The Integrated Breeding Platform

Enhancing a time-tested ancient art with modern tools to support crop improvement

Since the dawn of agriculture, humankind has sought to improve crops by selecting individual plants with the most desirable characteristics or traits. Agricultural productivity has thus been progressively enhanced by constant innovation and selection, including improved crop varieties to increase production in specific environments.

Selection has traditionally been carried out at the whole-plant level (ie, phenotype), which naturally results from a combination of the plant's genotype (G) and the impact of the environment (E) the plant finds itself in. Both of these factors lead to the subsequent G×E interactions that influence the plant morphology and productivity. And while phenotypic selection has delivered tremendous genetic gains in most cultivated crops, this approach can be greatly enhanced by the use of molecular markers, especially for complex traits that are regulated by a large number of genes at once and are easily affected by the environment. This is especially the case when the plant is under stress, such as excessive drought or heat.

Molecular breeding for complex, or polygenic, traits has been successfully deployed in the private sector, and several experts in the art consider molecular plant breeding as the foundation for 21st century crop improvement. Integrated crop breeding hastens genetic gain by combining phenotypic selection with cost-effective molecular breeding (MB) methods. While major private-sector players have reaped handsomely from MB approaches, in sharp contrast, the impact of molecular breeding in the public sector and in small enterprises is thus far limited for various reasons such as limited resources (particularly for reliable phenotyping), lack of access to analytical pipelines, to crop information systems or to largescale genotyping facilities. This unfortunate gap in the critical public and small- and medium-scale enterprise (SME) sectors has limited the development of new cultivars, thus hampering progress towards greater food security in the developing world.

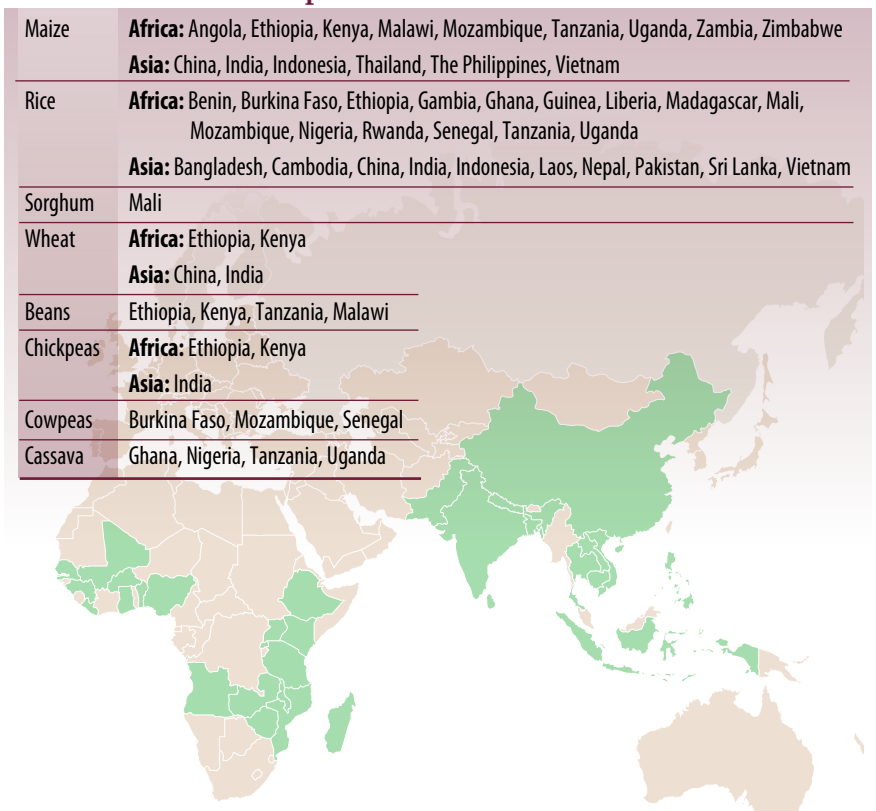
Bridging the gap, meeting real needs, and amplifying the gains

Addressing this gap and providing access to molecular breeding in developing countries is an imperative for agricultural research and development, and is a major objective of the Integrated Breeding Platform (IBP). IBP is envisioned as a sustainable, web-based one-stop shop for information, analytical tools and related services to design and carry out integrated breeding projects. 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.

The Generation Challenge Programme (GCP) of the Consultative Group on International Agricultural Research (CGIAR) has coordinated the development of IBP in collaboration with partners from different universities, CGIAR Centres and developing-country programmes to serve the needs of 14 pioneer 'user cases' – active breeding projects on eight crops across 32 developing countries in Africa and Asia. This ensures that from the outset, IBP development is driven by real breeder needs, and that its interface is user-friendly.

Initial user cases: 8 crops across 32 countries

Maize	**Africa:** Angola, Ethiopia, Kenya, Malawi, Mozambique, Tanzania, Uganda, Zambia, Zimbabwe **Asia:** China, India, Indonesia, Thailand, The Philippines, Vietnam
Rice	**Africa:** Benin, Burkina Faso, Ethiopia, Gambia, Ghana, Guinea, Liberia, Madagascar, Mali, Mozambique, Nigeria, Rwanda, Senegal, Tanzania, Uganda **Asia:** Bangladesh, Cambodia, China, India, Indonesia, Laos, Nepal, Pakistan, Sri Lanka, Vietnam
Sorghum	Mali
Wheat	**Africa:** Ethiopia, Kenya **Asia:** China, India
Beans	Ethiopia, Kenya, Tanzania, Malawi
Chickpeas	**Africa:** Ethiopia, Kenya **Asia:** India
Cowpeas	Burkina Faso, Mozambique, Senegal
Cassava	Ghana, Nigeria, Tanzania, Uganda



Capacity building, communication, collaboration and communities of practice

Beans

Cassava

Chickpeas

Cowpeas

Groundnuts

Maize

Rice

Sorghum

Wheat

Photos: CIAT– beans, cassava, groundnuts; CIMMYT – wheat; ICARDA – chickpeas; ICRISAT – sorghum; IITA – cowpeas, maize; IRRI – rice

Professional network:

- Crop data management

Capacity building is an integral part of IBP, encompassing training and support in using molecular breeding techniques and markers, designing breeding strategies, quality data management, information analysis, decision modelling, phenotyping protocols, and protection of intellectual property. See also *Genotyping Support Service* overleaf.

IBP provides fora and other community tools via a user-friendly website, to stimulate and sustain crop- and discipline-based communities of practice (CoPs) and networks.

The CoPs promote the application of molecular breeding techniques and the utilisation of facilitative information management technologies, data and germplasm sharing, and overall advance modern breeding capacity by linking developing-country breeding programmes and research organisations with CGIAR Centres and other advanced research institutes.

The IBP website currently hosts nine crop communities and one professional network (see left). While the core of the IBP communities is drawn from the user cases and GCP Research Initiatives, membership is however open to all.

Marker service and the Genotyping Support Service

To maximise efficiency and cost-effectiveness, GCP has contracted several service providers for its Marker services. In 2011, providers included Biosciences Eastern and Central Africa (BecA), Diversity Arrays Technology, Pty Ltd (DArT P/L, Australia), DNA LandMarks Inc (Canada), KBioscience (UK) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

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. By using the KBioscience KASPar system, SNP conversion was completed in 2011 for common beans and wheat, and for the sorghum aluminium-tolerance gene Alt_{SB}. By the end of 2011, valid sets of 1,000–2,000 SNPs were available for cassava, chickpeas, cowpeas, maize, pigeonpeas and sorghum. All in all, the IBP marker service handled 27 requests, covering eight crops in 2011.

The Genotyping Support Service (GSS) aims to introduce developing-country researchers to the advantages of molecular breeding by providing grants for genotyping and for training in the analysis and interpretation of the data generated by those projects. In 2011, the GSS strategy changed from the open-call system to an internal call to country partners in Africa already involved in GCP's RIs, covering relatively limited genotyping activities for marker-assisted breeding (MAB) and marker-assisted recurrent selection (MARS). GSS uses the same service providers as the Marker service.

Monitoring, funding and sustainability

Strategic guidance is provided by the Scientific and Management Advisory Committee (SiMAC) comprised of leading professionals drawn from relevant fields, many from the private sector. IBP is jointly funded by the Bill & Melinda Gates Foundation, the European Commission, the United Kingdom's Department for International Development, and, more recently, the CGIAR Fund Council. The IBP Business Plan and GCP's *Transition Strategy* both envision the platform's future as a sustainable service supported in part by annual fees paid by members of a formal IBP user community. As a cross-cutting platform, IBP will serve the breeding needs of CGIAR Research Programmes on crop improvement, as well as initiatives outside the CGIAR.