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Combating Hidden Hunger in Latin America Biofortified Crops with Improved Vitamin A, Essential Minerals and Quality Protein

Final Report to the Canadian International Development Agency

18 January 2011

Biofortified crops, developed through conventional plant breeding to have superior agronomic and nutrition characteristics (compared to current predominantly grown crops), can be part of the solution for increased food sufficiency and greater food and nutrition security in Latin America and the Caribbean.

AgroSalud is a consortium of centers from the Consultative Group on International Agriculture Research (CGIAR), national agricultural research systems (NARS), universities and others formed in 2005 through funding from the Canadian International Development Agency (CIDA). AgroSalud partners work in 14 Latin American and Caribbean (LAC) countries in the development, evaluation, dissemination and promotion of biofortified crops and food products. AgroSalud has the backing of Central American Ministers of Agriculture and the World Food Program-LAC who recognize the contribution of biofortified crops to improve food and nutrition security.

AgroSalud seeks to contribute to solving the problems of malnutrition in Latin America and the Caribbean through staple cultivars with improved nutritional value. Rice, beans and maize are primary staples of the diet in the greater part of the region. Sweet potatoes are native to the Americas and can potentially satisfy human requirements for provitamin A. These crops are within reach of the poorest of the poor, both in rural areas where they are produced and consumed, and in marginal urban areas where diets are often deficient. Genetic improvement employs conventional plant-breeding methods to reach these ends.

To date, AgroSalud partners have commercially released 21 maize cultivars with higher tryptophan and lysine levels in Bolivia, Colombia, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua and Panama; 8 rice cultivars with higher iron in Bolivia, Cuba and Panama; 5 bean cultivars with higher iron in Bolivia, Brazil Cuba, and Guatemala; and 8 sweet potato cultivars with more beta-carotene in Brazil, Cuba, Dominican Republic, Haiti, and Peru (Figure). An additional 10 nutritionally enhanced cultivars are in the pipeline for release in 8 countries in 2011-2012.

With released and disseminated cultivars in place, engaged national and international partners, and a need for improved food and nutrition security in LAC, the region is well-situated to benefit from CIDA's initial investment in biofortification. Next steps include breeding to push the levels of nutrients even higher, training of partners to multiple quality seed, integration of biofortified seed into national and regional food-security programs to accelerate massive dissemination of crops, alliances with food industry to get biofortified ingredients into processed foods, and evaluation of the impact of these actions on food and nutrition security. Target countries where these activities can quickly move forward include Bolivia, Brazil, El Salvador, Guatemala, Haiti, Honduras, Mexico, and Nicaragua.

Key Achievements in the AgroSalud Project

In the past five years, AgroSalud plant breeders have made <u>significant breeding progress with increasing the nutrient concentration of target crops</u>. As such, there are now experimental and advanced breeding lines that meet or surpass the nutrient goals established for rice, sweet potato, beans and maize. For example, advanced breeding lines in rice have met 90% of the iron (8 mg/kg) and zinc (24 mg/kg) goals established (Martínez et al., 2010), and sweet potato in variety release have clearly surpassed the beta-carotene goal (247 mg/kg) and are approaching iron (8 mg/kg) and zinc (5 mg/kg) goals (Gruneberg et al., 2010).

Getting these improved crops into the hands of farmers has been achieved through a diversity of partners, as these examples attest. First, with NARS, NGOs or universities, 41 nutritionally enhanced cultivars were commercially released in 13 LAC countries from 2007-2010 (e.g., CENTA, 2008; IDIAP, 2010). Second, available seed was disseminated to farmers (e.g., Visión Mundial Nicaragua, 2009). For example, in Haiti, 30 tons of quality protein maize seed were distributed in collaboration with the FAO staple-crop seeds program, reaching over 1500 farmers in 2008. In the same year, the Nicaraguan NARS distributed 27,000 orange-fleshed sweet potato cuttings to four NGOs to establish family gardens among their program beneficiaries. In Central America, the commercial production of quality protein maize seed reached 190 metric tons in 2008; enough to plant ~12,000 ha to obtain grain for human consumption. In 2009, commercially released rice with higher iron was planted by 180 farmers in Bolivia and 150 farmers in Cuba. In 2006-2010, 2386 (30% female) technicians and farmers in Central America received training in biofortification, seed production (thus reducing their dependence on outside sources for this seed), and crop management, among others.

Consumers in urban settings in Colombia are being reached through an alliance between AgroSalud partners and the private industry. Nutritionally improved crops have been used in the production of three food products developed with maize, rice and sweet potato. For example, 1700 units of biofortified maize-substituted *mazamorra* were sold by Pampa Ltda. using the same marketing strategy and price as the product made with conventional maize. Company representatives reported no problems with this product (Sonia Gallego, CLAYUCA, personal communication). Further, a wide array of products have been developed with nutritionally enhanced crops, but not at commercial scale, such as maize grits, extruded maize, *arepas* made from maize, maize or sweet potato beverages, sweet potato noodles, as well as snacks (Rangel et al., 2008a, 2008b; Silva et al., 2008a, 2008b, 2009).

Political support for AgroSalud has been obtained at different levels. AgroSalud has the backing of Central American Ministers of Agriculture who recognized the contribution of biofortified crops to improving food and nutrition security, requested continued collaboration of AgroSalud with NARS, and resolved to support the continuation of activities carried out by AgroSalud (Appendix 2). Biofortification has been integrated into the National Anemia Control and Prevention Plan in Cuba (Magaly Padrón, Instituto de Nutrición e Higiene de Alimentos, personal communication). In Panama, biofortified crops form part of the National Micronutrient-Deficiency Control and Prevention Plan (Comité Nacional de Micronutrientes, 2008), as well as the National Food and Nutrition Security Plan (Eyra de Torres, World Food Program-Panama, personal communication). Nicaragua's National Food and Nutrition Security Plan also includes biofortification (MAGFOR, 2009). Further, the World Food Program promotes biofortification as a public-health strategy and is interested in forming a strategic alliance with AgroSalud (Helena Pachón, CIAT, personal communication). They have actively supported national biofortification workshops in Panama (August 2009), Ecuador (October 2009) and Peru (March 2010).

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Institutionalization of the biofortification approach has occurred and will serve to enhance its sustainability. In Brazil, this is evidenced by the BIOFORT (http://biofort.ctaa.embrapa.br/ eng/index eng.php) and CNPQ grants obtained by EMRAPA for biofortification activities in-country. The Panamanian government has self-financed biofortification research in maize, rice, beans and sweet potato for the past 4 years. In countries where AgroSalud works, there has been an important paradigm shift whereby plant breeders see themselves as protagonists in improving the nutritional profile of the foods their countrymen eat. Many have also engaged, for the first time, with colleagues in health and nutrition, who also see the role for agriculture in addressing food and nutrition insecurity. Taken together with the policy changes effected at national levels, these cross-sectoral engagements portend internalization of biofortification in future agriculture and nutrition actions taken in many countries throughout LAC.

Methodological standards were tested and implemented to (1) control for year-to-year nutrient variation through the use of checks, (2) minimize nutrient contamination and degradation during harvest, handling and analysis and (3) rapidly and reliably measure nutrient concentrations in thousands of samples annually. These activities were conducted in coordination with the HarvestPlus project (for example, "Crop Sampling Protocols for Micronutrient Analysis" published by HarvestPlus (Stangoulis & Sison, 2008) was translated to Spanish by AgroSalud) and with support from CIP scientists.

Training was offered to partners in Latin America and the Caribbean in a diversity of topics: biofortification, breeding, NIRS technology, seed production, hybrid maize seed production, crop management, validation trials, handling of in vitro plantlets, use of tissue-culture technologies for cassava and sweet potato, development of food products, extrusion technologies, nutrient analyses, and sensory evaluation.

Communication efforts focused on maintaining partners informed as well as the larger Latin American community about biofortification and advances in AgroSalud. This was accomplished through quarterly e-bulletins, a dynamic website (www.AgroSalud.org) with over 16,000 visitors in four years, news releases, hosting of visitors (487 in CIAT alone), participation in conferences, social network presence through facebook, television and radio interviews, and support with print materials for crop releases and other activities in partner countries. Embrapa colleagues were especially effective in publishing, with more than 140 abstracts, papers and book chapters and over 500 media insertions.

Further achievements obtained in different topical areas in the first phase of AgroSalud are discussed in the following appendices:

- Annex 1. Bean breeding
- Annex 2. Maize breeding
- Annex 3. Rice breeding
- Annex 4. Sweet potato breeding
- Annex 5. Seed production and dissemination
- Annexes 6 and 7. Food-product development
- Annex 8. Geographic targeting
- Annex 9. Nutrition-impact evaluation
- Annex 10. Socioecnomic-impact evaluation
- Annex 11. Communications

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Lessons learned

Lessons learned in AgroSalud include:

- Nutrient levels in staple crops can be increased through conventional plant breeding.
- Germplasm exchange among partners in different countries is essential to getting the best cultivars in as many countries as possible; intellectual-property issues in some countries are negatively affecting this exchange.
- Cultivars bred for one country can be favorably taken up in other countries with similar agro-ecological conditions and farmer/consumer preferences (e.g., small-seeded black beans in Central America and the Caribbean).
- Nutritionally enriched materials for drought conditions are particularly needed in Central America.
- Consumers favorably evaluated most nutritionally enhanced crops in sensory evaluations, suggesting they will consume them when they are released and locally available.
- Seed multiplication and dissemination systems in LAC require strengthening and supporting to ensure that commercial release of crops is accompanied with abundant, quality seed for farmers.
- Dissemination of biofortified crops should be supported by their inclusion in government-supported input-subsidy programs targeting small farmers.
- Some NARS require strengthening in infrastructure and capacity building to be able to develop, evaluate and disseminate biofortified crops.
- Government and non-governmental partners see value in biofortification as a food-based approach to address food and nutrition insecurity; these partnerships need to be strengthened.
- The magnitude of the potential nutrition and economic impacts of biofortified crops varies by country, crop and nutrient; targeting is needed to optimize resources.
- The food-basket approach, whereby multiple biofortified crops are promoted in one country, is a good model for LAC and should be encouraged.
- The private sector is interested in developing food products with biofortified crops; for this to come to fruition, a reliable, constant supply of improved crops is needed.
- Delivering biofortified crops to rural families can be done through existing partners; new alliances need to be formed to get biofortified crops and food products to nutritionally vulnerable urban populations.
- New estimates from the World Health Organization suggest that vitamin A deficiency is a much less important public health problem in LAC than iron deficiency.
- The impact (agronomically, economically and nutritionally) of biofortified crops is widely unknown as these past years focused on crop development; *ex-post* analyses are needed to accurately quantify these impacts.

These lessons learned point to what should be considered in a second phase of AgroSalud:

- A focused approach in selected countries where nutritional need is greatest, high consumption levels provide good potential for impact, and working relationships with local partners are established.
- Openness to the potential for secondary spread whereby cultivars biofortified for one country setting can be easily transferred to others.

- An innovative strategy to improve existing distribution channels as a means to increase the urban poor's access to biofortified crops and food products.
- Strengthening of government and non-governmental partnerships to increase the number of farmer families receiving or purchasing quality, biofortified seed.
- Replacing currently available breeding population at NARS with biofortified breeding populations.
- An adequate approach to solve intellectual property concerns regarding germplasm sharing through a meeting with concerned NARS who share the mission to deliver public goods.

Partners

Achievements in AgroSalud were due to work among the following committed partners:

CIAT, Colombia
CIMMYT, Mexico
CIP, Peru
CLAYUCA, Colombia
EMBRAPA, Brazil

Academia de Dibujo, Colombia
ADEL, Guatemala
Alcaldía del municipio de Caldono, Colombia
Asociación de Ingenieros Agrónomos del Atlántico, Colombia
ASPAR, Bolivia
CAMAGRO, El Salvador
CARITAS, Nicaragua
CENTA, El Salvador
Centro Filogenético Pairumani, Bolivia
CeSSIAM, Guatemala
CIAT-Santa Cruz, Bolivia
Corpoica, Colombia
Cristiani Burkart, Central America
CRS, Guatemala, Nicaragua
DICTA-Honduras
Escuela Agrícola Panamericana-Zamorano, Honduras
FAO, Nicaragua
Federación Nacional de Arroceros (FEDEARROZ), Colombia
Federal University of Rio de Janeiro, Brazil
FENALCE, Colombia
FIDAR, Colombia
FIDER, Nicaragua
FIPAH, Honduras
Fundación EPSA, Colombia
Fundación Familia Padre Fabretto
Gobernaciones del Valle, Cauca, Nariño & Cesar, Colombia
ICTA, Guatemala
IDIAF, Dominican Republic
IDIAP, Panama
IMPRHU, Nicaragua

INIA, Peru
INIFAP, Mexico
INIVIT, Cuba
Instituto Colombiano de Bienestar Familiar, Colombia
Instituto de Investigaciones de Granos (antes, IIARROZ), Cuba
Instituto de Nutrición e Higiene de Alimentos, Cuba
INTA, Nicaragua
ISA, Dominican Republic
MAG, El Salvador
MAGA, Guatemala
MAGFOR, Nicaragua
Maranhoa State, Brazil
Ministerio de Agricultura y Ganadería, Costa Rica
Ohio State University, USA
ORE, Haiti
Pampa Ltda., Colombia
Patronato de Nutrición, Panama
PIMCHAS-MARENA, Nicaragua
ProSemillas, Guatemala
Red SICTA, Nicaragua
Secretaría de Agricultura y Ganadería, Honduras
Self Help International
SEMSA, Nicaragua
Sergipe State, Brazil
Tokyo University of Agriculture, Japan
UCA, Nicaragua
Unidad de Extensión, Investigación y Capacitación Agropecuaria de Holguín (UEICA-H, antes ETIAH), Cuba
UNA, Honduras
Universidad Autónoma del Occidente, Colombia
Universidad Autónoma "Gabriel René Moreno", Bolivia
Universidad Centroamericana, Nicaragua
Universidad del Cauca, Colombia
Universidad de Costa Rica, Costa Rica
Universidad de Panama, Panama
Universidad del Valle, Colombia
Universidad Federal de Sergipe, Brazil
Universidad Industrial de Santander, Colombia
Universidad Nacional Autónoma de Nicaragua, Nicaragua
Universidad Nacional de Colombia, Colombia
University of Connecticut, USA
University of Copenhagen, Denmark
University of the State of Rio de Janeiro, Brazil
Visión Mundial, Nicaragua
World Food Program, Panama
Yale University, USA

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Figure

Crops released during the AgroSalud project between 2007 and 2010. Figures in parentheses represent the number of cultivars released. An underlined year indicates the year the crop was released.

Released: 42/52 Nutritionally Improved Cultivars

Country	Crop			
	Rice	S potato	Beans	Maize
Bolivia	2009 (2) 2011 (1)	-	2009 (1)	2008 (1)
Brazil	2011 (1)	2009 (1)	2008 (2)	-
Colombia	2011 (1)	-	2011 (1)	2010 (2)
Costa Rica	-	-	2011 (1)	-
Cuba	2009 (1) 2010 (1)	2009 (1)	2009 (1)	-
El Salvador	-	-	2011 (1)	2008 (3)
Guatemala	-	-	2010 (1)	2009 (1)
Haiti	-	2009 (2)	-	2008 (1)
Honduras	-	-	2011 (1)	2008 (1) 2010 (2)
Mexico	-	-	-	2007 (2) 2009 (2)
Nicaragua	2011 (1)	-	2011 (1)	2007 (2)
Panama	2010 (4)	-	-	2008 (2) 2009 (2)
Peru	-	2010 (2)	-	-
Dominican Republic	2011 (1)	2009 (2)	-	-
Total	13	8	10	21

Courtesy: Róger Urbina

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List of annexes

The reports listed under each annex also have additional appendices, which can be found in the DVD accompanying this report.

Annex	Title
1	Bean breeding
2	Maize breeding
3	Rice breeding
4	Sweet potato breeding
5	Seed production and dissemination
6	Food-product development, Clayuca
7	Food-product development, Embrapa
8	Geographic targeting
9	Nutrition impact

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Annex	Title
10	Socioeconomic impact
11	Communications