Excellence in Breeding PLATFORM

Annual Report 2017

Tools and services that create synergies and accelerate genetic gains of breeding programs targeting the developing world

CGIAR | Excellence in Breeding Platform

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CGIAR Excellence in Breeding Platform (EiB)	The International Maize and Wheat Improvement Center (CIMMYT)

List of participating Centers and other key partners

AfricaRice	AfricaRice	biosciences eastern and central africa	Biosciences eastern and central Africa - International Livestock Research Institute Hub
Bioversity International	Bioversity International	CIAT	International Center for Tropical Agriculture (CIAT)
CIMMYT International Maize and Wheat Improvement Center	CIMMYT	CIP International Potato Center	International Potato Center (CIP)
Cornell University	Cornell University	CORTEVA agriscience	Corteva Agriscience
CSIRO	Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Diversity Arrays Technology	Diversity Arrays Technology (DArT)
CROP TRUST	The Crop Trust	FAO	Food and Agriculture Organization of the United Nations (FAO)
ICARDA Science for Better Livelihoods in Dry Areas	International Center for Agricultural Research in the Dry Areas (ICARDA)	INRA Science & Impact	Institut National de la Recherche Agronomique (INRA)

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International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

International Institute of Tropical Agriculture (IITA)

International Livestock Research Institute (ILRI)

Integrated Breeding Platform (IBP)

International Rice Research Institute (IRRI)

James Hutton Institute

John Innes Centre

Kansas State University

Nottingham University

Monsanto

Oregon State University

Queensland University

Syngenta

United States Department of Agriculture (USDA)

Wageningen University

World Agroforestry Centre (ICRAF)

WorldFish

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1. Key Results

1.1 Highlight Platform Outputs:

The platform leader was hired in August of 2017. The platform leader, Michael Quinn, and CIMMYT DDG, Marianne Bänziger, visited a large number of CGIAR-supported breeding programs – Africa Rice (Nigeria), CIAT (Colombia), CIMMYT (Kenya, India, Mexico), CIP (Kenya, Peru), ICRAF (Kenya), ICRISAT (Kenya, India), IITA (Nigeria), ILRI (Kenya), BeCA (Kenya), IRRI (Philippines, India), WorldFish (Malaysia) – to better understand challenges, needs and opportunities, and to explain how EiB can provide value to CGIAR breeding institutions and how best to work with EiB. A membership agreement that describes the commitments expected of breeding programs participating in EiB and the benefits they can expect to receive in turn was developed and distributed to CGIAR institutions. Signed membership agreements were returned from most CGIAR breeding programs.

A meeting of EiB contributors and expert advisory group (EAG) members from CGIAR was held in Amsterdam. The outcomes of the meeting shaped the objectives and work plans of EiB for 2017 and will continue to do so for the next five years. It was also the first time that CGIAR breeders jointly discussed product development concepts and how to improve breeding program management. Another successful workshop was held at the National Crops Resources Research Institute in Uganda and supported by EiB, the High Throughput Genotyping Project (HTPG), the Genomics Open Source Breeding Informatics Initiative (GOBii) and the Integrated Genotyping Support and Services Project (IGSS). The objective of the workshop was to enable CGIAR and NARS programs to implement marker-assisted selection and integrate forward marker breeding strategies into the actual breeding process. In contrast to previous training approaches, the focus was on overcoming practical constraints and approaches for integrating markers into the breeding pipeline to accelerate genetic gains. The team worked on developing decision guides for breeding programs, and practical tools for DNA sampling in challenging environments. Another workshop assessed bottlenecks in high-throughput phenotyping among centers implementing such approaches, in order to identify how to implement lower cost phenotyping approaches.

EiB supported the implementation of the Breeding Application Programming Interface (BrAPI), advancing towards the goal of interoperability of breeding and germplasm information systems, both existing and in development. In collaboration with the BigData Platform it emphasized the need for uniform data standards driving data integration. EiB further developed the first version of a Drupal-based Toolbox as a repository and gateway for tools, use cases, best practices and training materials, while serving as a discussion platform for the EiB community.

EiB expanded its annual funding from US$ 2 million to US $6 million through bilateral funding from the Bill & Melinda Gates Foundation (BMGF), thus reaching 60% of its base budget.

1.2 Platform-specific quality control activities

EiB enables breeding programs to make improvements through the implementation of best practices. Quality control within the Platform relies on ensuring that the skills, knowledge, know-how, tools and services being promoted and made available through EiB are aligned with best practice. For this it is important for EiB to understand exactly what best practice is. This is achieved in a number of ways, including an annual contributors' meeting where experts from all over the world and from each discipline of breeding are brought together to discuss and decide on the practices, tools and services that EiB will promote and make available to breeding programs.

Another quality control measure used by EiB is the Breeding Program Assessment Tool (BPAT), implemented in collaboration with Queensland University and BMGF. The BPAT is a standard review approach for identifying what improvements can and should be considered by breeding programs. By using recommendations derived from the BPAT as guide to the specific improvements that should be prioritized for participating breeding programs, EiB is responding to the goals outlined by an external and highly qualified review process. In time, the BPAT will also serve as a means to measure the success of EiB in enabling breeding programs to adopt these recommendations.

1.3 Progress by Platform Modules:

Module 1: Breeding program excellence

The focus of Module 1 was to introduce key concepts and better understand the needs of the CGIAR and national agricultural research and extension system (NARES) breeding community. The concept of a product advancement process (stage gate management) was introduced through a series of workshops. The position of Product Manager/Market Analysis was opened to support the adoption of variety replacement strategies, in which breeding teams adopt market-oriented product profiles to increase variety turnover or initiate a market shift. Through a series of CGIAR/NARES breeding community network meetings, the breeding community has been made aware of how Module 1 can better help the programs achieve impact. In general, there is a reluctance to implement a structured approach due to the risks introduced with greater measurability. Based upon open discussions with meeting participants, it was determined that Module 1 objectives can be achieved by designing simple means of implementing best practices and with the constant involvement and support of Center/CRP leadership.

The need for an emphasis on measuring breeding program success through the assessment of genetic gains was also introduced in the partner breeding community. The value of assessing genetic gains was recognized, but the preference among breeders was for more immediate feedback on the value of breeding program changes. Based on these conversations, we will continue to develop best practices for genetic gain improvements, but also develop a more practical assessment that would provide a less comprehensive but more frequent assessment of breeding program improvements. The annual assessment of program improvement would be a vehicle for ushering in Module 2 breeding program assessments.

Progress over the reporting period was impeded by the lack of dedicated Module 1 leadership, with the early leader of Module 1 holding a separate role as the IRRI Breeding Lead during a time when IRRI was focused on restructuring for impact. As of 7 May 2018, Module 1 leadership has been engaged on a full-time basis. A greater impediment may exist if the Center DG/DDGRs do not actively oversee the implementation of Module 1 principles. Without the direct involvement of the DG/DDGR, breeders will continue to develop tool- or trait-driven products, rather than products designed for combined market and development impact.

Module 2: Optimizing breeding schemes

The focus of Module 2 was changed during 2017 from “Trait discovery and the toolbox” to “Optimizing breeding schemes”. This is in acknowledgement that the tools and services provided through modules 3, 4 and 5 will only have impact if applied as part of a strategic plan to increase rates of genetic gain, according to the targets set by Module 1. As a result, Module 2 will enable breeders to optimize their breeding strategy and improve new tools strategically, focusing on cost-benefit analyses of genomics and phenotyping tools and secondary traits, improved integration of trait breeding into mainstream breeding, and tools for optimizing breeding schemes. The Toolbox is now situated outside the modules, housing inputs from all five modules.

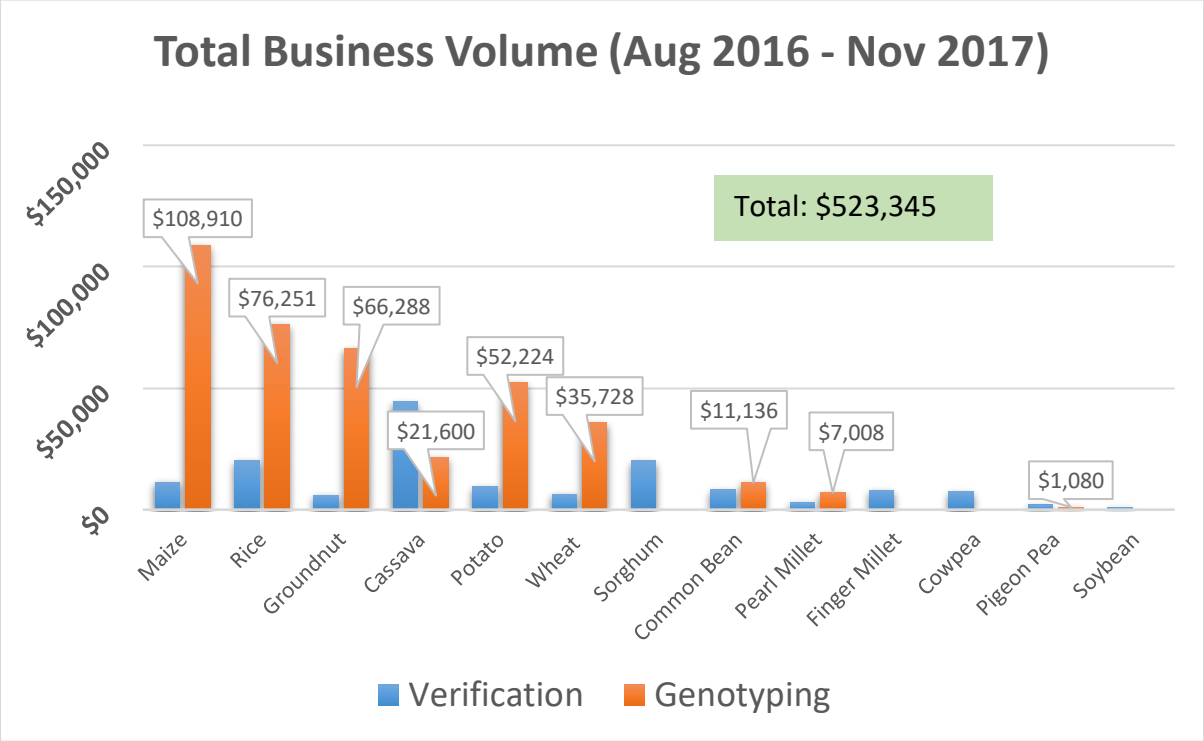
A headhunter has been recruited to find a leader for Module 2. After the first round of searching none of the candidates were found suitable. The second round of searching is coming to a close and it is expected that an offer will be made for the Module 2 leadership early in Q3 2018. Without a Module leader (and without an EiB Director for most of the year) very little Module 2 activity was conducted in 2017.

A draft template to capture breeding programs' current breeding schemes has been developed. Toward the objective of developing a simulation tool to provide decision support to breeders, discussions have been held with a private company that has developed such tools for Syngenta.

Module 3: Genotyping / sequencing tools and services

The focus of Module 3 is to promote and provide support for shared genotyping services to all EiB member programs, whether in the CGIAR or in NARES. A survey was sent out to all member programs to assess the needs, challenges and expectations for Module 3 covering three main areas of genotyping application: (i) A low density marker platform for forward breeding, (ii) a mid to high density sequencing platform for genomic selection and germplasm fingerprinting, and (iii) Quality Assessment/Quality Control (QA/QC) for breeding pipelines. The outcome of the survey supports genotyping sample forecasting, which is critical to service contract negotiation with various genotyping service providers, thereby supporting a key Module 3 objective. In 2017, most of the module outputs were delivered through two BMGF-funded sister projects, HTPG and IGSS.

The HTPG project is geared towards low-density genotyping platforms (KASP markers technology) and a service contract led by ICRISAT was signed with Intertek to provide services to all EiB members as well as private partners. The project offers significant cost reduction in low-density genotyping (25% to 50% savings vs. in-house facilities) to all users and most of the CGIAR and NARS users also received genotyping subsidies from BMGF. The HTPG mode of operation relies on collective bargaining and sharing of marker information among all users in order to maintain low pricing; the minimum business volume to maintain the pricing agreement with Intertek was US $200,000 per annum. In 2017, the annual business volume was reported at over US $500,000, more than twice the annual minimum volume. The success of the project was mainly due to the expansion of the user base, with the inclusion of multiple private sector partners as well as growing number of crop programs switching over to outsourced genotyping providers such as HTPG. By the end of 2017, users representing a total of 13 crops had enrolled in the HTPG service, spanning seven CGIAR centers and over 30 NARS and private partners.



Acknowledging the need for cross-EiB module integration to provide better support for member programs, HTPG had multiple activity planning meetings with the Genomic Open-sourced Breeding Informatics Initiative (GOBii) in 2017. One key activity was the joint workshop in East Africa hosted by the National Crops Resources Research Institute (NACRRI), Uganda and sponsored by EiB, GOBii, IGSS and HTPG. The joint workshop covered three high-level components: (i) Initial engagement on the work of EiB in East Africa, (ii) decision support tools and services provided by GOBii, and (iii) HTPG and IGSS project discussions. Following that, on 4-6 December 2017, the HTPG annual meeting was held at ICRISAT, Hyderabad with participants from 30 public and private institutions from 19 countries. The annual meeting provided a good avenue for all HTPG users to interact and provide feedback. Overall, sampling logistics and decision support tools were identified as major constraints for many users to scale-up adoption of genotyping tools. The feedback provided in these meetings has helped set the direction for Module 3 to work even more closely with Module 4 and Module 5 in 2018.

Furthermore, 2017 was the first year that the IGSS genotyping service was offered; previous years were dedicated to setting up the lab and providing training. IGSS initiated approximately 47 projects in which genotyping was offered at a subsidized price to initiate long-term molecular breeding within these programs. These projects are forecast to produce around 70,000 samples for genotyping between 2017 and 2019. In addition, two communities of practice (CoP) for maize and beans were set up with the participation of breeders from Ethiopia, Kenya, Uganda, Rwanda and Tanzania. These projects were initiated by forming a diversity panel composed of lines from all members. The IGSS hosted a workshop to organize the CoP and discuss genomic selection. The IGSS also participated in workshops/meetings for EiB, MERCI and MARI in Ethiopia, Rwanda, Tanzania and Uganda.

Module 4

Survey to assess current status in phenotyping and TPE analysis

An in-depth survey was executed following the EAG meeting in March 2017. The main objective of the survey was to assess the status of phenotyping in support of breeding in the different agri-food system

CGIAR research programs (AFS CRPs), and then define a benchmark to guide the choice of EiB interventions and further monitoring of progress. The survey was applied in five domains: (i) Informant information and perceptions. This included the CoP participant ID and initial perceptions; (ii) Targeting and screening. This domain refers to the environmental characterization of the target population of environments (TPE), to capture how well the conditions in which phenotyping is carried out are documented and reported, and whether traits are measured with specific facilities or high throughput phenotyping methods; (iii) Phenotyping/mechanization. This domain serves to identify the most frequent phenotypes being measured/recorded, and in what conditions, methods and stage in the breeding program. It also attempts to establish a baseline/benchmark/need diagnosis in the different AFS CRPs in terms of throughput/mechanization and automation, or infrastructure and management of research stations; (iv) Data storage, analysis and ranking. This domain refers to the use of statistical tools and methods to correct phenotypic data and increase their quality and the information for breeding selection; (v) Specialized phenotyping. This provides an inventory of needs for routine analysis of physicochemical composition and functional properties in plant and animal materials in support of breeding (e.g. near-infrared reflectance spectroscopy analysis for grain quality); (vi) Tools, training and support. This identifies possible tools that could be shared across the different AFS CRPs and training needs.

A detailed analysis report was generated from the answers to the survey. The survey report is a rich diagnosis of the status of the AFS CRP breeding programs in terms of phenotyping. The survey report gives information on "low hanging fruit" (for instance, only about 60% of AFS CRP breeding programs use barcoding routinely and achieving a 100% mark seems to be a logical short-term target), areas where investment is needed (for instance mechanizing operations such as planting, weeding and harvesting), etc.

From this survey, which gathered about 80 responses, the community of practice was created. An analysis of the survey was shared within the CoP along with other Module 4 updates.

Tools and best practices:

The documentation of best phenotyping practices and their conversion into adaptable/deployable solutions across AFS CRP breeding programs lies at the core of EiB Module 4. A first stage is to develop content by tapping into on-going experiences in the CoP and upload such content onto the ToolBox. The idea is to develop technical manuals and videos to show tools in action for easier replication/implementation, provide troubleshooting sections and links to potential equipment providers, providing a holistic information source for potential implementers. The concept was discussed with potential contributors and topics of common interest identified for elaboration in 2018.

High throughput phenotyping

A meeting was held on 6-7 November to discuss the use of drone-based imaging to generate phenotyping data in support of breeding programs. The rationale for the meeting was to gather together experts in the field to evaluate what is possible and identify remaining bottlenecks. Discussions focused on how to make these tools accessible to non-practitioners, and to breeders in particular. A solution was discussed that would allow new potential users to incorporate drone-based imaging in the scope of their breeding program while avoiding the obstacle of high initial time and material resource investment in technology adoption. Currently, some CGIAR centers have started to generate drone imagery, but the initial time and resource investment required to create a working solution in context has prevented the creation of solutions that can be easily replicated elsewhere. The solution developed in this meeting consists of a two-part service model:

1. Image generation (either in the scope of a regional hub or through a local service provider) with a standard operating procedure (SOP) manual to generate these images and a local app to ensure quality.

2. A cloud-based platform for data processing (with the possibility for a local version in cases of poor internet connection), inputting image data and outputting spectral indices.

In implementing this solution, Module 4 would tap into the experiences of world experts in this domain (such as the University of Queensland, the Kansas State University (KSU)-French National Institute for Agricultural Research (INRA) group and a commercial startup) to set a gold standard of drone-based imaging operation in the CGIAR and NARES breeding programs.

This solution would require expert support in IT-image analysis to facilitate both steps. A start-up associated with INRA-Avignon is currently developing a similar platform for INRA and would be keen to explore the expansion of this activity node in the CGIAR. Such node(s) could also be based in any of the regional phenotyping hubs being considered by the CGIAR.

Module 5: Bioinformatics, biometrics and data management

Module 5 survey results

As an initial activity of EiB Module 5, a survey was conducted to assess the breeding informatics (IT, bioinformatics, and biometrics) support for CGIAR breeding programs. There were around 80 respondents from multiple CGIAR centers and geographies, as detailed in Table 1. To gauge awareness and interest in EiB and Module 5, participants were asked if they had heard of EiB and were interested in participating in Module 5. Of the 80 participants, 70% indicated they had heard of EiB and 91% responded that they were interested in participating in Module 5 activities. This clearly indicates that there is significant interest in EiB and the goals of Module 5.

Table 1

Centers Responding to the Survey	Bioversity, CIAT, CIMMYT, CIP, ICARDA, ICRISAT, IITA, ILRI, IRRI.
Countries Represented	Belgium, Colombia, Ethiopia, France, Ghana, India, Kenya, Mali, Mexico, Morocco, Niger, Nigeria, Peru, Pakistan, Philippines, Tanzania, Turkey, Zimbabwe.

The survey focused on several key areas: IT infrastructure, data management, breeding process support and breeding decisions support. From the outset, it was believed that internet connection reliability was viewed as a major issue in many geographies; however, responses to the survey indicate only a small percentage of participants consider internet connections to be unreliable. Responses indicate that data accessibility and access to adequate computational resources are issues that need to be addressed, with 26% of participants indicating that it is difficult to access the data required to do their jobs. Survey results relating to IT infrastructure are presented in Annex 1.

In terms of data accessibility and analysis related to decision support, the survey results indicate that only 41% of survey participants agree that they have easy access to data needed to make advancement decisions. Even more troubling is that only 30% of respondents agreed that they had easy access to information needed to make parental selections. This low number is likely related to poor access to historical data (only 20% agreed there was easy access) and the ability to trace advancement decisions (only 25% agreed there was easy access). Not only does this affect the ability to make well-informed decisions for parental selection, it also makes it very challenging to track genetic gain and evaluate the efficiency of breeding programs. These represent critical and fundamental issues that must be addressed if EiB is to be successful. The first key step in accomplishing this will be the full adoption of

breeding management software. Survey results relating to data accessibility and decision support are presented in Annex 2.

Results related to data analysis and statistical consulting fared better in the survey, with 60% of respondents indicating that they had the biometrics consulting capacity and software needed to design and analyze field trials; however, only 20% of respondents agreed that it was straightforward to program analysis pipelines against databases. This may explain why only 47% of respondents agreed that all trials are analyzed in time to make advancement decisions, despite indications that software and consulting are available to breeders. Given the resource investment in planting, growing, and harvesting field trials, the inability to analyze the data on time is costly. It is clear decision support tools will benefit breeding programs, but bottlenecks in data access and data cleaning need to be addressed as a first step.

Efficient breeding workflows and processes are another key driver in breeding program efficiency. Minimizing errors and reducing both time and cost for breeding processes can have a huge impact on the performance of breeding programs. The fact that industry breeding programs commonly use lean and Six Sigma principles to improve breeding processes is testament to the importance of optimizing SOPs. While the development of SOPs falls outside the scope of Module 5, building the IT support for efficient implementation of the SOPs should be a focus. While the survey only covered a subset of breeding processes that will require IT support, there clearly needs to be improvement in this area, with only 33% of respondents agreeing that they have adequate IT support for breeding workflows and processes. However, significant standardization of breeding process and workflows will be required to effectively build IT support. In the absence of standardization, developing tools will be costly and challenging, if not impossible. This is an area where Module 5 will need to collaborate closely with the other modules in EiB. Survey results relating to breeding process support are presented in Annex 3.

Current landscape for breeding data management

There are multiple systems in various stages of development for breeding management but, as indicated in the survey, these systems have yet to be adopted for routine use. One major focus of Module 5 needs to be facilitating the routine adoption of available systems, as this will address many of the needs identified in the survey. There can be several reasons for lack of adoption, including system performance, inadequate user training, lack of proper incentives or the cost of deploying and maintaining the systems. For all EiB member programs, clear metrics on the adoption of breeding systems should be required, and in cases where adoption rates are low, programs should provide clear feedback as to the root causes. Modern and efficient breeding programs are built on a foundation of fully adopted breeding management systems. These systems are the basis of accurate decision support and efficient breeding process.

Figure 1 details major breeding management systems available to EiB breeding programs. While adoption is the most critical and urgent deliverable of Module 5, the interoperability of these systems is necessary to deliver downstream benefits of breeding process and decision support. To achieve interoperability, Module 5 must achieve 3 key deliverables:

1) Compatible implementations of Universally Unique Identifiers (UUIDs) for germplasm and other relevant entities.
2) Definition and full adoption of minimally acceptable metadata standards for all breeding data collected by member breeding programs.
3) A common BrAPI must be developed and implemented in all critical database systems adopted by member programs.

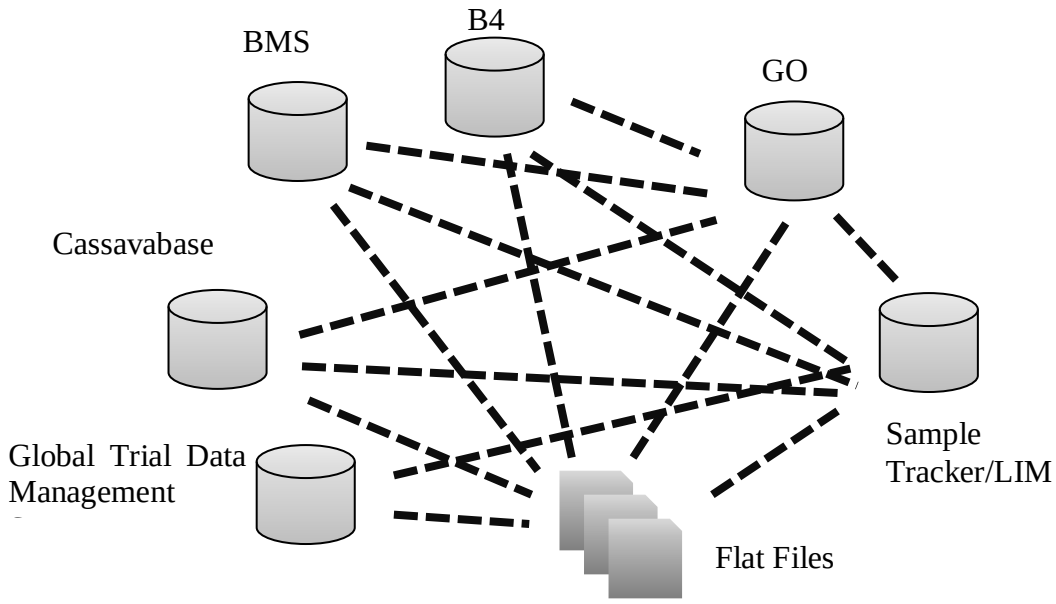


Figure 1. Current methods for managing data in CGIAR breeding programs. Dashed lines indicate that systems need to exchange information but are not interoperable.

To support these efforts, M5 initiated two CoPs. Following the initial survey, a second survey was sent to solicit participation from people focused on M5-related activities. Eighty individuals from the AFS CRP system and from key Module 5 projects and partners, such as GOBii and the James Hutton Institute, indicated an interest in contributing to these CoPs on (1) Bioinformatics and Biometrics and (2) Breeding Data Management. These groups will hold online meetings and will also form working groups to address specific topics requested by the Module 5 EAG. The first meetings of these CoPs and working groups commenced in Q4 of 2017.

Module 5 results framework and progress on year 1 deliverables

The initial focus of Module 5 will be the routine adoption of breeding management systems and interoperability of key databases. A further major deliverable, a sustainable architecture for breeding management, process and decision support, will then follow. While it is key to implement a sustainable IT architecture, it is unlikely that this will be achievable in the first five years of the project. With that said, Module 5 will need to deliver a model for IT architecture and make significant progress in building towards this architecture in Phase I of EiB.

Table B contains the key Module 5 deliverables for Year 1 of the project. The deliverables are combination of Year 1 deliverables established in the March 2017 EiB meeting (due at the end of 2017) and the deliverables from the BMGF results framework (due at the end of October 2018). The deliverable “Establish overall strategy and prioritize pipeline/breeding use case studies and related tools” will be a critical driver of subsequent Module 5 efforts. While data generation, acquisition, and quality control are obvious first steps, a clear path forward for development strategy and priorities needs to be established and approved by the EiB steering committee. It is also recommended that initial software and database development work be focused on more advanced breeding programs in terms of adoption of data management systems and best practices in data collection. Systems developed for advanced breeding programs could then be modified for adoption as additional programs are ready for implementation.

While great progress has been made on deliverables due by the end of 2017, there is significant work left on deliverables due in October 2018. For the deliverable "Establish overall strategy and prioritize pipeline/breeding use case studies and related tools", it is proposed that a working session be held at the 2018 EiB EAG meeting, with the goal of identifying and prioritizing key use cases for the development of breeding IT support. For the deliverables "Report on the current landscape of databases, bioinformatics capabilities/software, and biometric capabilities/software", "Documented gap analysis for the Year 1-2 case studies" and "Existing databases and tools assessed and updated", it is recommended that a consultant be contracted to work with the newly formed Breeding Data Management CoP to identify and evaluate key database systems. For bioinformatics/biometrics software and capabilities, a working group has been formed as part of the Biometrics and Bioinformatics CoP to compile a list of available software and recommendations for improving accessibility and adoptions rates. A training and workshop plan is being formed in collaboration with partnering projects to address the deliverable "Exposure to and adoption of appropriate databases in member breeding programs" with the goal of having a finalized training schedule in place for 2018/2019 following the March 2018 EiB EAG meeting.

In conclusion, the initial EiB Module 5 survey indicates there is significant interest in the Platform and critical gaps that must be addressed to improve the efficiency of member breeding programs. The highest priority will be addressing fundamental issues with data management, with a focus on increasing the adoption of breeding management systems and improving the interoperability of critical systems. Improvement of interoperability will focus on data QC and metadata standards, BrAPI and UUIDs with a focus on supporting the highest priority breeding use cases.

1.4 Cross-Cutting Dimensions (at Platform Level):

1.4.1 Gender, Youth and Capacity Development:

Gender

The CGIAR EiB Platform actively ensures that gender is a major component of its strategy by including women in its communities of practice, expert advisory groups, and training events. Through the documentation of personnel in membership agreements, we are able to emphasize the importance of gender balance in our membership. Furthermore, a Product Manager/Market Researcher for Breeding Product Development and Uptake has been hired to ensure socially inclusive needs and circumstances, particularly of women and youth in rural households in target geographies, are considered in product design and scaling strategies.

Youth

The CGIAR EiB Platform has addressed youth by hiring a Product Manager/Market Researcher for Breeding Product Development and Uptake to ensure that socially inclusive needs and circumstances, of youth in rural households in target geographies are considered in product design and scaling strategies. It is anticipated that new technologies will stimulate youth interest in the field, and that young scientists will make full use of resources available on the Platform web portal and Toolbox.

Capacity Development

The three primary areas of capacity development in EiB are: 1) Workshops/trainings, 2) Toolbox, and 3) Learning Management System (LMS). In 2017, the Platform held workshops/training events, including in East Africa, targeting improved use of genomics tools, and another which was focused on developing a centralized service for processing drone-based images. The Platform has invested in the documentation of tools by members, and in Platform personnel and consultants adapting those tools for a wider range of users, as part of a web-based Toolbox. Although the LMS is currently in its initial stages, it will be significant in ensuring that EiB is accessible to a greater number of people.

1.4.2 Open Data:

While EiB may provide access to tools, services and knowledge from different sources, with varying usage policies, open access will always be prioritized and the outputs of EiB and its members through the Platform will be openly and freely available.

The Platform will serve as a broker of genotyping services. Products submitted to the Toolbox and data generated by genotyping service providers will remain the intellectual property of the users with neither the Platform nor the service provider gaining any rights to the germplasm or data. Members of this Module will need to sign an agreement that contains the requirements for Platform service use and supply provisions. Platform staff will negotiate services with input from finance and legal experts. Pricing agreements reached with service providers will, if required by service providers, remain confidential.

Members contributing to this Module shall ensure proper stewardship of their intellectual property as well as intellectual property belonging to other parties who have granted and confirmed permission to use. All parties using third party intellectual property must do so as part of any agreement they sign for this Module.

Intellectual assets developed with Platform funding (including tools, germplasm, inventions, improvements, data, processes, technologies, software, trademarks, publications and other information products) will be made available to the public under appropriate licensing conditions. In circumstances where third-party intellectual property is utilized, conditions may be added as permitted under Section 6 of the CGIAR Principles on the Management of Intellectual Assets, which establishes the conditions for 'limited exclusivity' or 'restrictive use' agreements. Open-source solutions are preferred to facilitate inter-connectivity of tools and wide adoption.

Management of pay-to-access third-party commercial software, computational infrastructure or expert advice may require cross-member licensing agreements that could be beneficial to providers while allowing for a larger user base and greater adoption. User feedback on the web platform will demonstrate if tools or services are performing poorly. The web administrator will need to ensure that user feedback is based on fact.

1.4.3 Intellectual Assets:

A. CIMMYT, participating CGIAR Centers and partners manage the CGIAR EiB Platform Intellectual Assets (IA) in accordance with the CGIAR Principles for the Management of Intellectual Assets and the CGIAR Open Access and Data Management Policy. The CGIAR EiB Platform is not a legal entity distinct from the Centers that implement CRPs, and therefore IAs are managed across the research portfolio of each entity, without specific regard to MAIZE CRP projects or to outputs produced with CRP funding.

   Early each year, CGIAR Centers submit an Intellectual Asset report to the CGIAR System Management Board. In each report, the Center describes the most relevant IA management strategies and practices implemented during the previous calendar year; the Center also includes a separate detailed summary of intellectual property arrangements for Limited Exclusivity Agreements and Restricted Use Agreements (normally labeled as confidential, as a prerogative for the Center and due to obligations acquired with partners). As this information already has been provided through this avenue and under the same confidentiality restrictions it will not be duplicated here.

   All Centers are subject to obligations under (i) the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), (ii) the privacy of individuals; (iii) confidential obligations acquired; and/or (iv) intellectual property rights of third parties.

B. CIMMYT has not filed, nor has any CIMMYT partner informed CIMMYT, of any application for patent or plant variety protection associated with intellectual assets developed by the CGIAR EiB Platform.

C. The most critical challenges for IA management in the context of the CGIAR EiB Platform are as follows:

1. Ensuring sufficient funding (including sufficient human resources), to implement all actions needed for a proper IA management on a timely basis.
2. Harmonization of licensing practices to disseminate digital sequence data with the Open Access obligation, in light of concerns raised among some ITPGRFA stakeholders in relation to the use of such datasets;
3. The rising bar for Centers' privacy protection and accountability in the context of dealing with datasets, wherein such data include personal information that carry with them accompanying dissemination obligations under Open Access.

Finally, it is unclear what the expected difference could be between IA management practices under the CGIAR EiB Platform versus those reflected in the IA reports to the CGIAR System Organization.

2. Platform Effectiveness and Efficiency

2.1 Variance from Planned Platform Activities:

(a) Have any promising research areas or services been significantly expanded? Please give specific examples. Where has the money for expansion come from?

No, there was no significant expansion of research areas or services.

(b) Have any research lines, activities or services been dropped or significantly cut? Please give specific examples and brief reasons. If funding was reallocated to other work, where did the money go?

Nothing has been dropped or significantly cut, but there was significantly less activity than planned within the first year of the Platform. This was due to a number of reasons, including that the Platform director did not begin until August, memberships still needed to be established, member breeding team action plans are yet to be defined, material for delivering to member breeding teams still needed to be developed, and, part-time module leadership has proven to be extremely challenging. To address this last point full-time staff will be appointed within each of the modules in 2018.

(c) Have any research areas taken new directions due to unexpected research results (positive or negative)? Please give specific examples. Put "N/A" if not applicable.]

Module 2, which was "Trait discovery and the Toolbox" been altered to focus on "Optimization of breeding schemes". This is in acknowledgement that access to tools and services will have highest impact when applied strategically in a way that is aligned with the fundamental principles of plant breeding, quantitative genetics and biometrics. Trait discovery remains an important part of EiB and within the Platform the Toolbox now sits apart from the modules, providing services to all five.

Module 4 has developed a greater focus on improving the quality, throughput and cost of phenotypic data for key traits on the product profile. This will primarily occur through improved mechanization and automation. This focus will come at the expense of more general phenotyping activities (including for example for research purposes), physiology approaches and proof of concept work. As an example, high throughput phenotyping will not have such a strong focus going forward except for in cases where

it has been shown to result in increased rates of genetic gain for key traits described in the product profile.

2.2 Use of W1-2 Funding:

The main areas of expenditure of W1/2 funding for 2017 were Personnel Costs and Collaboration Costs. W1/2 funding made it possible to collaborate with the following key partners: Cornell University, IRRI, ICRISAT, and IRD. This collaboration was important while the Platform was understaffed, and many of its objectives could not have been accomplished without the involvement of partners. The Platform had a significant carryover in 2017 because many of its key positions were not in place; in 2018 it is expected that all key positions are hired and that pending milestones are accomplished.

Type	Restricted
Consider	> 2017

Row Labels	Carryover from 2016	Total Budget 2017	Total 2017	Balance
01 W1 & W2 Funding - Phase II	-	2,000,000	1,181,564	818,436
01 g. EiB	-	2,000,000	1,181,564	818,436
01 - Personnel Costs	-	719,299	424,021	295,278
02 - Other Collaboration Costs	-	589,716	301,472	288,244
03 -Supplies and Services	-	401,723	184,284	217,439
04 - Operational Travel	-	58,477	83,497	(25,020)
05 - Depreciation / Amortization	-	24,163	60,388	(36,225)
07 - Indirect Costs	-	206,622	127,902	78,720
Grand Total	-	2,000,000	1,181,564	818,436

2.3 Key External Partnerships:

Key external partnerships have been developed with Monsanto, DArT, Cornell University, Corteva The University of Queensland, HIPHEN, INRA-Avignon, CSIRO and Kansas State University. **Monsanto have been driving many of the same objectives EiB is also targeting through a targeted project with IITA. Monsanto and EiB will work together to drive these objectives for IITA at an institutional level in addition to Monsanto committing to become an EiB Contributor, reflecting broader contributions to the Platform. This is proving to be an extremely valuable collaboration for many reasons. Monsanto have invested heavily in identifying and developing** best practices which will be invaluable when shared with CGIAR breeding programs. Moreover, Monsanto have a very good reputation for executing breeding best practices, and their support for recommendations made to CGIAR breeding programs will contribute significantly toward their uptake in the CGIAR. Monsanto also have valuable

experience in the modernization CGIAR breeding programs through their work with the IITA Cowpea program.

Across all modules, a meeting took place with representatives from Corteva. Outcomes of the meeting included Corteva committing as a contributor EiB, and the benefits of public-private collaboration through EiB were discussed, including the advantage of interacting with CGIAR breeding programs through a single entity, mutual interests in the area of pre-competitive breeding and development of future markets, and the creation of non-confidential knowledge. Potential areas for collaboration discussed included the sharing of Corteva knowledge and participation in communities of practice, co-investment in partner capabilities and use of DuPont Pioneer services, technical exchange programs, process documentation support, access to prior generation equipment and direct financial support. Further details to better define this partnership with Corteva will be finalized in 2018.

The BPAT is managed by the University of Queensland. BPAT output is essential to the delivery of EiB objectives, being that BPAT recommendations form the foundation of action plans for each CGIAR Center to increase rates of genetic gains which EiB is tasked with enabling. As such, collaboration with the University of Queensland has been and continues to be extremely important.

Cornell University is developing computation tools for genomic selection. Once developed, these tools will enable many of EiB's objectives to be realized, particularly in modules 2, 3 and 5.

Partnerships with HIPHEN and with INRA-Avignon, CSIRO and Kansas State University have been used to make progress on Module 4 objectives relating to remote-sensing imaging.

2.4 Cross-CGIAR Partnerships (CRPs and other Platforms):

Excellence in Breeding works extremely closely with all CGIAR breeding centers, including AfricaRice, Bioversity, CIP, CIAT, CIMMYT, ICARDA, ICRAF, ICRISAT, IITA, ILRI, IRRI and WorldFish. In August CIMMYT DDGR Marianne Bänziger and incoming EiB Director Michael Quinn visited the headquarters of each Center, in addition to many regional offices, in order to establish better relationships. The visits were invaluable to create awareness and understanding of EiB, and to understand the individual and collective challenges and opportunities of the respective institutions.

In 2017 the Expert Advisory Group met and set the following priorities for the CGIAR EiB Platform:

- Cross-commodity learning – what works?
- Access to expertise
- Reducing redundancy
- Reinvesting savings from previously redundant efforts or more effective approaches in better focused larger scale programs
- Joint bargaining / better deals = pricing
- Joint standards
- Joint communication / stronger voice
- Aligned proposals / attract the attention of donors

2.5 Monitoring, Evaluation, Impact Assessment and Learning (MELIA):

- In 2017, Excellence in Breeding developed a results-based management framework to support strategic planning, monitoring, reporting, evaluation and learning. This framework builds on the EiB theory of change and includes a monitoring, evaluation, and learning plan, and indicators to monitor outputs and outcomes.
- EiB was represented within the CGIAR Monitoring, Evaluation and Learning Community of Practice for the first time this year and began to work on issues related to measuring

development impact of the platforms, as well as consistent templates and tools for Phase II. The Community of Practice also provided excellent opportunities to share best practices and learning amongst monitoring, evaluation and learning specialists.

- In 2017, EiB began to explore the use of a new management information system (MARLO-Managing Agricultural Research for Learning and Outcomes) in order to more easily plan and budget its work, monitor research progress, and report on Platform results in coming years.

2.6 Improving Efficiency:

The adoption of high throughput genotyping services, as opposed to carrying out genotyping in-house, has improved efficiency in various CGIAR Centers. The cost savings of switching to HTPG is specific to each Center and crop, but user feedback indicates overall cost reductions of between 25 and 50%, due to reduced-cost outsourcing, better data quality and faster turnaround time.

3. Platform Management

3.1 Platform Management and Governance:

No major changes to management and governance occurred in 2017.

3.2 Management of Risks to Your Platform:

Programmatic Risks:

Attracting the required staff to run the CGIAR EiB Platform took longer than expected, and many key positions remained open throughout 2017. An external headhunter was hired to assist in the recruitment of key Platform positions.

Contextual Risks:

In 2017 the CGIAR EiB Platform experienced no contextual risks.

Institutional Risks:

For the EiB CGIAR Platform, it is an institutional risk that Breeders are adequately funded and are willing to learn, adopt and adapt documented tools. Although the Platform is not a funder, through center visits it has identified bottlenecks affecting breeding programs.

3.3 Financial Summary:

The financial status of the CGIAR EiB Platform is strong, in 2017 the Platform received US $2,000,000 from W1/W2 and closed with a carryover of $820,000 from W1/W2 funds. W3 funding for the period October 2017-September 2018 totals $1,866,811.90. Assuming the Platform receives $2,000,000 annually from W1/W2, EiB will reach a budget of $6M by 2020, as there is $4.8M budgeted from W3 (BMGF) for the period Oct 2019 – Sept 2020 and $5.2M for Oct 2020 – Sept 2021. Furthermore, the EiB will continue to look at other sources for additional funding.

TABLES

Table A: Reporting against Platform Specific Indicators

Module	Indicator	Description	Comments (in relation to target, if one available)
2	An online resource of validated tools and best practices, knowledge and product resources documented following a "use case" approach. Resources developed periodically reviewed/revised using a common framework. Public communities implementing best tools and practices self-identify; All partners engaged in targeted implementation of high return to investment tools and practices across CG and NARS discovery and breeding programs. Clear knowledge of the range of best tools and practices available.	Infrastructure and functionality developed and implemented in the beta version of the portal. Implementation of the live version of the portal will take place in 2018 as more content becomes available.	
2	Number of training resources developed and disseminated and the number of courses/workshops conducted.	EiB has adopted and will implement guidelines generated by the CIMMYT Learning Management System (LMS). External material has been identified for the toolbox but needs to be reviewed, vetted and possibly modified before making available through the toolbox. An EiB workshop was held in Africa in November addressing forward marker breeding applications, including DNA sampling, sample tracking and laboratory information management systems.	

5	Development of data management systems is focused on priority breeding use cases and coordinated across development teams.	A strategy for developing priority use cases has been developed and use cases prioritized.	
5	Use of BrAPI-enabled high priority use cases.	Peter Selby (BrAPI coordinator) was hired in the Fall of 2017. BrAPI and local APIs developed and development remains ongoing. The strategy to implement year 1-2 case studies was developed.	
5	Breeding programs that routinely load phenotype and genotype data into data management systems as part of routine breeding practices.	Critical existing databases are BMS , B4R and the RTB databases (ie Cassavabase, Yambase, etc.). All member programs are aware of the existence of these databases. Further development of B4R is required to achieve adoption. Further work will be in 2018 and 2019 to ensure adoption.	
5	Development of tools are aligned with high priority use cases and coordinated across programs. Tools and databases are accessible to all CGIAR breeding programs. Support the development of databases and tools to complement and expand the usefulness of existing bioinformatics initiatives.	To better understand what tools are required, what is currently being used and the use cases that future tools need to support, a survey was conducted and summarized in 2017 (included in this report). In addition, follow up surveys are underway for 2018 to provide more detailed landscape analyses.	
5	Use of breeding views that provide breeders easy access to data needed for variety advancement and parental selection.	Key analysis software has been identified and work is underway to develop open-source pipelines for trial analysis and candidate selection. An EiB alpha release of a galaxy analysis pipeline has been achieved: http://galaxy-demo.excellenceinbreeding.org	

5	Implementation of common ontologies and PUIDs for germplasm, as indicated by BrAPI use.	The AFS CRPs will be represented in the Big Data Platform Ontology CoP through the M5 Breeding Data Management CoP being led by Kate Dreher. The Data Management CoP identified several versions of UUID generators as the recommended system. More specific instructions on best practices are in preparation by the CoP.	
5	Use of protocols, manuals, and best practices for data management and biometrics in Toolbox. Access to prioritized biometrics and bioinformatics advice, services and resources.	Kate Dreher (CIMMYT) and Abhishek Rathore (ICRISAT) were elected as the first CoP leaders. Best practices to first be defined by a community of practice (CoP).	

Table B: Status of Planned Milestones [Please include the status update on the planned milestones (i.e., complete, extended or cancelled). If completed, please include evidence; if extended or cancelled, please provide a rationale.]

Module	2022 Platform outcomes (from proposal)	Milestone*	2017 milestones status (Complete, Extended or Cancelled)	Provide evidence for completed milestones** or explanation for extended or cancelled
1	Creation of clear product profiles, a stage gate process "from breeding cross-to-farm", and appropriate breeding schemes commensurate with level of investment, best practices and tools available results in accelerated breeding cycles and rates of genetic gain per unit time	(i) Members document current product profiles and existing GxE information in Toolbox (i) Members agree on standardized templates and approaches for defining and further improving product profiles, considering gender and market informed seed-to-fork value chains, information about the target	Extended	Part-time Leader was not able to accomplish in 2017. Issue has been addressed by securing a full-time leader for module 1 on May 7, 2018.

	that are 25% greater than current approaches.	population of environments (TPE), and clear variety replacement strategies.		
1		(i) Member breeding programs establish a format and process for implementing a stage gate system in their breeding program (ii) Best practices discussed and developed for appropriate incentivization of breeding team members based on individual and breeding team performance relative to overall genetic gain and varietal replacement indicators and metrics.	Extended	Part-time Leader was not able to accomplish in 2017. Issue has been addressed by securing a full-time leader for Module 1 on May 7, 2018.
1		(i) Members upload methods and results for current genetic gains assessments in Toolbox. (ii) Review current approaches to assessing rate of genetic gains (ROGG) within member programs, private companies and published literature. (iv) Face-to-face workshop among breeders, socio-economists and seed specialists about purpose and approaches for germplasm-related impact assessment	Extended	Part-time Leader was not able to accomplish in 2017. Issue has been addressed by securing a full-time leader for Module 1 on May 7, 2018. 2017 activities included working with CGIAR and Private Sector Quantitative geneticists on developing standard operating procedures to assess breeding program success and genetic gain assessments.
1		Breeding programs access advice or visit to best-practices sites on a self-funded basis	Extended	Module 1 concepts have been introduced to various CGIAR and NARS breeding teams.
1		(i) Benchmark which CGIAR breeding programs have BPAT assessments completed; (ii) together with BMGF develop plan for prioritization and implementation of BPAT assessments with CGIAR breeding programs	Extended	EiB is in close contact with BPAT.
1		(i) Center leadership and participating breeding programs sign membership	Extended	In 2017, we created two forums representing a combination of private and public breeders. The

		agreement documenting commitment to the EiB modernization process. EiB resources (time, financial resources) will be directed at members only. (ii) CGIAR research leaders participate in workshops with private sector breeding managers to gain an understanding of modern breeding program management.		interaction was not good because the private sector participants did not share while the competition was present. We will be developing a different format in the future for greater success.
1		(i) Together with BMGF develop a plan for the prioritization and implementation of BPAT assessments with up to 4 pilot NARS breeding programs. (ii) Membership agreements are signed with NARS research managers and breeding programs documenting commitment to the EiB modernization process. EiB resources (time, financial resources) will be directed at members only. (iii) NARS research leaders participate in workshops with private sector breeding managers to gain an understanding of modern breeding program management.	Cancelled	BMGF would prefer to prioritize the BPAT reviews according to their own internal interests. The other sub-milestones are covered elsewhere in the work plan.
2	Increased rates of genetic gain through use of best practices, optimization of breeding strategy and more effective use of resources (time, finances).	(i) Common infrastructure and frameworks for documentation of best practices, tools, workflows and resources developed. Link to user review system. (ii) Restricted domain developed for members documenting their breeding programs and progress.	Complete	Infrastructure and functionality developed and implemented in the beta version of the portal. Implementation in the live version of the portal will be conducted in 2018 as more content becomes available.

2		Formation of / communication with CoPs from relevant members of each module.	Extended	Development of CoP prior to placement of module 2 lead would be premature as the CoP would lose interest due to lack of engagement.
2		Draft review guidelines and infrastructure developed.	Extended	Limited need for this at end of 2017 due to limited material on the toolbox at that time. Discussions for guidelines have occurred and are largely finalized and are being documented Infrastructure still needs to be developed.
2		(i) Development of best practice documentation for e-learning based on materials used at regional workshops (ii) Identification of, and links to relevant external e-modules and courses	(i) Complete (ii) Extended.	(i) EiB has adopted and will implement guidelines generated by the CIMMYT LMS (ii) External material identified but needs to be reviewed, vetted and possibly modified to make appropriate for the toolbox.
2		(i) Use cases of successful implementation of predictive tools providing value towards breeding for product profiles documented. (ii) Use cases of failed attempts of development of predictive tools documented.	Extended	Lack of capacity to achieve these milestones due to lack of headcount generally and lack of Module 2 lead specifically.
2		Members document trait and core breeding pipelines in Toolbox	Extended	Draft template for members to document pipelines developed. Lack of capacity to achieve this milestone due to lack of headcount generally and Module 2 lead specifically.
2		Members document breeding strategy in Toolbox.	Extended	Draft template for members to document pipelines developed. Lack of capacity to achieve this milestone due to lack of headcount generally and module 2 lead specifically.
2		Physical and virtual blue-sky discussions associated with scientific meetings, to raise	Cancelled.	Low priority given to this at this time considering the size of opportunities to improve breeding with

		and discuss ideas for high-payoff approaches and discuss and design the incubation of project ideas. Allocation of modest resources to validate technologies in the incubator while jointly seeking additional funding to test more substantive “game changers”.		currently available methods and technologies before considering "game changers".
3		At least 5 best practices/use cases and tools developed and documented.	Extended	Could not be achieved with part-time module lead. Going forward this is being addressed by applying a full-time staff in Module 3 from the last half of 2018.
3		Cost-benefit analysis approaches developed and tested with 2 breeding programs. (iii) Members develop genomics data inventory for their breeding program, including marker type, trait value, trait genetic variance, range of genetic variance accounted for, costs etc.	Extended	Could not be achieved with part-time module lead. Going forward this is being addressed by applying a full-time staff in Module 3 from the last half of 2018.
3		(i) Best practices and tools developed and documented. (ii) Key program parents profiled at high density and characterized for diagnostic SNPs. (i) Develop use cases and develop/contribute to implementation guidelines for genotyping application in discovery and breeding. (ii) Update and refine existing documents, remove those no longer appropriate/applicable or when reviews are negative. (iii) Contribute to courses and workshops.	Extended	Could not be achieved with part-time module lead. Going forward this is being addressed by applying a full-time staff in Module 3 from the last half of 2018.
3		$2.00 SNP genotyped sample; $15 genome profile.	Extended	$2.50 per SNP genotype samples available through HTPG. Low cost genome profile available through IGSS.

3		400K SNP genotyped samples; 50K genome profiles. (i) Obtain and aggregate AFS demand for supplies and services. Determine cross-AFS; Genotyping platform preferences, Minimum genotyping quality criteria, Maximum permissible turnaround time for genotyping applications, Minimum number of samples required (at defined unit costs), Minimum number/volume of supplies required, Minimum marker conversion rate, Number of markers for marker conversion, etc. (ii) Use collated demand information to broker potential arrangements with service providers and solicit pricing feedback from AFS. (iii) Finalize brokering of supplies and services and obtain minimum order commitments from AFS. (iv) Obtain feedback from service providers and AFS clients and document issues, concerns and positive feedback collating to form a review for the Trait Discovery and Breeding Toolbox.	Partially completed through HTPG.	
3		(iv) Enlist expertise in marker conversion from SSRs/INDELS to SNP-based platforms	Cancelled.	This is generally offered as part of the service by service providers.
3		Prospect newer methods/approaches for sampling/genotyping; use inputs from participating AFS, ARIs, private sector partners and technology developers/providers; evaluate costs and constraints for application in discovery and breeding. Prepare annual review paper for	Extended.	Could not be achieved with part-time module lead. Going forward this is being addressed by putting on a full-time person in Module 3 from the last half of 2018.

		posting in the Trait Discovery and Breeding Toolbox.		
4	Lower-cost, better targeted phenotypic data supports larger, more cost-effective programs.	(i) Process engineering specialist hired. (ii) A completed diagnosis of the gaps, needs and best approaches to increase plot throughput/reduce costs through high-throughput phenotyping, mechanization, automation. (iii) Identification of existing best practices and equipment in use by various programs. (iv) Community of practice for high through-put phenotyping established	Extended.	Could not be achieved with part-time module lead. Going forward this is being addressed by applying two full-time staff in Module 4 from the last half of 2018.
4		(i) Take stock of current use of laboratories, their capabilities and costs; prioritize needs based on member survey and feedback; (ii) establish community of practice among NIRS users/internal service providers	Extended	Could not be achieved with part-time module lead. Going forward this is being addressed by applying two full-time staff in Module 4 from the last half of 2018.
4		(i) Survey to assess phenotype and environmental data collected, adoption of high-through-put tools, GxExM and gene-to-phenotype methods, and barriers to adoption in coordination with BPAT. (ii) Workshop on existing practices, with ARI and private sector participation; identification of quick wins. (iii) Join and participate in existing plant phenotyping networks.	(i) Complete; (ii) Complete; (iii) Complete	(i) Survey document, results, report provided; (ii) Meeting purpose and notes, Meeting presentations on the EiB portal, and Action plan report; (iii) Subscription to IPPN network.
4		Consult with breeders and ARIs to identify tools for capture and analysis of high-throughput data – Priority setting	Complete and interrupted	Proposal draft developed.
4		Consult with breeders and ARIs to identify approaches for GxE analysis – Priority setting.	Extended.	Could not be achieved with part-time module lead. Going forward this is being addressed by putting on

				2 full-time staff in Module 4 from the last half of 2018.
5	Bioinformatics tools that support automation, data integration and decision making are fully integrated for use in AFS breeding networks.	Establish overall strategy and prioritize pipeline/breeding use case studies and related tools.	Completed.	It should be noted that development of strategy is a work in progress all throughout development of data management systems as new use cases are identified. Having made that point, a strategy has been developed and use cases prioritized.
5		(i) BrAPI coordinator hired. ii) Reference client/server developed to test compliance. (ii) Strategy to implement the Year 1-2 case studies developed. (iii) Implementation of BrAPI and local APIs for different systems.	Completed	(i) Peter Selby was hired in the Fall of 2017. (ii) Strategy to implement year 1-2 case studies developed. (iii) BrAPI and local APIs developed, with further development ongoing.
5		(i) Exposure to and adoption of appropriate databases in member breeding programs. ii) Identify existing systems that are critical to achieving the EiB's objectives across breeding management systems.	Completed.	Critical existing databases are BMS, B4R and the RTB-bases (i.e. Cassavabase, Yambase, etc.). All member programs are aware of the existence of these databases. Further development of B4R is required to achieve adoption. Further work will be in 2018 and 2019 to ensure adoption.
5		(i) Report on the current landscape of databases, bioinformatics capabilities/software, and biometric capabilities/software; (ii) Documented gap analysis for the Year 1-2 case studies; (iii) Existing databases and tools assessed and updated. (iii) Development or acquisition of new database and tools.	(i) Completed	(i) The initial survey and report is included in the annual report. Follow up surveys are underway to provide more detailed landscape analyses
5		(i) Identify key analyses and data required for selection candidate advancement and parental selection (ii) Catalogue existing analysis tools and pipelines. (iii) Initiate open-	Extended.	Development efforts for analysis tools for candidate selection are less centralized than for database development. Thorough cataloguing of all analysis software may not be an effective approach. Key analysis software has been

		source collaboration on breeding optimization suite.		identified and work is underway to develop open-source pipelines for trial analysis and candidate selection. An EiB alpha release of a galaxy analysis pipeline has been achieved: http://galaxy-demo.excellenceinbreeding.org
5		(i) Crop and Agronomy Ontology CoP incorporates reps from AFS CRPs; (ii) identify system for generating PUIds for breeding germplasm. (iii) Crop ontology documented for Tier 1 crops. (v) Strategy for GUIDs defined.	(i) Completed; (ii) Completed	(i) The AFS CRPs will be represented in the Big Data Platform Ontology CoP through the M5 Breeding Data Management CoP being led by Kate Dreher. (ii) The Data Management CoP identified several versions of UUID generators as the recommended system. More specific instructions on best practices are in preparation by the CoP.
5		(i) CoP for statisticians and bioinformatics leaders identified, participant list compiled, and meetings initiated. (ii) First Annual Bioinformatics and Biometrics "Hackathon". (iii) Core operational guidelines for bioinformatics and biometrics defined. (iv) Common BrAPI defined. (v) Capacity development strategy for bioinformatics and software adoption developed. (v) Support capacity building and the evaluation of new bioinformatics and biometrics tools and approaches in collaboration with distinct user groups and use cases prioritized in Modules 2-4. (vi) Training workshops for biometricians in CGIAR target countries to expand the number of resource persons. (vii) Broker access to proprietary software and computational capacity on a pay-per-use basis.	(i) Completed; (ii) Extended	(i) Kate Dreher and Abhishek Rathore were elected as the first CoP leaders. Initial meetings were held in November and December of 2017. (ii) Due to travel schedules and availability of key participants the hackathon was moved to February 2018.

* Milestones include both outputs, output use and outcomes along the impact pathways.

** Provide link to any relevant open accessible document.

Table C: Cross-cutting Aspect of Outputs [Please present % of outputs with principal (scored 2), significant (scored 1), and not targeted (scored 0), for gender, youth and capacity development and total overall number of outputs]

Cross-cutting	Number (%) scored 2 (Principal)	Number (%) scored 1 (significant)	Number (%) scored 0	Total overall number of outputs
Gender	5%	0%	95%	34
Youth	0%	80%	20%	
CapDev	0%	100%	0%	

Table D: Common Results Reporting Indicators

Table D-1: Key Platform Results from 2017, in Numbers

Sphere	Indicators	Data	Comments
Influence	I1/I2*. Projected uptake (women and men) /hectares from current CRP investments (for innovations at user-ready or scaling stage only – see indicator C1)	N/A	Some CRPs may have some data here for 2017, which would be welcome, but not required
	I3. Number of policies/ investments (etc) modified in 2017, informed by CGIAR research	N/A	(e.g. Example of major achievements)

Control	C1. Number of innovations by phase - new in 2017	N/A	
	C2. Number of formal partnerships in 2017, by purpose (ongoing + new)	Monsanto, University of Queensland, DArT, CIP, CIAT, CIMMYT, AfricaRice	
	C3. Participants in CGIAR activities 2017 (new +ongoing)	In 2017, 81 people were trained, 22% of the people trained were women.	
	C4. People trained in 2017	In 2017, 81 people were trained, 22% of the people trained were women. The trainings took place in Kenya and Uganda. The organizations represented included: ICRISAT, IITA, IRRI, CIMMYT, Karlo, ARI, EIAR, NaCCRI, SARI, NaSSRI-Uganda, DarT, Cassava-Tanzania, and the Ghana National Program.	No Limited training conducted in 2017 due to lack of head count.
	C5. Number of peer-reviewed publications	None.	Publ Publications are not a core objective of the Platform.
	C6. Altmetrics	New indicator being introduced in 2018 – details tbc	

*Please note: I = Sphere of Influence and C = Sphere of Control

Table D-2: List of Platform Innovations in 2017 (From indicator #C1 in Table C-1)

Title of innovation (minimum required for clarity)	Phase of research *	Novel or adaptive research	Contribution of Platform (sole, lead, contributor)	Geographic scope: for innovations in phases AV* or USE* only (one country, region, multi-country, global)
None.				

* Phases: PC - proof of concept, PIL - successful pilot, AV - available/ready for uptake, USE - uptake by next users.

Table E: Intellectual Assets

Year reported	Applicant(s) / owner(s) (Center or partner)	Patent or PVP Title	Additional information *	Link or PDF of published application/ registration	Public communication relevant to the application/registration
2017	None	None	N/A	N/A	N/A

* For patents, please indicate: (a) type of filling: provisional / non-provisional; national direct, national designated; multi-territory; (b) patent status: filled, pending, matured to non-provisional, discontinued, registered or lapsed; (c) application / registration; (d) date of filling; (e) Date of Registration; (f) Date of Expiry / renewal

* For PVP, please indicate: (i) variety name, (ii) status, (iii) country; (iv) application/registration number, (v) date of filling, (vi) date of registration/grant; (vii) date of expiry/renewal, (viii) breeder and crop

Table F: Main Areas of W1/2 Expenditure in 2017

Optional

Expenditure area *	Estimated percentage of total W1/2 funding in 2017**	Space for your comments [please remove notes below]
Planned research: principal or sole funding source		
Planned research: Leveraging W3/bilateral funding		e.g. to strengthen the synthesis and international public goods nature of outputs by Platforms; or to respond to changes in research conditions including fluctuations in funding.
Catalyzing new research areas		e.g. foresight, proof of concept studies for novel areas of work
Gender		e.g. stand-alone programs, work by PMU, funding gender 'add ons' to other projects, and research projects tagged as 'principal' for gender. Research projects tagged with a 'significant' gender tag should be included under one of the first three rows above (research)

Youth		As for gender
Capacity development		As for gender
Start-up or maintenance of partnerships (internal or external)		
Monitoring, learning and self-evaluation		
Evaluation studies and Impact Assessment studies		Includes ex-ante assessments if these are specific studies, otherwise include under previous row
Emergency/contingency		e.g. immediate unplanned response to a new virulent disease, or moving germplasm collections as a result of conflict
Other		
TOTAL FUNDING (AMOUNT)		

*use these categories wherever possible, delete unneeded rows and add rows if none of these are suitable.

**we recognize that (i) some funding may fit more than one category but please try to apportion funding to its principal use and (ii) percentages may not add up to 100%

Table G: List of Key External Partnerships [Please list up to five important partnerships for 2017 for each Module, using the following table. An agreed list of partners' types and areas of partnerships will be provided in the common results indicators manual (available early 2018).]

Module	Stage of research*	Name of partner	Partner type*	Main area of partnership*
1	PC	Abacusbio Ltd (Peter Amir)	Economic Trait Assessments	Involved in Early Discussion with developing an Economic Trait Assessment Study. Contingent on the hiring of the Product Manager in Kenya.
1	PC	Syngenta Foundation & Market Edge Consulting	Client Based – Business of Plant Breeding	Leveraging Syngenta sponsored projects about creating impact in the CGIAR breeding programs.
1	PC	Roy Cantrell	Breeding Program Management From a Private Company Perspective	Collaboration on process & potential teaching opportunities.
1, 2, 3, 4 & 5	Ongoing	Corteva	Private	Corteva have made a commitment to be EiB contributors. Details that define this partnership are being finalized in 2018.
1, 2, 3, 4 & 5	Ongoing	Monsanto	Private	Through a targeted project with IITA Monsanto have been driving many of the same objectives EiB is also targeting. Monsato and EiB will work together to drive these objectives for IITA at an institutional level in addition to Monsanto committing to be an EiB Contributor contributing to the platform more broadly.
5		DArT		
		CIP, CIAT, CIMMYT, AfricaRice		
5		Cornell University	Collaborator	Development of computations tools for implementation of genomic selection
4	Pilot	HIPHEN	Private	Remote-sensing imaging
4	Pilot	INRA-Avignon / CSIRO / KSU	Public Research	Remote-sensing imaging
1,2,3,4, & 5		University Queensland	Public	BPAT assessments conducted. EiB has a role to enable breeding teams to implement recommendations from BPAT assessments.

* See instructions in the common results indicators manual (available early 2018).

Table H: Status of Internal (CGIAR) Collaborations between the Platform and Programs and among Platforms

Name of CRP or Platform	Brief description of collaboration (give and take between the Platforms and CRPs) and value added*	Relevant Module
CIP, CIAT, CIMMYT, AfricaRice and ICRISAT.	These centers have signed EiB membership agreements which describes their commitment to work with EiB to implement their action plan leading to improvements in rates of genetic gain and/or greater scale of impact.	1, 2, 3, 4 & 5
Big Data Platform	EiB was preparing for collaborations with the Big Data Platform in areas in which the platforms can work synergistically and/or that there are overlapping objectives. Examples include in the areas of environmental characterization (for genotype by environment modelling and for formation of product profiles); processing and interpreting high throughput phenotype data; handling, collating and interpreting data relating to what farmers are growing to inform product profiles and impact studies; and, to bring genomic, geographic, environmental and phenotypic data together for the purpose of better targeting of genebank accessions.	1, 2, 3, 4 & 5
Gender in Breeding platform	EiB was preparing in 2017 to engage closely with the Gender in Breeding to ensure that EiB gives a primary consideration is given to gender and in particular that primary consideration is given to gender.	Primarily 1 and indirectly 1, 2, 3, 4 & 5
Genebanks Platform	EiB has been preparing to engage with the Genebanks platform to provide value to them in particular through the tool and service-oriented modules to better enable their genotyping, phenotyping, data management and biometrics.	3,4 & 5

*e.g. scientific or efficiency benefits

Table I: Monitoring, Evaluation, Impact Assessment and Learning

Table I-1: Status of Evaluations, Impact Assessments and Other Learning Exercises Planned in the 2017 POWB

Studies/learning exercises in 2017 (from POWB)	Status	Comments
N/A	N/A	No evaluations, impact assessments or learning exercises were conducted, as EiB is still getting set up and has not yet begun to undertake many of its activities.

Table I-2: Update on Actions Taken in Response to Relevant Evaluations (IEA, CCEEs and Others)

Name of the evaluation	Recommendation	Management response – Action Plan	By whom	By when	Status
Evaluation of partnerships in CGIAR 2017	All CRPs should have a distinct partnership strategy and accompanying operational plan.	N/A			
Evaluation of the Genebanks CRP 2017	Given that close linkages between the Genebank Platform and the Excellence in Breeding and Big Data Platforms will be essential for strengthening genetic conservation and use, the Genebank Platform Management Team should agree with the managements of the other two Platforms appropriate protocols for data exchange and use. This coordination will take advantage of CGIAR's unique position of spanning the whole range of activities from conservation to use, and minimize	SMO Response: Even if protocols for data exchange and use are primarily determined by Center implementation of CGIAR Open Access policy, the Board emphasizes the expected key role to be played by the Genebank Platform in connecting and articulating exchange of data and information between the three Platforms. These efforts will be reported in the respective Platform Annual Reports.			

	the Platforms developing as silos in isolation from one another.	Genebank CRP Response: The Crop Trust and MT agree with this recommendation, although it should be noted that protocols for data exchange and use are primarily determined by Center implementation of CGIAR Open Access policy. Linkages are being carefully forged between the three Platforms. Genebank Platform representatives have been appointed to and are participating in the Expert Groups in the Excellence in Breeding Platform and joint activities are being planned with the Big Data Platform.			
2014 IEA Review on CRP Governance and Management	Publish on CRP websites the names of members and their qualifications, posting meeting agendas and minutes, and otherwise sharing important information.	Making minutes available on-line would require having two versions of the minutes: an edited public version (without confidential personal or business information) and an unedited version restricted to internal purposes and information to boards, Center senior management and main partners.	MAIZE CRP Team	Ongoing	Substantial Implementation

Table J: Platform Financial Report

Amounts are in US$ Thousands

	Planned budget 2017			Actual expenditure 2017*			Difference		
	W1/2	W3/bilateral	Total	W1/2	W3/bilateral	Total	W1/2	W3/bilateral	Total
Module 1	1035	374	1409	199	100	300	836	274	1110
Module 2	249	69	318	213	3	217	36	65	101
Module 3	124	37	161	126	0	126	-2	37	35
Module 4	154	75	229	77	0	77	77	75	152
M5	240	65	305	238	0	238	2	65	67
Platform Management & Support Cost	197	79	277	336	0	336	-138	79	-59
Platform Total	2000	699	2699	1190	104	1293	810	596	1406

The source of the information is based on the L Series report submitted to the CGIAR.

Annexes

Annex 1: Module 5 IT infrastructure survey results

	Yes	No	Don't Know	
Does you center host a computational cluster/Do you have access to cloud computing resources?	55%	18%	28%	
	Not Accessible	Difficult to Access	Accessible	Easily Accessible
How accessible is your organizational data which is required to do your job?	5%	21%	58%	16%
	Computational resources are excellent	Computational resources are adequate	Computational resources exist but are not adequate	
Do you have computational resources to effectively do your job?	10%	45%	45%	
	Very Reliable	Somewhat Reliable	Unreliable	
Is your Internet connectivity reliable?	42%	55%	3%	
	Challenging	Somewhat Challenging	Easy	
Data transfer between institutional systems is (e.g. data on paper, slow file transfer, physical movement of hard drives)	32%	57%	11%	

Annex 2. Module 5 Data accessibility and decision support survey results

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
I have easy access to data needed to make advancement decisions.	7%	24%	27%	34%	7%
It is easy to access historical performance on key varieties.	13%	37%	29%	17%	3%
It is easy to trace advancement decisions on varieties.	7%	38%	29%	21%	4%
It is easy to retrieve pedigree history on varieties/animals.	7%	24%	29%	34%	7%
I have easy access to data on varieties developed in other breeding programs.	23%	40%	20%	16%	1%
I have easy access to genotypic/genomic data generated in my institution on varieties.	14%	36%	20%	17%	13%
I have access to relevant environmental information on experimental sites.	10%	14%	27%	37%	13%
All of my experiments are analyzed in time to make advancement decisions.	3%	21%	29%	33%	14%
I have access to biometrics consulting/software need to properly design and analyze experiments.	9%	14%	18%	47%	13%
I have access to bioinformatics software/consulting to analyze genomic data.	11%	13%	28%	33%	16%
I have access to software/consulting to perform QC on phenotypic and genomic data.	6%	17%	38%	29%	10%
Unique ids and standard ontologies make it easy to merge data across programs and years.	8%	11%	22%	42%	18%
All data is cleaned using appropriate QC methods.	8%	19%	42%	24%	8%
Both cleaned and raw data are easily accessible.	9%	33%	32%	19%	8%
It is straight forward to program analysis pipelines against databases.	6%	35%	38%	15%	5%
I have easy access to information needed to make parental selections.*	5%	15%	50%	25%	5%

*Indicates the question was added to an updated version of the survey (approximately 25% of the total respondents completed the updated version of the survey)

Annex 3. Module 5 Breeding process support survey results

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
It is easy to access verified pure seed sources for active varieties.	9%	15%	23%	45%	8%
I have adequate IT support for breeding workflows and processes.	8%	30%	28%	25%	8%
I have access to GIS and software for site selection and field mapping.	16%	29%	25%	25%	6%
I have access to effective field data collection tools and software.*	5%	35%	20%	35%	5%
It is easy to track samples from the field to the lab.	12%	15%	29%	37%	7%
Experiments rarely fail due to impure or incorrect parents being used in crosses.	13%	17%	25%	38%	8%
I have access to software/consulting to perform QC on phenotypic and genomic data.	6%	17%	38%	29%	10%
Inventory management tools and software are routinely used.*	0%	30%	70%	0%	0%
Barcoding is routinely use for plots, seed packets, tissue samples and DNA samples.*	10%	10%	20%	55%	5%

*Indicates the question was added to an updated version of the survey (approximately 25% of the total respondents completed the updated version of the survey)

Excellence in Breeding PLATFORM

Breeding program excellence. A standard breeding program performance management system to monitor successes from the lab to the farmers' fields, highlighting strategic areas for research and investment.

Optimizing breeding schemes. Access to support and knowhow to optimize breeding schemes, respond appropriately to changes in resources and to extract maximum value from implementation of new technologies, tools or services to the breeding process to achieve the highest possible rate of genetic gain.

Genotyping / sequencing tools and services. Access to genotyping services at reduced cost, and support for breeding programs to optimise the use of genomic data in their work.

Phenotyping tools and services. Information about new tools and approaches to quantify plant and animal traits, access to services and shared infrastructure, and support the routine use of cutting-edge phenotyping in breeding programs.

Bioinformatics, biometrics and data management tools and services. Access to integrated bioinformatics tools and biometrics support that allow breeding programs to harness the power of genotype, phenotype and other data.

The Toolbox. An online portal for tools, services, advice and training enabling breeding teams to successfully identify and incorporate new approaches into the breeding process, from trait discovery to cultivar development.