DRAFT FOR DISCUSSION

White paper on GCP research components: Improved germplasm

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Acronyms, short names and abbreviations – Molecular breeding

AfricaRice	Africa Rice Center
Agropolis–CIRAD	Centre de coopération internationale en recherche agronomique pour le développement, France
Agropolis–IRD	Institut de recherche pour le développement, France
BCMNV	bean common mosaic necrosis virus
BCMV	bean common mosaic virus
BCNAM	backcross nested association mapping
BIOTEC	National Center for Genetic Engineering and Biotechnology, Thailand
BMGF	Bill & Melinda Gates Foundation
CAAS	Chinese Academy of Agricultural Sciences
CARDI	Cambodian Agricultural Research and Development Institute
CB	capacity building
CBB	cassava bacterial blight
CBSD	cassava brown streak disease
CGIAR	No longer an acronym (*formerly* Consultative Group on International Agricultural Research)
CGM	cassava green mite
CIAT	Centro Internacional de Agricultura Tropical (*International Center for Tropical Agriculture*)
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (*International Maize and Wheat Improvement Center*)
CIRAD (see Agropolis–CIRAD)	
CMD	cassava mosaic disease
CoPs	communities of practice
CornellU	Cornell University, USA
CRI–CSIR	Crops Research Institute (of the Council for Scientific and Industrial Research), Ghana
CRPs	CGIAR Research Programmes
DAR	Department of Agricultural Research, Myanmar
DRSS	Department of Agriculture Research and Specialist Services, Zimbabwe
ECABREN	Eastern and Central Africa Bean Research Network
ELS	early leaf spot (fungal disease of groundnuts; *Cercospora arachidicola* Hori)
GCP	Generation Challenge Programme (of the CGIAR)
GLS	grey leaf spot (fungal foliar disease of maize; *Cercospora* spp)
GRiSP	Global Rice Science Partnership (a CGIAR initiative led by IRRI)
IARI	Indian Agricultural Research Institute (of the Indian Council of Agricultural Research)
IBP	Integrated Breeding Platform (of GCP)
ICABIOGRD	Indonesian Center for Agricultural Biotechnology and Genetic Resource Research and Development
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICS–CAAS	Institute of Crop Sciences, China (of CAAS)
IER	Institut d’Economie Rurale du Mali
IITA	International Institute of Tropical Agriculture

INIFAP	Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias, Mexico
INTA–Nicaragua	Instituto Nicaragüense de Tecnología Agropecuaria, Nicaragua
IPB	Bogor Agricultural University, Indonesia
IRD (see Agropolis–IRD)	
IRRI	International Rice Research Institute
ISPC	Independent Science and Partnership Council (of CGIAR)
KARI	Kenya Agricultural Research Institute
KU	Kasetsart University, Thailand
LAAS	Liaoning Academy of Agricultural Sciences, China
MARS	marker-assisted recurrent selection
MAS	marker-assisted selection
MB	molecular breeding
NaCRRI	National Crops Resources Research Institute, Uganda (of the National Agricultural Research Organisation or NARO)
NAFRI	National Agriculture and Forestry Research Institute, Laos
NARS	national agricultural research systems
NCSU	North Carolina State University, USA
NILs	near isogenic lines
NRCRI	National Root Crops Research Institute, Nigeria
P	phosphorus
PI	Principal Investigator (for GCP)
Pup1	phosphorus uptake 1 (gene)
RI	Research Initiative (of GCP), *formerly* Challenge Initiative (CI)
SABRN	Southern Africa Bean Research Network
SARI	South Agricultural Research Institute, Ethiopia
SPIA	Standing Panel on Impact Assessment (a subgroup of the CGIAR's ISPC)
SYAU	Shenyang Agricultural University, China
TLI	Tropical Legumes I Project (of GCP)
UoN	University of Nairobi, Kenya
USD	United States dollar
USDA	United States Department of Agriculture, USA

Background and process

A series of white papers are being drafted by the Generation Challenge Programme (GCP) team in collaboration with external experts. The goals are to communicate the outputs and deliverables from each research component during 2004–2014 and to explore options for enabling and ensuring that the potential benefits of these components will be fully realised in the future. At this stage, the white papers are really a first analysis for internal use.[1] They are expected to evolve over time, shaped by progress made during GCP's remaining time and by the evolution of international agricultural research for development, particularly in terms of the 'moving landscape' of socio-economic, political and environmental issues in which operate the research portfolios of the CGIAR Consortium of International Agricultural Research Centers and related CGIAR Research Programmes (CRPs). Each white paper is designed to contribute to GCP's orderly closure in 2014 by considering the following three questions:

1. What research assets will be completed by the end of GCP's lifetime in December 2014?

2. What research assets can best continue as integral components of the new CGIAR Research Programmes (CRPs) or elsewhere?

3. What research assets may not fit within existing institutions or programmes and may require alternative implementation mechanisms?

This paper focuses on the outputs and options for GCP's molecular breeding (MB) component. Outputs have been achieved through (a) collaborative work among three sets of actors: a broad network of partners in regional and country research programmes, the CGIAR and academia; and (b) through capacity enhancement to assist developing-world researchers to tap into new genetic diversity and access modern breeding tools and services. GCP research activities have produced the research products described below[2].

Introduction and rationale

GCP aims to demonstrate – through selected user cases – that molecular breeding approaches can have significant impact on crop productivity in developing countries. Improved germplasm, developed through MB, is the final product of that overall objective. Of a budget of USD 150 million spread over 11 years, about USD 22 million will have been invested in germplasm

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[1] This GCP white paper, like the others in this series, is not a conclusive, static document. Instead, it will continue to grow and evolve as the processes of evaluation and deliberation advance toward GCP's end in 2014.

[2] GCP is supported by generous funding from an array of donor organisations listed at http://www.generationcp.org/network/funders. See also descriptions of products at http://www.generationcp.org/impact/product-catalogue and of the institutions that generated them at http://www.generationcp.org/research/research-projects.

improvement (15% of GCP's budget). Phase I of GCP was devoted to building a network of partners to develop genomic, molecular and bioinformatics tools, and to execute capacity-building programmes in developing countries to facilitate crop breeding. The development and continuous improvement of each of these capabilities are essential for enabling increased crop productivity. Only by combining these components can drought tolerance in rainfed agriculture (GCP's major target) be delivered in such a way that resource-poor farmers will receive tangible economic and social benefits and impacts.

The main objectives of the MB component are to:

1. Demonstrate the potential of integrating MB into existing crop improvement programmes in developing countries. This objective further strives to illustrate that these molecular methods can be successfully implemented in developing countries by their own scientists.

2. Develop improved breeding materials that have a significant impact on crop productivity for targeted drought-prone environments.

3. Enable breeders in developing countries to access and use MB in such a way that it becomes an essential addition to their toolbox.

Project activities and outputs

GCP Research Initiatives

GCP Research Initiatives (RIs)[3] were developed by building on the achievements, products and partnerships from Phase I (2004–2009). The RIs are expected to serve as proof of concept to demonstrate the potential of integrated MB, and the use of molecular markers to improve crop productivity in typically harsh target environments. There are six crop RIs: cassava, legumes (chickpeas, common beans, cowpeas and groundnuts), maize, rice, sorghum and wheat. Another RI – on comparative genomics – takes advantage of knowledge in model crops to facilitate gene discovery across genomes.

This white paper focuses on the six crop RIs mentioned above and on developing germplasm through MB with improved tolerance of drought as a major target trait. Familiarisation and integration of MB techniques include those of marker-assisted selection (MAS), marker-assisted recurrent selection (MARS) and backcross nested association mapping (BCNAM).

To ensure both focus and impact, each crop RI concentrates on target countries and traits (Annex 1) selected from GCP's priority farming systems[4]. Scientists from country programmes are leading the RIs, or co-leading them with scientists from CGIAR Centres, under the

[3] For further information, see www.generationcp.org/research/research-initiatives.
[4] For further information, see http://www.generationcp.org/about-us/strategies

mentorship of experts from advanced research institutes. Phenotypic evaluations are conducted by country programmes (also known as national agricultural research systems or NARS) in target environments, ensuring that the resulting improved germplasm is adapted to local conditions.

The RIs began as a significant modification of GCP's operational *modus operandi* in 2009. Now three years old, the six crop-improvement RIs all follow the same general pattern of activities, although the magnitude and nature of the activities may vary from one to another. Each RI has the following features and prospective outputs:

- An early component focused on the phenotypic characterisation of contrasting and diverse sets of germplasm (eg, reference sets, introgression lines and synthetics). The main output is germplasm, with new elite alleles for agronomic traits, for pre-breeding activities.

- A strong MB component – the core of RI activities – focused primarily on the practical use of MB. The main outputs are MB approaches successfully conducted in Africa and Asia, and resultant improved germplasm for different target traits (Annex 2).

- A strategic data management component to ensure that scientists plan for sufficient time and resources to appropriately analyse, store and document the data generated. The main output is a user-friendly dataset accessible and useable by colleagues within and outside GCP.

- A strong capacity-building component of two parts – the development of human capacity and employment of local infrastructure – which are tightly embedded in GCP's research activities. The main outputs are improved phenotyping infrastructure, more skilled scientists in developing countries and MB communities of practice (CoPs).

Molecular breeding outside the Research Initiatives

Although most of the improved germplasm outputs are expected to result from the current RIs, improved germplasm lines were also obtained from projects initiated during GCP's Phase I (2004–2009). In some cases, crosses had even been made before GCP began. These projects generated new sources of promising breeding lines such as: sorghum NILs with improved levels of aluminium tolerance, Indonesian rice lines with improved phosphorus-uptake efficiency, cassava with improved levels of resistance to cassava mosaic disease (CMD) for Central and West Africa, and drought-tolerant bean lines for Central America. A total of nine varieties and 18 improved germplasm lines of four crops in 18 countries have been delivered so far (Annex 2). The list is expected to grow, as some projects continue to generate improved materials.

Measuring success

As indicated above, the primary objective of GCP's MB activities is to demonstrate that breeders in developing countries can access and use modern breeding approaches in their respective breeding programmes to increase selection efficiency. The improved germplasm already officially released (Annex 2) are good indicators of successful MB experiments supported by GCP. Molecular breeding approach permitted acceleration of selection and reduced costs by removing some cycles of phenotypic selection. Some of these lines, like the cassava varieties for virus resistance, rice varieties for low-P soil and bean varieties for drought tolerance are already registered in developing countries and available to extension workers and farmers. These products demonstrate that the use of new genetic or genomic resources, tools and services, embedded in suitable capacity-building efforts, can have a positive impact on crop productivity in target environments.

The RIs build on ongoing MB projects and are on time for most milestones and deliverables, as reported in the original workplans included in the first three-year proposal. The activities conducted in the RIs, with the support of the Integrated Breeding Platform (IBP), represent GCP's central effort to promote and enable access to MB methods and thus empower scientists from developing countries to add this new approach to their toolbox. Based on achievements obtained so far, and on the progress of ongoing activities, the three objectives of GCP's MB component, listed above, are likely to be fulfilled by December 2014.

In addition to the capacity-building component, the RIs' final product will be the further generation of improved germplasm. This will not only be one of the last products to be generated but it will also continue emerging well beyond 2014. The number of improved crop varieties released by country programmes using MB and the number of operational MB programmes in developing countries, in both the public and private sectors, will reflect on the value and adoption rate of modern breeding. Specific attention will be paid to the adoption rate of improved germplasm developed through using GCP funds. If at least three out of the six crop RIs are able to comply with all objectives, and the others with some of the objectives listed above, GCP will consider that the overall objective – that of MB being adopted by developing countries to significantly improve their breeding efficiency – has been be achieved. With a tight timeline, with a sunset in December 2014, any impediment to the experimental plan (rains, staff turn over, etc) might jeopardize success.

Post-GCP sustainability and projected impact

Molecular breeding activities supported by GCP today are embedded in the respective crop CRP workplans. Thus, products generated in GCP-supported projects, including improved germplasm, would likely be sustained by the responsible CRP partners. However, to meet future farmer's needs, important additional foresight and planning are essential for germplasm needing further research and development after GCP closes. Indeed, some products such as cassava varieties will not have been fully developed until well after 2014. Although a major objective for GCP is to produce improved lines for specific traits, such products will remain in a semi-final stage, as more work is required to develop varieties for release to farmers. Therefore, plans that are recognised and agreed to by all stakeholders must be in place well before December 2014 to address these requirements.

Anticipating the issue of sustainability, delivery plans have been developed for every project. These were developed by the key partners in each project and implemented by the different Product Delivery Coordinators, under the supervision of the Product Delivery Leader. Each plan defines the project's milestones and deliverables along a specific timeline and also identifies the main actors along the delivery chain, including primary and secondary users. The delivery plans will be a useful baseline in discussions with partners because they include clear definitions of the added value from further development or distribution (or both) of GCP products. These discussions will also take into account the need for financial resources to achieve the task. As a principle, GCP advocates for a means to support the costs of maintaining and distributing products with clear economic value. In this regard, discussions may involve chargeback, usage fees and other options to secure the income necessary to ensure these actions after GCP ends.

While the impact of the RIs – adoption of MB – is expected to spill over beyond the selected target countries, impact on breeding programmes in these countries for each RI will constitute GCP's proof of concept. By providing these tangible examples, GCP's efforts may stimulate other actors with research for development initiatives (eg, projects supported by the Bill & Melinda Gates Foundation) to extend and enhance these achievements, following the same fundamental approaches. For most of the products still needing to be delivered, assessing their impact is difficult. However, science-based mechanisms must be put in place to quantify impacts and thus evaluate GCP's success. The mechanisms adopted so far involve, where feasible, *ex ante* impact studies and the provision of funding for future *ex ante* studies after GCP's formal closure.

An example of such an *ex ante* impact analysis is a recent study that focused on the economic benefits of MB, using markers developed by GCP, to develop new rice varieties tolerant of salinity and P-deficiency in Bangladesh, India, Indonesia and the Philippines. Encompassing a broad set of economic parameters, the study concluded that the MB approach saved an estimated minimum of two to three years in varietal development time. Such an acceleration of the process resulted in significant incremental benefits – between USD 300 and 800 million – depending on country, extent of abiotic stress and lag of conventional breeding[5]. GCP plans to allocate resources and work in close collaboration with the Standing Panel on Impact Assessment[6] (SPIA of the CGIAR Independent Science and Partnership Council or ISPC) to define a post-GCP impact assessment for a series of key products.

Two and half years remain before GCP closes, during which time the shape and number of products to be delivered can evolve. Considering the upstream nature of GCP research activities, it is also fair to say that impact shall be measured based on concrete indicators 3–5

[5] Ismail AM, Heuer S, Thomson MJ, Wissuwa M. 2007. Genetic and genomic approaches to develop rice germplasm for problem soils. *Plant Mol Biol* 4:547–570.

Alpuerto VE, Norton GW, Alwang J, Ismail AM. 2009. Economic impact analysis of marker-assisted breeding for tolerance to salinity and phosphorous deficiency in rice. *Rev Agric Econ* 31:779–792.

[6] http://impact.cgiar.org/about

years after GCP ends (see *Transition strategy* for these indicators at http://www.generationcp.org/about-us/strategies). Therefore, instead of anticipating a relative or absolute value – the equivalent of gazing into a crystal ball – a relative scale of 1 to 5 can preferably be used, where 5 is the largest impact across all kinds of GCP products, regardless of activity or crop, and 0 is no impact. With this approach, promoting the use of MB (and deploying the resulting improved germplasm) is estimated to have an impact factor of 4. Such a score indicates that MB will have a highly significant impact on plant breeding efficiency in developing countries.

Analysing the post-GCP placement of the molecular breeding component

GCP has primarily a research and capacity-building function, but development investment must follow if outputs are to reach farmers in developing countries. GCP's goal was always to hand over those projects initiated during Phase II (including those on germplasm improvement) to country programmes or local private companies so they may develop or deliver new varieties to farmers.

What will be finished by December 2014

By GCP's sunset in December 2014, improved germplasm generated during GCP's Phase I and possessing clear added value, compared with existing materials, should have been converted into varieties, ready for farmers' use. Thus, we should be able to say: "job done!". Regarding timelines, the RIs' MB activities will have reached the stage of advanced genetic recombination (eg advanced lines) by December 2014. Further efforts (multilocation testing and improved-line registration) will be needed to arrive at a final product that can be made available to farmers. Perhaps one or two of the RIs will not successfully generate improved germplasm by December 2014. Those projects demonstrating significant lack of progress will be stopped, once the perspectives of the respective RIs are duly considered on a case-by-case basis.

The future of those capacity-building activities aimed at enabling scientists from developing countries to access modern breeding methodologies will be tightly linked to (a) the future of IBP (see white paper on IBP) and (b) the level of the RIs' success. For trainees involved in GCP's multiyear training effort (2012–2014) to promote and facilitate the use of MB methodologies (see white paper on CB), most shall learn sufficiently to be able to independently conduct further MB activities after December 2014. Expectations are high that these scientists, accessing tools and resources through IBP, will be able to use MB as a resource in their breeding programmes.

Extending activities to CRPs, Centres or other institutions

As indicated in the earlier section *Post-GCP sustainability and projected impact*, most products developed by the activity are destined for storage, maintenance and distribution from CRP breeding programmes. Additionally, because these products can be used either as breeding materials or for advancement to varietal release, they should be made available in relevant Centres and country breeding programmes. Because many of the sponsoring breeding programmes are Centre-based, the CRPs are the logical candidates for continuing this activity where it is determined as beneficial. By prior agreement with appropriate Centres, the management of RI projects not completed by 2014 will fall into the CRPs corresponding to the specific crops and, by default, the improved-germplasm activity. The decision to continue similar MB activities, as initiated in the respective CRPs in partnership with the various country programmes involved, will be left to the CRPs. But the extension of GCP MB activities from improved germplasm to varieties remains a GCP responsibility and action plans need to be discussed and agreed upon with respective CRP partners.

The CRPs now have a mandate to establish real partnerships through cooperative programmes and projects. By providing ongoing assistance towards the breeding activities of these projects by country partners, the RI projects present an excellent opportunity to assist the CRPs in fulfilling their partnership mandates. These are fundamentally capacity-building projects, and institutions with efficient breeding programmes will be more able partners. Good working relationships already exist between Centres and the country programmes involved, so the transfer should be smooth.

Maize and wheat

Hopefully, CIMMYT and the respective Maize and Wheat CRPs will take on the Maize and Wheat RIs, working with CAAS in China, IARI in India and other key partners in Asia.

Rice

AfricaRice is leading the Rice RI in collaboration with IRRI and CIRAD – all are key partners in the Global Rice Science Partnership (GRiSP).

Legumes

The Legumes RI was supported almost in its entirety by the Bill & Melinda Gates Foundation, which funded the Tropical Legumes I Project (TLI). The proposal is to merge this initiative with the BMGF-funded TLII breeding-based project, which is administered by ICRISAT. This will ensure that the improved germplasm component of the Legumes RI will continue for the foreseeable future.

Cassava and sorghum

The future of MB activities for cassava and sorghum will depend on the priorities defined within the Root & Tuber and Dryland CRPs. Among other factors, however, the Centres' decisions would depend very much on funding. If the activity were to continue as a capacity-building means for country programmes to conduct MB, only international programmes such as the CRPs would have the mandate capacity and resources to do so.

Strong country partners in current RIs will also have the capability for MB in their own countries. Indeed, a defining purpose of the RIs was to establish sustainable MB programmes in developing countries. Once established, these programmes should be able to continue to address local breeding needs. At a minimum, products could be shared at a regional level, through emerging networks and communities of practice. Last but not least, regional private companies will also have the possibility to use improved germplasm developed through GCP projects as pre-breeding materials or even for direct distribution after agreement with the respective CGIAR Centres.

Embedding the work in a new entity as a research activity

Embedding breeding activities to enable the development of improved germplasm in a new entity does not appear to have a comparative advantage over that of CRPs or strong national programmes. Even if breeding activities, led by clear research objectives, fit well within the CRPs, the opportunity to conduct research outside the CGIAR system to enable scientists from country programmes to be exposed to and use modern breeding tools and services should not be excluded.

Conclusion

Most GCP germplasm projects are on track to deliver their expected research product outputs by the end of 2014. For farmers to benefit from the crop improvements made so far, the work programmes need to transition into a development phase. This requires several additional crop cycles and evaluations to be done so that an improved line, derived from an MB selection, can become a new registered variety and made available to farmers through public or private sectors. Critical in the pursuit of this activity are clear agreements and plans. Investments are also needed for each respective CRP, home institution or country programme to lead MB activities.

The RI projects falling under Centre management after 2014 offer an excellent opportunity to reinforce partnerships with Centres that these projects engendered. This will be particularly important, given the strengthened partnerships mandated under the CGIAR reform and incorporated into CRP proposals. Stronger engagement and focusing on capacity-building cooperative projects will result in partners being more able to assist in the effort of producing improved germplasm to meet production constraints. To produce improved germplasm and to further germplasm development that addresses specific research objectives, the same approach, based on MB, should be followed. This would be most successful, we believe, if GCP activity is redirected through new country programme/CRP cooperative projects in partnership.

Annex 1: Countries targeted by the six Research Initiatives

No.	Research Initiative	Target countries	Target traits
1.	Cassava	*Africa:* Ghana, Nigeria, Tanzania, Uganda	Resistance to cassava mosaic disease (CMD) Cassava green mite (CGM) and cassava bacterial blight (CBB) Cassava brown streak disease (CBSD) Drought tolerance
2.	Legumes		
	a. Beans	• *Africa:* Ethiopia, Kenya, Malawi, Zimbabwe • *Latin America:* Mexico, Nicaragua	Resistance to bruchids Bean common mosaic virus (BCMV and BCMNV) Common bacterial blight and bruchids Drought tolerance
	b. Chickpeas	• *Africa:* Ethiopia, Kenya • *Asia:* India	Resistance to *Helicoverpa* pod borer Drought tolerance
	c. Cowpeas	*Africa:* Burkina Faso, Mozambique, Senegal	Flower thrips Root-knot nematode Bacterial blight and fusarium Drought tolerance
	d. Groundnuts	*Africa:* Malawi, Senegal, Tanzania	Early leaf spot (ELS) Rust and rosette disease resistance Drought tolerance
3.	Maize	• *Africa:* Kenya • *Asia:* China, India, Indonesia, Philippines, Thailand, Vietnam	Drought tolerance
4.	Rice	*Africa:* Burkina Faso, Mali, Nigeria	Blast resistance Bacterial leaf blight Drought tolerance
5.	Sorghum	• *Africa:* Ghana, Kenya Mali, Senegal • *Asia:* India	Tillering Stay-green trait Drought tolerance
6.	Wheat	• *Africa:* Ethiopia, Morocco • *Asia:* China, India	Drought tolerance Heat tolerance

Annex 2: Improved germplasm and released varieties produced with GCP resources, as of June 2012

Crop and duration	Description	Principal Investigator, institute Collaborators (name, affiliation)	Target country
Cassava Jan 2008– Dec 2010	Molecular markers were used to combine South American and African germplasm with CMD resistance, resulting in the high-yielding, disease-resistant cassava variety 'UMUCASS33' with improved cooking quality. It was released in Nigeria, 2011.	**PI:** Emmanuel Okogbenin, NRCRI, Umudike, Nigeria **Collaborators:** • Chiedozie Egesi (CIAT/NRCRI) • Elizabeth Okai (CRI–CSIR, Kumasi, Ghana) • Yona Baguma (NaCRRI, Namulonge, Uganda) • Anthony Pariyo (NaCRRI) • G Melaku (IITA)	Ghana Nigeria Uganda
Rice Jan 2005– Dec 2008	• A new hybrid cultivar (Liaoyou 5224), derived from the cross between a selected DT IL (C5224) and a CMS line (Liao5216A), is approved for release to farmers in Liaoning Province and recommended for multilocation testing in northern China. • Another new hybrid cultivar (Liaoyou 5249), derived from a cross between an IL (C5249) and Liao99A, is tested in Liaoning Province. • A high yield DT japonica IL (HR95) under multilocation testing in Ningxia Province.	**PI:** Zhi-Kang Li, ICS–CAAS, China **Co-PIs:** Yongming Gao, ICS–CAAS, China; Gary Atlin, IRRI **Collaborators:** • Ze-Tian Hua, Rice Research Institute, Liaoning Academy of Agricultural Sciences (LAAS) • Zheng-Jin Xu, Shenyang Agricultural University (SYAU)	China
Rice Aug 2007– Dec 2009	One interspecific line (SIK400-b-56-1-361-18), which performs well in terms of leaf rolling and reduced leaf burning, is able to recover from drought, and possesses resistance to leaf blast.	**PI:** Marie-Noelle Ndjiondjop, AfricaRice **Collaborators:** • Manneh Baboucarr, Drame K Nani, Inés Sánchez (AfricaRice) • A Ghesquière, V Verdier (Agropolis–IRD, France) • Mathias Lorieux (Agropolis–IRD/CIAT) • Fousseyni Cissé (IER, Mali)	Benin Mali
Rice Jan 2005– Dec 2008	Advanced rice lines resistant to blast: six Vandana-like lines with added blast resistance from 'Moroberekan' for upland sites in India.	**PI:** Rebecca Nelson, CornellU **Collaborators:** • Casiana Vera Cruz, Darshan Brar, Hei Leung (IRRI) • Masdiar Bustamam (ICABIOGRD, Indonesia) • Utut Widiyastuti Suharsono (Research Center for Bioresources and Biotechnology, IPB, Indonesia)	India Indonesia Philippines
Rice Jan 2007– Oct 2009	'Sin Thwe Latt', a rice variety improved for salt tolerance by the community of practice for rice in the Mekong region, which used	**PI:** Theerayut Toojinda, BIOTEC, Thailand **Collaborators:** • Jonaliza L Siangliw (Rice Gene Discovery Unit, KU, Thailand)	Cambodia Laos Myanmar Thailand

	introgression techniques with MAS. Variety released in Myanmar, 2011.	• Toe Aung (DAR, Myanmar) • Monthathip Changpangxaen (NAFRI, Laos) • Men Sarom, Ouk Makara (CARDI, Cambodia)	
Rice Jan 2008– Dec 2009	Four Indonesian, upland, rice breeding lines tolerant of P deficiency, carrying the P-efficiency uptake gene (*Pup1*) from rice varieties IR64 and IR74.	**PI:** Sigrid Heuer, IRRI **Collaborators:** • Abdelbagi Ismail (IRRI) • Masdiar Bustamam, Joko Prasetiyono (ICABIOGRD, Indonesia)	Indonesia Philippines
Common beans May 2007– April 2010	Two drought-tolerant lines of common beans resulting from inter-genepool crosses made from five commercial genotypes from southern Africa and ten sources of drought tolerance from Central America.	**PI:** Matthew Blair (CIAT) **Collaborators:** • Idupulapati Rao, Manabu Ishitani, Steve Beebe (CIAT) • Paul Kimani (UoN/ECABREN, Kenya) • Rowland Chirwa (CIAT/SABRN, Malawi) • Asrat Asfaw Amele (SARI, Ethiopia) • Godwill Makunde (DRSS, Zimbabwe) • Motoaki Seki, Kazuo Shinozaki (RIKEN, Japan)	Colombia Ethiopia Kenya Malawi Zimbabwe
Common beans Jan 2008– Dec 2011	'INTA Fuerte Sequia', a drought-tolerant variety of common beans released in Nicaragua. Recommended by Nicaraguan authorities for zones with limited water.	**PI:** Jorge Acosta (INIFAP, Mexico) **Collaborators:** • Steve Beebe, Matthew Blair (CIAT) • Aurelio del Llano, Julio Molina (INTA–Nicaragua) • Ernesto López, Raul Rodríguez, Victor Montero (INIFAP, Mexico)	Colombia Mexico Nicaragua
Maize Jan 2005– Dec 2010	Four Kenyan hybrids improved for resistance to grey leaf spot (GLS).	**PI:** Rebecca Nelson (CornellU) **Collaborators:** • Margaret Smith (CornellU, USA) • Peter Balint-Kurti (USDA/NCSU, USA) • James Gethi (KARI, Kenya)	Indonesia Kenya Philippines
Maize Jan 2006– Dec 2011	Two high-yielding, disease-resistant maize hybrids (MTPEH200803 and MTPEH200804) developed in Kenya. Both are short-statured and resistant to GLS and maize streak virus. They perform well in dry coastal lowlands.	**PI:** James Gethi (KARI, Kenya)	Kenya