Generation Challenge Programme

For millennia, generations of farmers have known about – and used – plant genetic diversity. Farmers identify plants with particular traits, or plants that thrive in unfavourable conditions. Seeds and cuttings from these selected plants are carefully preserved for the next sowing season. This ancient and time-tested breeding strategy is now the root of novel plant science in our time.

Partnerships in modern crop breeding for food security

Our vision: A future where plant breeders have the tools to breed crops in marginal environments with greater efficiency and accuracy for the benefit of the resource-poor farmers and their families

The Generation Challenge Programme (GCP) is a 10-year initiative of the Consultative Group on International Agricultural Research (CGIAR), focusing on crop improvement in developing countries with an emphasis on drought tolerance. Designed in two five-year phases (2004–2008 and 2009–2013, with 2014 as a transition year for orderly closure), its mission is to use genetic diversity and advanced plant science to improve crops by adding value to conventional breeding for drought-prone and harsh environments. This is achieved through a network of more than 200 partners (as of 2011) drawn from regional and national research programmes, the CGIAR and academia, and through capacity enhancement to assist developing-world researchers to tap into new genetic diversity and access modern breeding tools and services.

Research and services

GCP's workplan for Phase II is building on a set of seven focused Research Initiatives (RIs) supported by an integrated breeding service component. While the RIs aim to demonstrate – through selected user cases – that modern and integrated breeding approaches can have a significant impact on crop productivity in developing countries, the service component the Integrated Breeding Platform, (IBP) is conceived as a vehicle for dissemination of knowledge and technology, enabling broad access to – and proactive distribution of – crop genetic stocks and breeding material; molecular, genomics and informatics technology and information; cost-effective high-throughput laboratory services; and capacity building programmes. Each RI is crop- or crop cluster-, region- and trait-specific for meaningful impact by the Programme's closure (see diagram and table inside).

Working with diversity

The germplasm banks of the CGIAR were originally conceived purely for conservation but breeders now also realise the high value of also studying these collections and how they perform under different field conditions. To bring this diversity down from the shelf for breeding, GCP Phase I supported the identification and evaluation of reference sets for 19 important food crops: these sets comprise a few hundred accessions widely representative of each crop's own genetic diversity. In addition, GCP supported the development of mutants, introgression lines, nested and multi-parent advanced generation intercross (MAGIC) populations, as well as segregating bi-parental line populations to identify new favourable alleles (ie, different forms of a gene [one member of a pair] located at a specific position on a specific chromosome). These DNA codings determine distinct traits that can be passed on from parents to offspring.

Creating crop resources

Availability of appropriate genetic resources is critical to identify genes of interest and breed for them in target germplasm – a crucial activity in the seven RIs. Through a concerted and sustained effort in Phase I, GCP supported the development of genetic resources for a broad range of crops, with a particular focus on less-studied (also referred to as 'orphan') crops to a level that now makes molecular breeding a reality for those important staple crops in developing countries. By mid-Phase II, GCP supported the conversion, for ten target crops, of a core set of publicly available single nucleotide polymorphism resources (SNPs) to a breeding-friendly genotyping platform to render them accessible for high-throughput and low-cost molecular breeding applications through IBP. These genetic resources have helped to identify several genes important for both biotic and abiotic stress tolerance, as well as improved germplasm for several major cereals, legumes and clonally propagated crops such as cassava and sweet potatoes.

Strategy and data management

Since its inception, GCP also invested significantly in the development of analytical and decision tools as well as suitable infrastructure for efficient data management within and across teams, a critical issue for a network aiming at adding value to individual contributions.

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Over the last few years, GCP has continued to build on the foundations laid in the Programme's formative years, and to refine its Strategic Framework. This refinement has been complemented by a set of reference studies – *ex ante* analyses that provide data on GCP's impact targets (farming systems and crops).

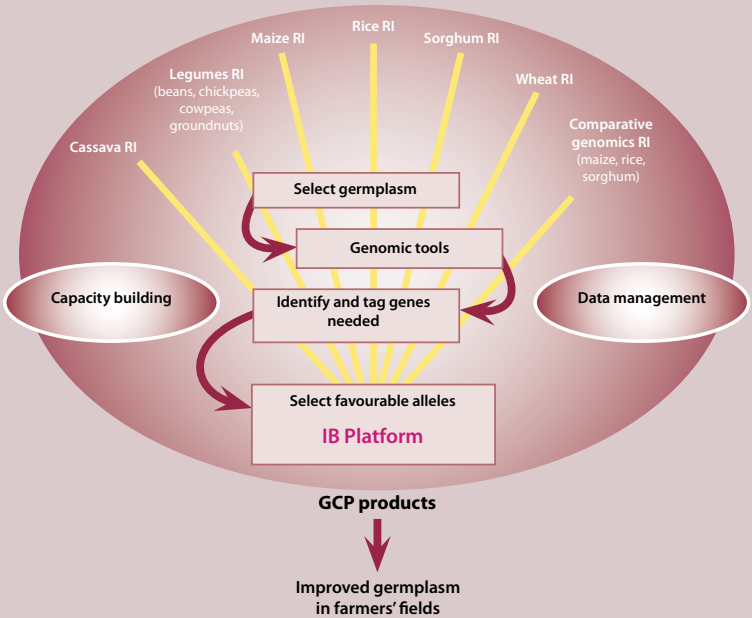
Inside the Research Initiatives (RIs)

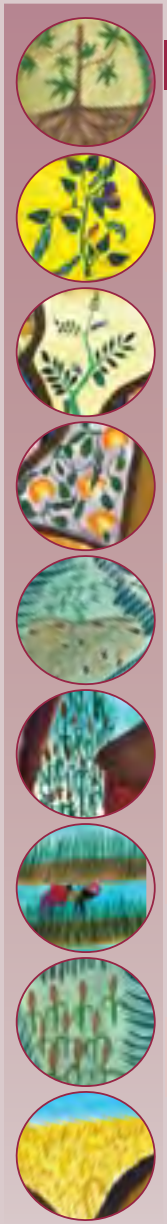
Building on achievements, products and partnerships from Phase I, these RIs – most of which are led by partners from developing countries – are expected to serve as proof of concept for the potential of integrated molecular breeding, and the use of molecular markers to improve crop productivity in target – and for most part harsh – environments.

The six crop-based RIs focus primarily on the identification of genes and the stacking of favourable alleles with molecular markers for drought tolerance, alongside other key biotic and abiotic stresses such as pests and diseases. The seventh RI focuses on the use of comparative genomics to identify homologous loci for aluminium tolerance and phosphorus-uptake efficiency across three major cereals (maize, sorghum and rice). This RI builds on major achievements from GCP Phase I – the cloning of a key gene for aluminium tolerance in sorghum, jointly by Cornell University (USA) and the Brazilian Agricultural Research Corporation (EMBRAPA), as well as the identification of a major gene for phosphorus-uptake efficiency in rice from work led by scientists from the International Rice Research Institute (IRRI) and validated with partners at Indonesia's national programme.

Jointly, the seven RIs span 26 target countries in the tropics (see table: 14 in Africa, 10 in Asia, two in Latin America), with additional research in another 10 countries around the globe (Africa, Asia, Australia, Europe and the Americas).

GCP's research and research support activities





Research Initiative target and partner countries

Research Initiative	Target countries	Partner countries
1. Improving **cassava** yield in Africa's drought-prone environments	• ***Africa:*** Ghana, Nigeria, Tanzania, Uganda	Brazil, Colombia, USA
2. Improving tropical legume productivity for marginal environments in sub-Saharan Africa and South Asia		
a) **Beans**	• ***Africa:*** Ethiopia, Kenya, Malawi, Zimbabwe • ***Latin America:*** Mexico, Nicaragua	Colombia
b) **Chickpeas**	• ***Africa:*** Ethiopia, Kenya • ***Asia:*** India	
c) **Cowpeas**	• ***Africa:*** Burkina Faso, Mozambique, Senegal	USA
d) **Groundnuts**	• ***Africa:*** Malawi, Senegal, Tanzania	Brazil, Niger
3. Improving drought tolerance in **maize** for Asia	• ***Africa:*** Kenya • ***Asia:*** China, India, Indonesia, Thailand, Philippines, Vietnam	France
4. Improving drought tolerance in **rice** for Africa	• ***Africa:*** Burkina Faso, Mali, Nigeria • ***Asia:*** Bangladesh, Cambodia, China, India, Laos, Myanmar, Philippines, Thailand	Colombia, Benin, Canada, France, USA, UK
5. Improving drought tolerance in **sorghum** for Africa	• ***Africa:*** Ghana, Kenya Mali, Senegal • ***Asia:*** India	Australia, France, USA
6. Improving drought tolerance in **wheat** for Asia	• ***Africa:*** Ethiopia, Morocco • ***Asia:*** China, India	Australia, Mexico, Syria
7. **Comparative genomics** to improve cereal yields in high-aluminium and low-phosphorus soils (maize, rice, sorghum)	• ***Africa:*** Kenya, Niger, Senegal • ***Asia:*** Indonesia, Philippines,	Brazil, Japan, USA

Our mission: Using genetic diversity and advanced plant science to improve crops for greater food security in the developing world

Services and community building– the Integrated Breeding Platform

A major goal for GCP in Phase II is to establish and sustain a set of plant-breeding support services as sustainable public goods. The purpose is to facilitate access by developing-world breeders to modern plant science technologies at optimal cost, and with logistical and technical support, including appropriate tools. To this end GCP launched the Integrated Breeding Platform (IBP) in mid-2009. The platform encompasses several breeding services and tools which address germplasm, markers and traits. The services and tools are all inter-related, but each component – or service – can also be used independently. IBP also hosts community spaces for the nine GCP crops, as well as a crop data professional network because data management and access are critical aspects of the platform. Additional networks are envisioned, including one for genomics.

Threading it all together...

Capacity development, data management and sustainability

In GCP Phase II, capacity development and crop data management are fully integrated into both the research and the service components, and not treated as stand-alone concepts.

Going into the future, vibrant communities of practice (CoPs) are proposed to anchor Phase II capacity building and provide mechanisms for sustainable delivery and use of research products beyond GCP's existence. As of October 2011, ongoing CoPs were for beans, cassava, chickpeas, cowpeas and soya beans (a joint CoP), and rice (Asia's Mekong region).

CoPs also provide a good channel for training local scientists and improving infrastructure. For example, in 2010, 16 PhD students from sub-Saharan Africa and South Asia embarked on, or continued, their training in various fields of mutual interest to their home institutes and GCP. In the same year, GCP also invested about USD 2m to improve field infrastructure for participating national programmes to ensure reliable phenotyping.

The RIs also offer an avenue for connections to – and close interactions with – an international community of crop researchers resulting in several active communities of practice, like the ones on cassava for Africa and rice in the Mekong basin (Asia).

Delivery and impact

Each RI has a product Delivery Plan. The Plan requires that project teams clearly identify – *a priori* – the tangible products that will be generated from project outputs, as well as potential users of these products. The products are deployed along the entire research pipeline, from characterisation of genetic diversity up to molecular breeding. They include genetic and genomic resources; molecular markers for target traits; innovative tools, technologies and methodologies; learning materials; and ultimately, more resilient and higher-yielding germplasm for farmers in harsh resource-poor cropping systems.

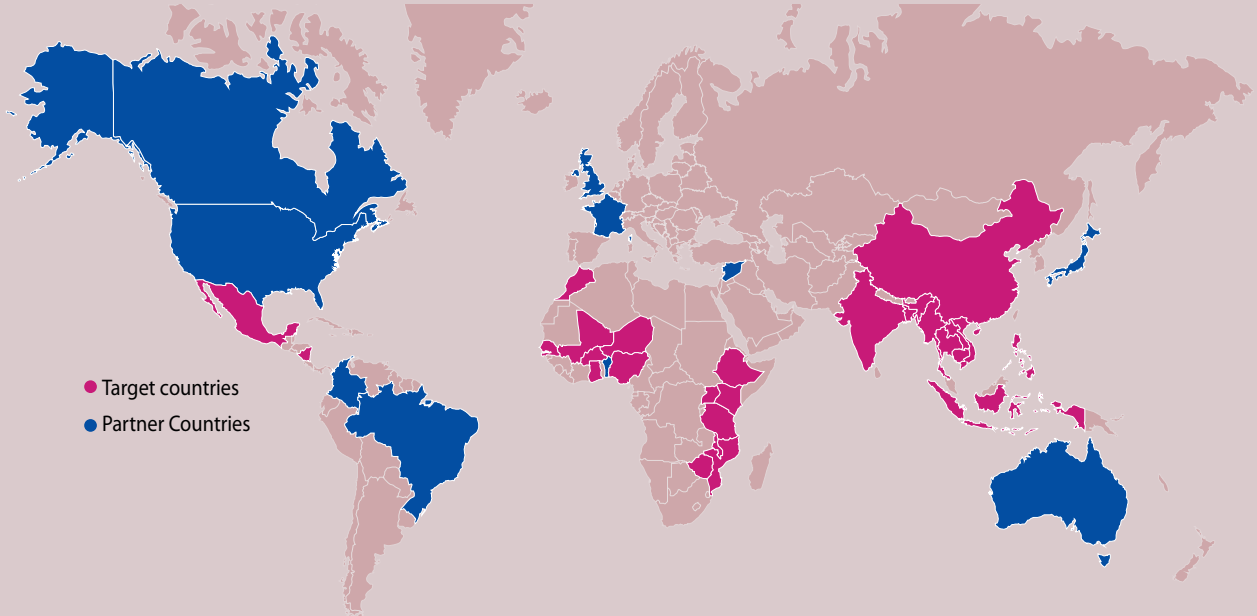
Expected outcomes from the utilisation of these research products include enhanced capacity of developing-country partners to conduct molecular-breeding experiments and more efficient exchange of crop information within and across regions.

Overall, and building on more sustainable breeding programmes in developing countries, the ultimate result would be enhanced food security, better nutrition and improved incomes and livelihoods in the targeted agro-ecologies.

GCP anticipates and trusts that a successful demonstration of these concepts will lead to adoption – as may be appropriate – of integrated breeding by developing-country partners to increase productivity and quality for these crops, and that it will further provide a strong business case for increased funding in this area.

While the anticipation and expectation is that the impact of the RIs will spill over beyond the selected target countries, impact on breeding programmes in the focus countries for each RI is what will constitute GCP's proof of concept. GCP will continue to demonstrate that a research approach tapping into crop diversity and using modern biotechnology-based breeding can have impact on crop breeding in drought-prone environments. By so doing, GCP hopes that R&D initiatives and national governments will be willing to build on GCP achievements, and extend and enhance these achievements based on the same – or largely similar – approaches.

Where in the world is GCP? The GCP network in 2011



After 2014…

The year 2014 will be the wind-down year to bring the Programme to an orderly closure, in order to fulfil our commitment to our partners, stakeholders and funders. The closure will include an evaluation of the Programme's performance and impact, identifying the lessons learnt and positioning GCP's products and legacy in a sustainable manner in the R4D landscape.

In mid-2010 GCP drafted its *Transition Strategy* as a blueprint for its final years, taking into account the CGIAR reform in 2010–2011, which had implications for this final stretch. In keeping with the *Transition Strategy*, research activities in the GCP workplan for 2011–2014 have been integrated into the respective crop-based CGIAR Research Programmes (CRPs). GCP will continue monitoring these activities, in collaboration with scientists from the crop CRPs, until the end of current contractual obligations to GCP grant recipients. Should any of these research activities be extended beyond GCP's lifetime, they shall be managed by the CRPs in keeping with their respective strategies.

For other current GCP activities outside the CRPs that may continue after December 2014 – and only if there is a demand and added value for them – in line with the philosophy underlying the Challenge Programmes, the priority will be to embed such activities within existing efforts. It is however feasible that some activities may not fit within existing institutions or programmes, and may therefore require some sort of autonomous implementation mechanism.

IBP is envisioned to continue after 2014, and its future will need to be defined.

Funding: GCP's annual budget of about USD 15 million is supported by the generosity of various funders, most coming through the CGIAR. Funders in 2011 were (in alphabetical order) the Bill & Melinda Gates Foundation, the CGIAR Fund Council, the Department for International Development (UK), Pioneer Hi-Bred Inc, the European Commission, the Swedish International Development Agency, the Swiss Agency for Development and Cooperation and the Syngenta Foundation for Sustainable Agriculture.

The major asset of the Programme is its network and people!

CGIAR Generation Challenge Programme (GCP)
Hosted by CIMMYT

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