RTB Mega Program: Roots, Tubers and Bananas for Food Security and Income

ABSTRACT

More than 500 million poor farmers in Africa, Asia, the Pacific and Latin America and the Caribbean grow energy- and nutrient-rich roots, tubers and bananas (RTB). These farmers—many of them women—and their families depend on RTB to meet the basic human need for food security and livelihoods. Often grown on marginal land, these crops are especially important in combating hunger caused by droughts, floods and other climatic disasters; pests and diseases; or civil strife. RTB are fundamental sources of energy and vital nutrition, with some varieties contributing significant iron, zinc and vitamin A to diets.

RTB can produce very high yields, but farmers in developing countries may be realizing less than half this amount because of limited genetic potential of landraces, low-quality “seed,” biotic and abiotic constraints and poor management practices. Expanding the benefits of these crops for food security and as drivers of agro-economic development for rural households requires policy shifts that include greater agro-industrial and research investment, more attention to added value and better market access. High payoffs can consequently be expected through productivity-focused research, postharvest management, product development, value-chain organization and improved policy. As RTB production, use and marketing are often women’s tasks, gender equity should be central.

The Roots, Tubers and Bananas for Food Security and Income Mega-Program (RTB MP) proposal aims to realize the potential of RTB as reliable sources of nutritious foods, feeds, and income for enhancing the food security and livelihoods of the poor. Sustainable productivity gains will come from selection and breeding for adaptation to stressful environments, improved quality of planting material and management practices and judicious use of external inputs. The dynamic conservation and strategic on-farm use of crop genetic diversity will ensure resilient cropping systems and capacity to respond to evolving pest pressures. Improving what are sometimes inadequate efforts to integrate RTB conservation and use of genetic resources at national and regional levels will lead to a more enabling policy environment.

There are many similarities across RTB in the constraints, the scientific opportunities, the breeding principles and processes, the seed systems for delivery and the value-added options, which the RTB MP seeks to capture through several key programmatic initiatives:

- **Create** economies of scale and scope, as scientists involved in the conservation and use of RTB explore common research questions, share labs, develop common tools and methods, coordinate work on common project sites and build capacity together.
- **Generate** income by linking farmers to markets for RTB products. Features such as improved storage and processing for added-value foods, superior livestock feed, industry-preferred starch profiles and emerging private-public partnerships will promote more stabile income generation and tap into the potential for broad-scale market linkages.
- **Facilitate** capacity building and knowledge sharing through partnerships, networks and training to enhance innovation system capacity and performance.
- **Link** with other MPs to make a vital contribution to sustainable and profitable production systems and improved nutrition,
- **Provide** decision support and simulation tools and germplasm that will help in adapting to climate change or mitigating its effects.
- **Advance** gender equity and **empower** women and small farmer organizations through RTB innovation systems.

1. OBJECTIVES

The general objective of the roots, tubers and bananas[1] Mega-Program (RTB MP) proposal is to fully exploit the potential of these crops in order to increase food security and income of the world's poor who depend on them. The specific objectives are to:

1. **Enhance** the role of RTB in diversified global food security systems to reduce risk of food shortages and nutritional shortfalls.
2. **Better position** RTB as market crops to increase incomes and reduce poverty.
3. **Assess**, **enhance** and **use** international collections of RTB genetic resources to contribute to resilient food and farming systems.
4. **Improve** RTB productivity through breeding for adaptation to stressful environments, higher quality of planting material and management practices.
5. **Empower** women and small farmer organizations through RTB innovation systems.
6. **Improve** efficiency and impact of RTB research-for-development through exploitation of synergies among crops and collaboration among CGIAR centers and partners.

2. JUSTIFICATION OF THE PROJECT

RTB are some of the most important primary crops. They play a critical role in the global food system, particularly in the developing world, where they rank among the top 10 food crops. The advantages of RTB relative to many essential food crops are impressive:

- They provide one of the cheapest sources of dietary energy in developing countries, as their high yields ensure an energy output per hectare per day considerably greater than grains.
- They contribute to the energy and nutrition requirements of more than 2 billion people. They provide an estimated 14–60% in some countries of the daily per capita calorie intake of the 741 million people living in the least developed countries.
- Some are nutrient-dense (e.g., high in vitamin A) and rich in dietary fiber, helping to ease the health burden caused by deficiencies in nutrition.
- They are unique in providing high water productivity in developing countries and they constitute an important source of income in rural and marginal areas.
- Because they are locally produced and traded, RTB are less vulnerable to abrupt price changes from volatile international markets that affect cereal crops. They are consequently key elements in a strategy to diversify global food supplies, buffer against market shocks and improve food security around the world.
- Their adaptability for cultivation on varied soils and their stable yields under conditions in which other crops may fail add to their strategic importance. For example, cassava, sweetpotato, and certain banana groups respond well to simple cultivation methods and require relatively low external inputs; potato and other banana cultivars are exceptionally responsive to appropriate soil and pest management. Significantly, for all RTB, varietal improvement can deliver reliable yields and reduce risk of crop loss.

The RTB MP will build on the inherent advantages of RTB for improved durable and sustainable productivity, better market integration of smallholders and enhanced nutrition of consumers, especially children and women of child-bearing age. RTB have many potential industrial uses, and value chains and market access are key drivers for alleviating poverty. The gap between yields realized at experiment stations and on farms remains a persistent challenge but is, at the same time, an opportunity for high payoffs in research investments.

[1] Banana is used here *sensu lato*, and includes both dessert and cooking bananas and plantain (subset of starchy cooking bananas) forms of the genus *Musa*.

The RTB MP seeks to overcome the yield gap through research that enhances uptake of outputs and knowledge, ultimately adding value and improving productivity.

RTB share common characteristics in their genetic structure, conservation methodologies for genetic resources, breeding, seed systems, physiology, crop nutrient demands, agronomic management, gender/farmer organization focus, postharvest handling and value chains. Outcome and impact assessment of RTB offer an opportunity for increased efficiencies from a critical mass of scientific expertise in the organization of research for development. In general. The efficiency and impact of RTB research-for-development will be enhanced through increased collaboration among CGIAR centers and with partners.

The RTB MP aims to position these essential crops as an efficient option for diversifying and strengthening the global food system. Concerted policy research and advocacy will demonstrate to decision makers the current role and future potential of RTB in mitigating risks to global food security and buffering the effects of climate change.

3. MEASURABLE RESULTS

The expected outputs of the RTB MP are shown in the impact pathway figure (section 12). The MP3 participating centers each have well-established output and outcome monitoring systems. These systems will be refined to capture the investments of the MPs. Significant outputs will include new knowledge, new genetic materials, increased supply of quality seed and new value-chain opportunities as examples of many more outputs and outcomes. Indicators will include open-source publications, numbers of individuals trained, numbers of materials released, volume of quality seed used, value of material marketed through new value chains, on-farm productivity increases as well as other indicators.

4. CENTERS INVOLVED AND THEIR INPUT

The RTB MP integrates 30-plus years of experience in the root and tuber research agenda of the three CGIAR centers most engaged in these crops: the International Potato Center (CIP), the International Center of Tropical Agriculture (CIAT) and the International Institute of Tropical Agriculture (IITA). Augmenting the scope of RTB MP is the banana research work of Bioversity International, IITA and CIAT.

CIP has almost 30 years of unparalleled experience in ex- and in-situ conservation of clonally propagated crop genetic resources. The Center, with the world’s largest, ISO 17027-accredited in-vitro genebank, has studied in-situ conservation and developed models for dynamic conservation linking in- and ex-situ conservation. CIP has expertise in breeding potato for lowland and highland tropics and for temperate regions, and sweetpotato for Sub-Saharan Africa and Asia. The center has established expertise in systems approaches and systems productivity, and the application of geographic information system (GIS) and remotes sensing technologies.

CIAT has access to the largest germplasm collection of both cassava and to pests, diseases and biological control agents of this crop that originated in South America. The Center interacts productively with national programs in Latin America and the Caribbean (LAC) and Asia and with IITA in Africa. CIAT has also developed expertise and partnerships to address pests and disease issues that affect the banana sector in LAC.

IITA develops agricultural solutions with its partners to tackle hunger and poverty in Africa. RTB represent a major focus for IITA, including cassava, yams, bananas and edible aroids. The Center has a field and clonal genebank of RTB tissue cultures. Its multidisciplinary teams include specialists in plant protection (pathology, virology, entomology, nematology), agronomy, molecular biology, biotechnology, physiology, genetic resources, GIS, value chains and economics.

Bioversity International aims to improve livelihoods through the conservation and effective use of biodiversity, with a long-standing commitment to banana, for which it maintains the world collection, both in vitro and cryopreserved. Its teams located in Europe, Asia/Pacific, Africa and LAC conduct targeted research across continents to sustainably enhance the productivity and resilience of banana systems and manages information and knowledge platforms. Bioversity implements its mandate, collaborating closely with partners through research-for-development and scientists networks, and information and knowledge platforms that are available to all partners involved in the banana agenda in RTB MP.

These four centers are involved in climate change research and participatory technology generation, and have incorporated gender analysis for research targeting, implementation and uptake. They aim to improve the competitiveness of RTB growers through the development of technologies, assessment and characterization of local genetic resources a facilitating access to markets. The institutes with genebanks are located in centers of genetic diversity for these crops and the pests and diseases that co-evolve with them as well as the traditional knowledge in farming communities from the millennia of cultivation.

5. MANAGEMENT ARRANGEMENTS FOR IMPLEMENTATION

An Advisory Committee, consisting of representatives from the centers and key partners, will provide general direction, coordination and monitoring of the RTB MP. The committee will nominate contact persons for interacting and coordinating with other MPs in order to ensure synergy and efficiency and avoid duplication. For mobilizing synergies among partners, task forces across centers will be formed to facilitate the common design, sharing and cross-learning of common tools and methods. The task forces will work on specific project design and identification of funding opportunities according to common or crop-specific priority research themes. An additional task force will identify mechanisms for gathering needs from RTB-related stakeholders, facilitate participatory assessment of solutions and collect and analyze stakeholder feedback.

Implementation steps will include the formalization of the MP and the governance and coordination structures across centers. Task forces will work on specific project design and identify funding opportunities according to common or crop-specific priority research themes. Once funds are available, project-specific coordination teams will guide the implementation and define monitoring and evaluation (M&E) mechanisms (e.g., annual assessment of progress, midterm review, etc.). The results of monitoring will be incorporated into the planning of the following phases of particular projects and the MP in general. Implementation will also exploit synergies between crops and centers, including the sharing of facilities and staff.

6. TIMEFRAME

The research output and outcome delivery pipelines in the participating centers are producing results that are available for the RTB MP. The centers have mature crop improvement programs with a wide array of materials in development and deployment. Many significant advances can be made on the realization of the MP objectives in the six-year planning framework. New improved materials and inexpensive simplified diagnostic testing platforms are examples of outputs that will become available. Greater capacity in our research partners, improvements in seed quality available to farmers and new value-chain options are examples of outcomes that will be measurable at the end of the initial six-year cycle.

7. EXPECTED OUTCOMES

The expected outputs of the RTB MP are shown in the impact pathway figure (section 12). We expect the outcomes, both research (next users) and development (end users), of the RTB MP to produce impacts benefiting *at least* 500 million poor farmers and their families in the tropical and sub-tropical regions of the world in the next 10–20 years. Men and women farmers will have easy and more equitable access to eco-efficient cultivars, production practices and value chains that **increase** productivity, **reduce** poverty, **improve** nutrition and **promote** more effective and sustainable resource use under changing climates. The program will also directly **contribute** to future generations' food security via rational conservation and sustainable use of agro-biodiversity.

8. NECESSARY PARTNERS AT THE INTERNATIONAL, NATIONAL AND REGIONAL LEVEL

The participants in the RTB MP proposal will form a learning alliance of output and outcome partners. Partnership institutions will include universities, National Agricultural Research Systems (NARS), advanced research institutions, scientific networks, research for development networks, private sector, farmer organizations and nongovernmental organizations (NGO). Regional networks, innovation platforms and other mechanisms for scientific and development collaboration will be mobilized in order to make available the expertise of large producing countries, such as Brazil, China, India and Nigeria, to each other as well as to many African, Asia/Pacific and LAC countries with less developed research capacity. The sharing of leading-edge research expertise will promote exchange and collaboration between and among researchers and users. Strengthening of partners' capacity in African, Asia/Pacific and LAC countries will be prioritized through participation of NARS scientists as well as professionals of NGOs and farmers' organizations. In addition to more upstream consortia, partnerships will emphasize participatory research and development (R&D), identifying real demands from the value chain as a market-driven and public-private sector led strategy. A value-chain strategy will also allow interaction in a decision-making process to determine demands and support from the international, national and local research institutions. In this way, developing market-driven research for an articulated value chain will involve an extensive set of actors at different scales and levels: farmers' organizations, pre-processors and processors, bulking centers, transporters, exporters, wholesalers and retailers.

9. INNOVATION

The RTB MP will build on common RTB characteristics to add value and expand on the existing CGIAR investments to develop pro-poor research outputs and help achieve gender-sensitive development outcomes. There are large areas where the integration of approaches and investments in RTB crops offer sizable efficiency gains in the generation of new knowledge and materials, use of shared research infrastructure and experience, establishment of a critical mass of researchers, contacts with partners, needs and opportunity assessment, (policy) advocacy, capacity building, technical assistance and outcome–impact evaluation. Innovative work will come at three levels: (1) by working across RTB crops and across centers, (2) by more targeted and coordinated research activities leading to clear outcomes and (3) by developing new partnerships, including those with the commercial sector. The perishable, bulky and perennial nature of RTB strongly influences strategies for conservation; seed systems; and crop/postharvest management, food systems and use. Approaches, innovations and successful models for the conservation, propagation and use of genetic resources to enhance productivity and minimize crop losses can be shared among RTB, and provide spillover to additional species of interest to NARS programs.

Genetic resources and genetic diversity

Ex-situ RTB germplasm collections consist largely of clonal genotypes of improved or landrace cultivars. (Potato, whose wild species collections are conserved as seed, is the exception.) For the other crops, seed-based collections of wild progenitors are generally nonexistent but urgently required because of threats to species and habitats posed by climate change and urbanization. Ex-situ conservation and safe exchange of clonal RTB germplasm rely on in-vitro culture and cryopreservation. Progress has already been made in this area through the Intercenter Working Group on Plant Genetic Resources collaborative activity involving CIP, CIAT, IITA, and Bioversity. Guidelines for the in-vitro conservation of clonal crops have been developed and protocols have been tested across centers for cassava, potato, yams and bananas. This initiative will be continued and applied to other crops—sweet potato, cocoyam and Andean root and tuber crops—before transfer to national programs. Standardized tools for characterization and evaluation will be further developed, as well as genetic resources information and knowledge platforms.

Improved varieties: stable yields, stress resistance and high nutritional value

Genetic structures, breeding methods and schemes. Most RTB crops are heterozygous, outcrossing polyploid hybrids subject to inbreeding depression, with immediate loss of genotype if propagated by botanical seeds. These features imply that similar breeding methods are applied across RTB. Crosses are made between highly heterozygous parents and desirable genotypes are “fixed” through clonal propagation. Ploidy manipulation and working at different ploidy levels are common to most RTB crops. Similar molecular genetic research strategies can thus be applied across RTB to add breeding precision. Use of heterozygous parents dictates breeding strategies such as population improvement (e.g., recurrent selection, heterosis breeding) and makes RTB excellent candidates for transgenic improvement. RTB also stand to benefit from breeding methods involving mutagenesis or ploidy manipulation, in combination with tissue culture. Vegetative propagation ensures the off-springs to be genetically identical, as such preserving advantageous traits. Ploidy manipulation or development of homozygous stocks for genetic studies can be achieved by gamete culture or unreduced gametes. Alternative methods to develop and benefit from inbreeding, like those currently being explored for cassava, could help other crops. Genome sequences of several RTB (e.g., cassava, banana, potato) are or will soon be available, enabling the use of comparative genomics to identify genes for important target traits and making use of existing consortia/platforms.

Breeding objectives. Priority traits for crop improvement to benefit the poor are common across RTB. The traits include efficient accumulation of carbohydrates (even under stress), high density and bioavailability of **micronutrients**, and durable resistance to pathogens, especially those carried by the vegetative seed. RTB host different viruses, but mitigation methods are shared. Approaches to understanding and exploiting genetic variability of heterozygous polyploid crops include the need to understand intra- and intergenic interactions that contribute to phenotype, calling for research on epistasis and the consequences of polyploidization. A novel initiative for the RTB MP would be apomixis to produce superior clonal varieties via botanical seed, increasing reproduction rate and decreasing disease load.

Bringing nontraditional areas into cultivation and inserting RTB between grain seasons are important strategies for both income generation and diet diversification. Reduced vegetative cycle of RTB (e.g., potato, sweetpotato), combined with tolerance to high temperatures, herbicide tolerance and limited water supply, will make them more flexible in cropping systems and contribute to overall systems productivity and diversified agriculture. The maintenance of quality after harvest of RTB is responsive to both genetic and environmental control. This prioritizes the need for genetic improvement in the context of innovations at all stages in the postharvest system—from harvesting, through handling, storage, processing, and marketing and final delivery to the consumer to prevent postharvest losses in quantity and quality of foods. The logistics of RTB breeding programs are similar: producing and moving enough clean planting material for multi-location trials are common challenges for all RTB crops.

Farmers, both men and women, and other value-chain actors will be involved in participatory crop development and evaluation of RTB through the use of a range of approaches. Information on farmer preferences for agronomic traits and consumer preferences for use traits will be disaggregated by gender and brought together in regional platforms to inform and direct the research agenda of NARS and the CGIAR centers involved. As RTB enter processing markets, the criteria of agro-processors need to be included in evaluation and development.

Novel and nontraditional partnerships with the private sector will be fomented in order to increase returns on investments in public research without compromising the pro-poor nature of the RTB MP's research efforts. These partnerships will be designed to widen technology dissemination; create synergies between public and private skills; and generate income through corporate responsibility schemes, temporally or spatially ring-fenced exclusivity and intellectual property mechanisms. Moreover, the increasing importance of processing opens an array of possibilities for public-private partnerships, for which guidelines will be developed.

Priority pests and diseases and beneficial microbial communities

Vegetatively propagated crops have similar disease issues. For example, viruses are transmitted in similar ways either via vegetative seed or vectors such as whiteflies or aphids, which are common across crops. This limits rapid exchange and dissemination of planting material of improved varieties. Therefore, exploiting the synergies among centers will help develop common and more efficient and effective low-cost virus (and other pathogens) detection methods for use across RTB for screening in breeding and seed programs.

The use of these methods will also improve the characterization of microbial communities in planting material of RTB, and plans will be developed for taking advantage of their role in crop productivity. Robust disease-detection platforms will facilitate the safe international movement of germplasm that is essential for introducing, assessing and deploying new varieties. Improved methods will be essential for detecting existing, emerging and re-emerging pathogens of RTB and contribute key information for modeling and risk assessment under changing and uncertain scenarios (globalization, climate change, increased human mobility, pathogen and vector evolution). Principles for the integrated management of vectors and other pests in different RTB will be shared and synergies exploited.

Sustainable systems for clean planting material for farmers

Vegetatively propagated planting material is one of the most important common characteristics of RTB with accompanying features, low multiplication rates and high volume, transmission of pests and diseases from field to field and season to season and, frequently, the lack of an organized seed system. These commonalities call for a cross-crops approach. A number of research areas are important, such as inexpensive diagnostics, disease elimination procedures and the maintenance of clean stock. The slow rate of propagation necessitates investment in multi-crop infrastructure and capacity for management of plant health along the variety development and dissemination pipeline, for innovation in procedures permitting rapid mass propagation (tissue culture, cuttings, aeroponics) and for innovation in farmer-based seed production (the concept of quality declared seed is proposed for testing). Pilot programs with virus-resistant cassava varieties, sweetpotato, tissue-cultured banana, plants yam minisetts and potato seed selection offer lessons for a broader, more robust seed system initiative. The RTB partners, in conjunction with other international partners such as the FAO and the Inter-African Phytosanitary Council of the African Union, will leverage their crop-based expertise to develop innovative approaches that make clean, low-cost, superior germplasm available to rural communities, including policies and strategies to support seed production and facilitate private sector interventions. We envisage a set of tools, including modeling of seed systems in biophysical and socioeconomic terms, adapted for clonally propagated crops. The tools would enable the analysis of cost effectiveness and applicability for different grower groups of different seed chains in order to measure the productivity contribution of clean seed and the rate of degradation of seed quality and to formulate alternative seed system approaches. Platforms such as regional foundation seed units or well-organized, inter-center multiplication units—made feasible through harmonization of the phytosanitary regulatory environment—need to be analyzed in this framework.

Tools for more productive, ecologically robust crops

This section brings together the tools, knowledge and materials from outputs of the above themes for more productive cropping systems. Although such integration is often site-specific, we propose that widely applicable decision-support tools and agro-ecological understanding can be useful to the development of more productive, locally adapted systems. These tools span from crop growth models to farmer participatory technology development and learning. A particularly important tool for more efficient use of resources is crop-growth modeling coupled with field testing in order to understand the opportunities to expand the zones where these crops can be grown. In monocrop systems, the interactions of plant nutrition, soil and root health and the crop-based food web, including both pests and diseases and beneficial organisms, need to be understood and farmer-decision tools developed. Crop rotations among monocrops provide an additional dimension of interactions, such as the insertion of potatoes into grain-cropping systems in the tropics and subtropics. Throughout Sub-Saharan Africa, certain RTB are found in mixed systems based on accumulated farmer experience. Agro-ecological intensification can be based on improved resource-use efficiencies (e.g., of water and nutrients) and increased positive interactions among the crops to reduce pest and disease damage. RTB have similar nutrient demands with particularly high potassium requirements. Cross-crop and system-level synergies can be found in the development of field- and farm-level strategies for the mobilization of adequate crop nutrition based on local and external nutrients. Close interactions are expected with MP1 and MP5 and MP7 in this cropping systems work.

Postharvest technologies, value chains and expanded market opportunities

The bulkiness and perishability of RTB crops have often made them more difficult to store and market, unlike grains. This has led to complex systems for local use and has limited their potential for reaching more distant markets. The RTB MP has identified several important research opportunities to address these weaknesses:

- Cross-commodity starch research to understand the role of physicochemical, rheological and organoleptic properties in determining consumer preferences for and the acceptability of RTB varieties.
- Nutritional studies to understand retention of minerals and vitamins during storage, cooking and processing, and bioavailability to the human body.
- Food-safety issues and product quality related to specific compounds found in RTB.
- New product development, reverse-engineered starting with consumer preference.

- Life-cycle assessment to understand the environmental impact of production and processing as well as policy and economic analysis to find approaches to reduce value-chain transaction costs, urban waste generation and storage challenges.

The growing urban markets in all regions represent an enormous demand for RTB. A value-chain approach will be used to engage farmers and other market-chain actors in identifying new market opportunities for these crops and stimulating demand-driven innovation. Backward linkages from these opportunities will drive research mentioned above in improved technologies for harvest, storage, processing and development of new products. Participatory market-chain analysis being employed by the MP3 centers will be expanded and fine-tuned to bring together diverse partners in the supply chain around market opportunities with pro-poor outcomes. This approach can be applied to the marketing of new cultivars, including biofortified materials, new products from innovative processing and emerging niche markets for agrobiodiversity. The full potential for the value-chain approach will be developed through systematic review (with MP2) of the many local applications of the approach and the identification of key variants and characteristics for greater effectiveness.

Shared use of platforms and partnerships

For their research activities, the partners will develop and share infrastructure, platforms and outsourcing opportunities to reduce costs and impact.

Genotyping platform. The integrated use of precision phenotyping, high throughput, high-density genotyping, data management and analysis pipelines and decision support tools is a cornerstone of modern breeding applications. These applications are based in an understanding of the genomic sequence of the species of interest. As full sequence become available for RTB, use of these tools in breeding efforts is a viable option for applications—from understanding genetic structure within a breeding pool to genome-wide selection. The choice of system and throughput depends on specific needs. Some needs are best met from RTB in-house capacity and these can be shared to foster synergies. Others are better met through outsourcing. The Generation Challenge Program could provide a genomics and integrated breeding service to the RTB MP, via the planned integration of the Program's existing Integrated Breeding Platform (IBP),[2] into the MP3 structure. The IBP provides access to outsourced, cost-effective and high-throughput services for genotyping, including sequencing and specialized physiological/metabolic analyses. Current activities are driven by 14 use cases focusing on molecular breeding in eight crops, including cassava. Informatics tools and related support services developed under the IBP will also be integrated within and used by RTB activities to enhance commodity improvement.

Phenotyping platform. A phenotyping platform will be constituted based on where the RTB centers and major partners are actively evaluating germplasm. The relationship between testing and target environments will be analyzed using a combination of statistical and GIS tools. Facilities will be shared where and when possible. Efforts will be devoted to developing/ adapting and implementing the use of rapid phenotyping strategies, based on the use of modern technologies (e.g., near-infrared spectroscopy, thermal imaging spectro-radiometry, remote sensing). Shared purchases and centralized services will help bring new expertise and technologies to bear on agricultural research problems (e.g., CIP's quality and nutrition laboratory can offer services for micronutrient evaluation, whereas CIAT's postharvest laboratory can provide services for starch properties). Best practices on scientific record

[2] The IBP is an initiative partially funded by the Bill and Melinda Gates Foundation.

management and analytical tools should be shared to promote synergies—for example, through information transfer within crop clusters.

Germplasm multiplication, sanitation and preservation platform. The need exists to exchange germplasm across regions and continents and to develop long-term back-up systems for RTB (Svalbard vault equivalent). Strategic in-vitro technology platforms for safe and fast diffusion and cryopreservation of multiple crops could be developed in strategic locations.

Other platforms or cross-cutting activities. Novel tools will be used to study microbial associations within plant tissue, the rhizosphere and soil; develop crop growth models with cultivar- or type-specific parameters; and study RTB's functional, nutritional and bioactive properties. Shared interlinked platforms will also be established for developing novel, high-value breeding lines through use of mutation breeding, transgenics and doubled haploids. The partners in the RTB MP will capitalize on their own experience and that of others through additional partnership activities and networking. Information and knowledge platforms and delivery mechanisms, adapted to regional and national situations and closely linked to impacts among poor rural households and marginalized groups, will be strengthened.

10. INTEGRATION WITH OTHER MEGA-PROGRAMS

Promising opportunities exist for the RTB MP to integrate productively with other MPs:

- **MP1**. Most cropping systems in MP1 involve RTB crops, in pure culture or in association. Identification and analysis of pests, diseases and beneficial interactions carried out in the RTB MP is expected to contribute to healthier cropping systems—an important goal for MP1—and will also provide robust and adapted varieties to MP1 that will increase yield and productivity of smallholders' systems.
- **MP2**. Research conducted in MP2 on priority value chains, policies and investments that enable pro-poor growth as well as institutions and governance for the rural poor would be implemented in close coordination with the RTB MP.
- **MP3**. The RTB MP will interact with MP3 crop and genetic resources components. RTB are, for example, often part of cereal-based systems (e.g., potato in rice wheat systems in Asia, maize-yam association in Africa).
- **MP4**. In close collaboration with MP4, RTB MP will help fight malnutrition through diet diversification, biofortification and deployment of high-nutrient varieties.
- **MP5**. The research on water-use efficiency and nutrient-use efficiency carried out in RTB MP will be closely linked to MP5 efforts to develop more adapted management practices and build capacity to address natural resource management in the future.
- **MP7**. Interactions with MP7 will be critical. Together, the two MPs will develop holistic perspectives on crop and climates, look at shifts of pests and diseases and identify traits for adaptation to climate change. These traits will be then integrated into RTB breeding programs.

When necessary, the RTB MP will enter into a contractual relationship with other MPs to ensure the maximum synergy and focus of the work and the efficiency of service delivery.

11. RISKS

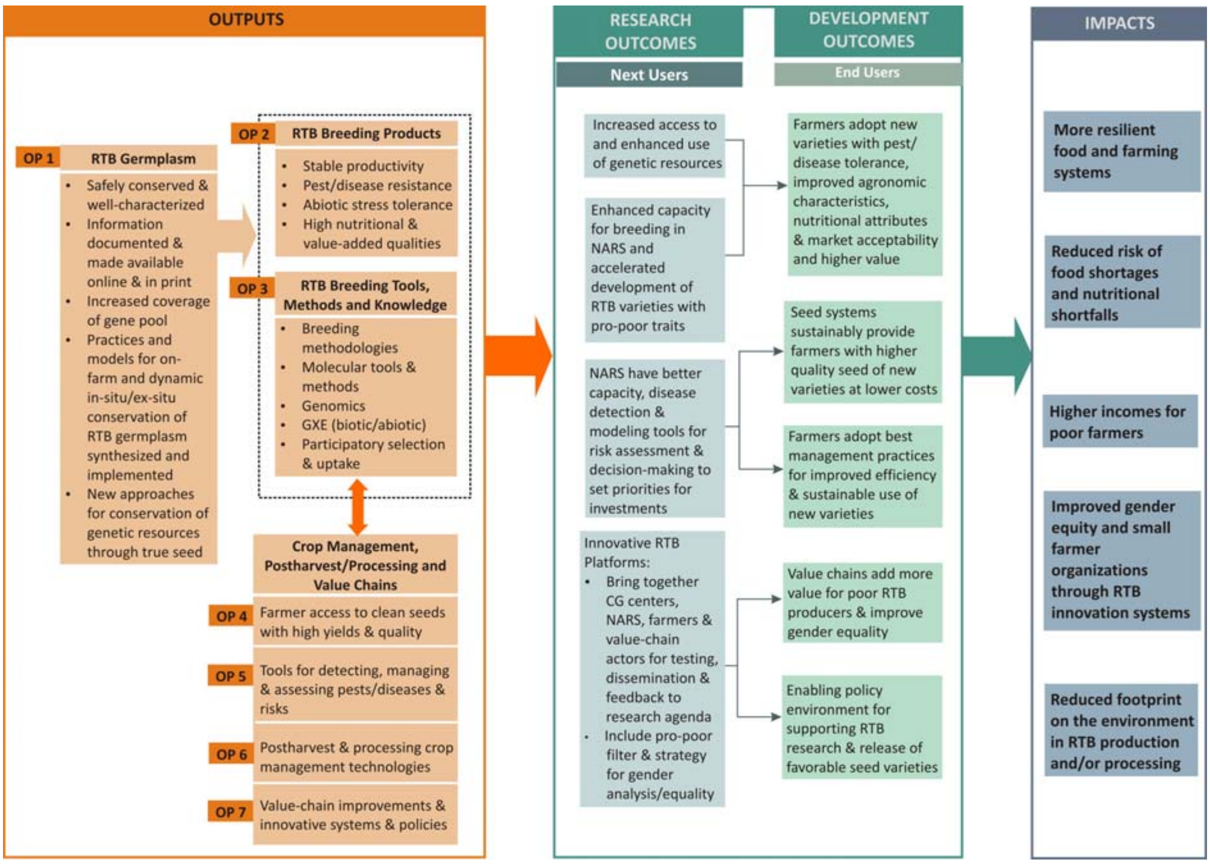
The RTB MP may face several risks. Changes in biological and socioeconomic environment can strongly affect the expected impact of the research carried out. The type of work that is proposed by the RTB MP implies new relationships across centers and partners, which have not been common in the past. This MP may require the participation of a range of partners, particularly governments, which may not act as quickly as expected to provide the additional investments needed to scale up and out research results and lessons learned. Among those risks, we anticipate the following as being the most important:

- Genetic resources needed for food security, poverty alleviation and sustainability are lost or their potential left untapped.
- Policies are adopted by international fora and individual countries that limit the exchange and use of genetic resources.
- Development of national seed systems and release or dissemination of new locally adapted varieties are reduced by the existence of lobbies and perverse incentives.
- Private sector fails to respond to opportunities for commercializing improved varieties, seed and associated beneficial microbial organisms, or fails to invest in innovative processing technologies.
- Investment is lacking and quarantines ineffective at reducing the spread of emerging pests/diseases.
- Individual countries have R&D policies that may limit the effectiveness of our work.

Risk assessment and management strategies will be set up for evaluating these risks and developing mitigation or alternative approaches.

12. QUANTIFIED IMPACT PATHWAY

Figure 1 illustrates the impact pathway envisaged by the RTB MP. Quantifiable impacts will be developed and presented in the full proposal.



13. GENDER RESEARCH STRATEGY

Women consistently play important roles in RTB production and postharvest handling, which is not always the case with other crops. The RTB MP promotes gender mainstreaming, gender equality in research management and the empowerment of women through several strategies. It includes specific commitments to producing evidence on the impact of gender equality and women's empowerment in achieving development goals and partnerships that significantly advance gender equity and empowerment. It builds on and strengthens the special role of women in household food security and nutrition. It will incorporate gender perspectives so that the overall research framework, approach and methodologies employed to conduct the research are clearly gender sensitive. Particular attention is given to gender analysis of roles in food systems, and to ensure that the perceptions and needs of both women and men are captured in participatory varietal selection, developing seed systems, crop management and engaging value chains, and that the outcomes favor gender equality.

14. CAPACITY STRENGTHENING

Given that this MP seeks to strengthen and/or reposition the role of RTB in food security and agricultural development, and address a policy gap that causes underinvestment in these crops, research capacity strengthening in the RTB sector is critical. The installed RTB research capacity in many partner countries is deficient. The RTB MP will address building research capacity of both individuals and institutions. Individual capacity strengthening, via training and scholarships, seeks to enable researchers and teams to design and conduct research, publish research findings and influence policy decisions. Institutional capacity strengthening includes how organizations can learn and the setting in which they operate, such as incentive structures, the political and regulatory context and the resource base in which research is undertaken and used by policy makers. Capacity strengthening in the RTB MP will be based on an agreed strategic plan that covers a needs assessment, identifies the methods to be used and employs an M&E component. A full-time capacity strengthening professional at one of the centers will ensure that investments in capacity strengthening result in the participating and collaborating institutions having developed their research capability and organizational capacity, as well as be able to engage in building an enabling environment and links with policy makers. At least 10 percent of the RTB MP will be dedicated to capacity strengthening.

15. COMMUNICATIONS STRATEGY

The RTB MP seeks to ensure that its research results are known and used, and having a strategy in place for communicating the results with the relevant stakeholders is key. A full-time professional communications manager from one of the participating centers will design an RTB MP communications strategy, mutually agreed by the participants. The strategy will address policy, communication and research stakeholders at all levels of understanding and will be built on a baseline assessment of awareness and knowledge of these groups. The strategy will include an M&E component. The RTB MP will have a distribution strategy based on open access, especially for research results, and will dedicate 10 percent of its budget to communications.

16. MONITORING AND EVALUATION

An M&E team, with members in each of the centers, will be established and tasked to work with partners to develop the specific impact pathways for different components, with gender-differentiated, intra-household outcomes, and network maps of the key partners to be engaged. The M&E team has several functions:

- Consolidate information and develop a standardized approach to measuring indicators for outputs and outcomes and collecting baseline information to establish initial values of key outcome and impact indicators.
- Identify which countries have nationally or sub-nationally representative surveys that include RTB or have other partners already conducting periodic agricultural surveys. This will provide the basis for collecting additional baseline information, putting in place an M&E system and subsequently measuring outcomes and ex-post impacts disaggregated by poverty status of households and gender.
- Exploit socioeconomic expertise among the participating centers for studies of technology adoption and other outcomes differentiated by gender and poverty content and for impact studies to capture rates of return, guide research and sustain an impact culture.
- Assess the adoption of the technology generated and promoted by the RTB MP.

BUDGET

The suggested budget is shown on the following (unnumbered) page.

BUDGET

MP Cost Summary

Centre Name **BIOVERSITY - CIAT - CIP - IITA - GCP**

MP Project Title :	**MP3: Sustainable Staple Food Productivity Increase for Global Food Security (Roots and Tubers, Bananas and Plantains), 2011-2013 Budget**
Billateral "Non Fund Investors"	List individual bilateral donors
Estimated starting date :	All projects assumed to be 1 Jan 2011 at present.
Project Duration :	**All Project budgets to be for first 3 years**

Project Cost (Expressed in 000 US$)

Cost group	Description	2011		2012		2013		Project Cost	
		Base	Upside	Base	Upside	Base	Upside	Base	Upside
1	Personnel Cost	18,141	20,150	18,929	21,929	19,607	24,313	**56,677**	**66,393**
2	Travel	3,087	3,392	3,225	3,780	3,279	4,114	**9,591**	**11,286**
3	Operating expenses	12,985	14,533	13,953	16,577	14,807	19,178	**41,745**	**50,288**
4	Traning / Workshop	1,233	1,301	1,247	1,343	1,318	1,438	**3,798**	**4,082**
5	Partners / Collaborator / Consultancy Contracts	8,597	9,681	8,782	10,304	8,744	11,165	**26,124**	**31,150**
6	Capital and other equipment for project	2,344	2,402	1,310	1,587	1,303	1,768	**4,957**	**5,757**
7	Contingency	312	323	324	336	362	375	**998**	**1,034**
	Total	**46,699**	**51,782**	**47,769**	**55,857**	**49,421**	**62,350**	**143,889**	**169,989**
8	**Institutional Overhead (as a % of Direct project cost)**	8,924	9,896	9,434	11,078	10,400	13,257	**28,759**	**34,231**
	Total Project Cost	**55,623**	**61,678**	**57,204**	**66,935**	**59,821**	**75,607**	**172,648**	**204,220**

Project Funding

Investor contribution per year

Description	2011		2012		2013		Project Funding	
	Base	Upside	Base	Upside	Base	Upside	Base	Upside
Funding								
CGIAR Fund - (Window 1 & 2)	**31,265**	**36,589**	**34,316**	**43,638**	**39,660**	**54,543**	**105,240**	**134,770**
Current Restricted Donor Projects	22,863	23,679	21,383	21,751	18,627	19,483	**62,873**	**64,913**
Current Restricted Donor projects "cofinanced by unrestricted funding"	-	-	-	-	-	-	**-**	**-**
Donor A							**-**	**-**
Donor B							**-**	**-**
Other Income:	1,495	1,411	1,505	1,546	1,534	1,580	**4,535**	**4,537**
							-	**-**
							-	**-**
Total Funding	**55,623**	**61,678**	**57,204**	**66,935**	**59,821**	**75,607**	**172,648**	**204,220**