. Mutagenesis in cassava (in collaboration with National Univ. Colombia). IAEA. US$.50,000 for five years.
6. Cassava Development Poles in Colombia. MADR/FENAVI. US$120,00/year (renewable every year depending on the delivery of results).
7. Identification of insect vectors and alternative hosts of phytoplasmas causing cassava frogskin disease. Presented to USAID. Funds requested: US$ 12,000 for one year.
8. Desarrollo de estrategias de manejo de cuero de sapo y superalargamiento en yuca, mediante investigación participativa. Presented to Ministerio de Agricultura y Desarrollo de Colombia. US$14.546 for one year.
9. Sustainable cassava production in key countries in Asia. NIPPON Foundation. Duration of the project is three years. 154,000US$/year.
10. Enhancing the Adoption of Improved Cassava Production and Utilization Systems in Indonesia and East Timor. Financed by ACIAR with 17,225 US$/year.
11. Elaboración de una guía técnica para procesos y análisis de almidones de yuca. FAO. US$13,800 for one year.

8.2 List of proposals submitted in 2004, value & donor.

1. BioCassava Plus, a project that will develop new cassava cultivars designed to improve the nutritional status of sub-Saharan Africa. Gates Foundation, US$260,000 for 5 years
2. Development of Low-Cost Technologies for Pyramiding Useful Genes From Wild Relatives of Cassava into Elite Progenitors. GCP, US$894,420 for 3 years
3. Identifying the physiological and genetic traits that make cassava one of the most drought tolerant crops. GCP, US$78,806 for 3 years.
4. Validation of Diversity Arrays Technology (DArT) as a platform for efficient discovery and utilization of molecular marker – trait associations in orphan crops. GCP, US$860,405 for 3 years

5. Capacity Building in molecular breeding and transfer of technology to improve preferred Cassava Varieties for consolidation of Food Security and generation of income for small-scale farmers in Africa. FAO, US$332,000 for 3 years
6. 'Express' Dissemination of Improved Cassava Varieties in Nigeria and Senegal Based on the Automated Temporary Immersion System (ATIS) and a Multi-stage Farmer Participatory Multiplication Program. DURAS, Equivalent to US$178,000 in Euros for 3 years, in collaboration with NRCRI, Nigeria.
7. Securing the Harvest: Molecular-Assisted Introgression of Genes for Delayed Post-Harvest Physiological Deterioration (PPD), high protein and beta-carotene content into African Cassava Gene Pools. DURAS, Equivalent to US$190,000 in Euros, in collaboration with NRCRI, Nigeria.
8. Manejo Integrado de Enfermedades del Cultivo de Yuca. Presented to Ministerio de Agricultura y Desarrollo de Colombia and IICA. Funds requested: US$ 77.700.
9. Pest and disease resistance, drought tolerance and increased shelf life genes from wild relatives of cassava and the development of low-cost technologies to pyramid them into elite progenitors. Presented to The generation challenge programme. Funds requested: US$ 289.200 per year, for 3 years.
10. An applied biotechnology for income generation of poor farmers communities growing cassava in Africa, Latin America and Asia. Presented to the Dgis / AVEBE on February 13, 2004. US$440,898 for four years.
11. Dynamic assessment of transgenic cassava conferring leaf retention: biology, physiology, proteomics and metabolics. Joint ETH-CIAT proposal to ZIL (Switzerland). March 31, 2004.Equivalent of 148,700US$ in Swisss Francs for three years.
12. Current status of nutritional quality of cassava roots regarding carotenes, iron and zinc. Joint proposal with Ohio State University, Danforth Center, ETH, and CIAT for part of the work to be conducted within the Harvest Plus initiative (This is a different activity to that our project is already doing for Harvest Plus). Fund requested US$ 200,000 for five years.
13. Comparative analysis of the beta-carotene and starch biosynthetic pathway in storage organs of cassava based on results obtained in sweet potato. A CIAT – ARC (Seibersdorf – Austria) research proposal. For different projects for CIAT for a total of the equivalent of US$88,000 in Euro.

9. NEW DIRECTIONS FOR 2005.

There is an important change in direction of the research activities in the cassava genetic improvement project. This change has already been mentioned as one of the highlights. A larger emphasis will be given to the development (through many different approaches) and identification (also using new techniques when appropriate) of high-value cassava germplasm. This change in direction involves many different research capacities ranging from the support from the Genetic Resources Unit and the Germplasm Bank it manages, to molecular approaches.

The project is gradually emphasizing the investment in developing more strategic research. Rather than producing new germplasm each year, we are also interested in developing new breeding alternatives. In this regard our strategies range from the introduction of inbreeding, to the application of marker assisted selection tools, to the development of quantitative genetic concepts specifically adapted to the case of cassava breeding.

10. RESEARCH ACTIVITIES FOR THE PERIOD 2005-2007.

Project IP-3: Improved cassava for the developing world

Project Description

Objective:
To develop germplasm, methods and tools for increased productivity and value of the cassava crop that will result in increased income and development of rural communities involved in cassava growth and processing.

Outputs:
1. Genetic base of cassava and related Manihot species evaluated and available for cassava improvement.
2. Genetic stocks improved gene pools developed and transferred to national programs.
3. New methods for cassava breeding developed.
4. Research on the industrial uses of cassava and elite germplasm produced.
5. Breeding for insect and other arthropods and disease resistance and development of alternative methods for their control.
6. Development and use of biotechnology tools for cassava improvement.
7. Integrated cassava-based cropping systems in Asia. Widespread adoption of farming practices that enhance sustainability.

Gains: The rural populations in Africa, Asia and Latin America and the Caribbean benefit by increased productivity, enhanced value of the products produced, and flexibility by the availability of different processing alternatives for cassava.

Milestones:

2005 Consolidations of the first "Trapiches Yuqueros" (Cassava Drying Mills) in Colombia. A novel approach for cassava to promote rural development that could be replicated in other countries.
Development of an alternative breeding method based on the production of doubled-haploids and introduction of inbreeding in cassava genetic improvement.

2006 The first set of S2 lines planted in the field and evaluated for key traits such as starch quality and cyanogenic potential.
Better understanding of methods for the control of post-harvest physiological deterioration. First generation of crosses specifically designed for increased carotene content in the roots evaluated in Clonal Evaluation Trials in target environments.
First genetically modified cassava planted in the field following strict biosafety regulations.

2007 New molecular markers developed for resistance to white flies and mites, carotene content, and high dry matter content.
TILLING system implemented in mutagenesis project to produce and identify cassava clones with novel starch properties.
Large number of crosses with wild relatives of cassava evaluated for key agronomic traits (insect and disease resistance, nutritional quality, extended shelf life of roots and acyanogenesis).

Users:
Immediate beneficiaries are farmers growing cassava as a cash crop or for subsistence farming. Close beneficiaries are processing industries related to cassava (for animal feed, for processed food, for starch or derived products).

Collaborators:
NARs in Asia (particularly in Thailand, Vietnam, China, India and Indonesia), Latin America (particularly Brazil, Colombia, Cuba, Dominican Republic, Haiti, Nicaragua, Peru and Venezuela), an Africa (Ghana, Ivory Coast, Nigeria, South Africa, Tanzania, and Uganda). IITA and IFPRI (CG Centers), CLAYUCA, and private sector involved in cassava processing. Advanced research laboratories (Danforth Center, Cornell and Ohio State University in the USA; Wageningen University in The Netherlands Uppsala University in Sweden, KVL University in Denmark and ETH in Switzerland).

CGIAR system linkages:
IITA cassava breeding (5%); Biofortification Initiative (25%); Training (15%); Information (15%); Networks (20%); Organization and Management (10%). Participates in the Global Cassava Strategy (10%)

CIAT: IP-3 PROJECT LOGFRAME (2003-2006)

PROJECT: IMPROVED CASSAVA FOR THE DEVELOPING WORLD
PROJECT MANAGER: HERNÁN CEBALLOS

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
Goal To improve the livelihoods of rural populations in Latin America, Africa and Asia by increasing cassava productivity, while protecting the environment and enhancing the value of products derived from this crop.	Increased productivity of cassava clones. Widened uses for cassava. Increasing the area planted to the crop.	National statistics of different countries where projects have been implemented. Recognition of private sector (processing)	
Purpose To develop methods and tools that will make the genetic improvement of cassava more efficient and to identify valuable germplasm for the breeding project. Eventually a technology package involving germplasm, cultural practices and processing alternatives will be made available to rural communities.	By the end of year 2006, the project has consolidated the technology packages for alternative industrial uses of cassava as well as strengthened the reliability and sustainability of the crop as a source of food security for subsistence farming.	Reports and project documents of our partner institutions. Reports from the processing sector. Scientific publications	Political and institutional support for sustainable rural and agricultural development at the reference sites and targeted countries is maintained. Natural disasters and civil strife do not impede progress toward contributing to the project's goal. Absence of drastic changes in the price of maize as a commodity that greatly affects cassava competitiveness.
Output 1 Genetic base of cassava and related Manihot species evaluated and available for cassava improvement.	True retention of carotenes after processing determined (2004) and published (2005). Method for storage/shipment of roots determined (2004) and published (2005). Effect of carotene content on PPD determined (2004) and published (2005). Number of new clones and self-pollinations produced and evaluated combining high carotene content and desirable agronomic traits (2004-2007). Confirmation of stability of carotene, Fe and Zn contents in roots from selected clones determined (2004) and published (2005).	Articles published. Annual reports and project proposals. Clones developed to take advantage of findings from this output.	Natural disasters or civil strife do not impede progress toward achieving the project's goal. Cassava germplasm bank is maintained in the field.

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
	Knowledge on the possibility of further increasing levels of carotenes through self-pollinations or specific crosses (2006). New generation of clones with higher carotenes or better agronomic performance (2007).		
Output 2 Genetic stocks improved gene pools developed and transferred to national programs**.**	Protein content in selected clones from Central America confirmed (2005). High and low amylose content in roots from selected clones confirmed (2005). Planting of 3000 genotypes induced for mutation (2004) production of self-pollinated seed (2005). Evaluation for starch quality (2006) and implementation of TILLING**.**	Project home page. Annual reports and working documents. Scientific publications. Shipment of germplasm to collaborators in different countries.	Natural disasters or civil strife do not impede progress toward achieving the project's goal. Adequate funding for research activities.
Output 3 New methods for cassava breeding developed	Number of S_1, S_2 and S_3 seed produced and planted in the field (2004-2007). Six articles on inheritance of quantitative traits submitted for publication (2004-2005). Two scientific articles on cassava breeding submitted for publication (2004-2005). Analysis of the impact of the new evaluation/ selection scheme conducted (2004) and published (2005). Search of useful recessive traits in partially inbred germplasm incorporated as routine in the breeding project (2004-2007).	Case studies published. Annual reports and working documents. Submission of joint research proposals. Support from private sector	Natural disasters or civil strife do not impede progress toward achieving the project's goal. Willingness of IITA to continue the collaboration we have had.
Output 4 Research on the industrial uses of cassava and elite germplasm produced	Number of germplasm produced and evaluated (2004-2007). Performance of elite germplasm identified 2004-2007 Number of officially released varieties. Area planted to cassava germplasm developed totally/partially by CIAT (2007). Number of *"Trapiches Yuqueros"* consolidated (2005). Information of alternative uses of cassava	Project proposals and reports. Accessions planted and maintained in the field. Introduction of new accessions	Natural disasters or civil strife do not impede progress toward achieving the project's goal.

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
	products developed by CLAYUCA from roots and foliage (2005). Progress to introduce artificial drying processes in other countries from Latin America (2007). Number of clones (vitroplants) or new genotypes shared with collaborating NARs and IITA (on a yearly base 2004-2007).		
Output 5 Breeding for insect and other arthropods and disease resistance and development of alternative methods for their control.	Number of germplasm evaluated for their reaction to insects and arthropods with emphasis in white flies and mites (2004-2007). Number of germplasm evaluated for their reaction to diseases with emphasis in bacterial blight, root rot and super elongation disease (2004-2007). Results of field studies to determine how and who transmits the frog skin disease (2007). Identification of the etiology of frog skin disease (2007). Number of crosses with wild relatives evaluated every year in search of resistance to pests and diseases (2005-2007)	Annual reports and working documents. Scientific publications. Development of commercial products for biological control of pests in cassava.	Natural disasters or civil strife do not impede progress toward achieving the project's goal. Adequate funding for research activities.
Output 6 Development and use of biotechnology tools for cassava improvement	More than 700 CMD resistant hybrids (10 plants per genotype) shipped to Africa (Tanzania, Nigeria, Uganda, and South Africa) and India. (2005). About 300 CMD resistant hybrids (10 plants per genotype) shipped to Tanzania, hardened and transferred to the field. Latin American germplasm transferred to the field in Ghana and Nigeria and evaluated for high protein content and resistance to pest and diseases. Field results on starch quality from a transgenic clone with waxy starch developed with anti-sense technology (2005-2006).		Natural disasters or civil strife do not impede progress toward achieving the project's goal. Adequate funding for research activities.

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
	Molecular markers for resistance to beta-carotene (2005) developed and validated with field data (2007). Molecular markers for resistance to dry matter content (2005) developed and validated with field data (2007). Molecular markers for resistance to mites developed (2005) and validated with field data (2007).		
Output 7 Integrated cassava-based cropping systems in Asia. Widespread adoption of farming practices that enhance sustainability	Research partnerships established in Laos and Cambodia (2005). Number of trials introducing new germplasm/ technologies established (2006). Number of communities adopting new germplasm/technologies in Laos and Cambodia (2006).		