



Breeding by the numbers: EiB Annual Report 2020-21

Report URL: <https://excellenceinbreeding.org/annual-report/2020/>

This PDF version: Created July 2, 2021. Contents may differ slightly from the online version.
Full CGIAR System report: See [CGIAR narrative report](#) for more details and financial report.

Message from EiB Director Michael Quinn

Dear Colleagues,

The numbers are in. And together with our CGIAR and national breeding partners, EiB is delivering real results.

The disruptions brought about by [COVID-19](#) have challenged people and programs across the globe. But the crisis also demonstrates the importance of our work – advancing the agenda of food and income security in the developing world.

To battle hunger, poverty and climate change, farmers in low- and middle-income countries need a genetically diverse portfolio of continually improving crop varieties. EiB helps breeders meet this challenge through coordinating efforts and supporting partners to modernize practices and technologies. We aim to help deliver farmers the seeds they need and will use.

It's fitting that the name of our first-ever EiB Annual Report is "Breeding by the Numbers." Numbers are data, and data drives modern breeding success. And numbers hold us

accountable. EiB and partners have their eyes focused clearly on the number **six**. We have a mandate from [Crops to End Hunger](#) and [One CGIAR](#) to deliver on [six key requests](#).

Please read through this selection of **27** numbers we highlight in this annual report. And enjoy **10** success stories detailing how EiB and partners are helping programs leap forward with data, digitization, simulations, gender tools, genotyping and more.

Over this challenging year, EiB and partners have made big strides along our journey toward transformation and greater impact. Clearly, the people are committed, the programs are primed, and the numbers point to a bright future indeed.

Best,

Michael Quinn, Director

CGIAR Excellence in Breeding (EiB)

Success stories

1. [Seeding excellence through breeding excellence - overall](#)
2. [Excellence in Breeding team working to catalyze change - overall](#)
3. [Identifying market segments and aligning breeding pipelines will focus CGIAR investments - M1](#)
4. [Breeding for better gender equity - M1](#)
5. [Computer simulations help CGIAR breeders create better varieties faster - M2](#)
6. [African breeding programs leap forward by accessing new genotyping data - M3](#)
7. [Assessing the current state of breeding operations in West Africa - M4](#)
8. [New EBS platform harnesses data – and unleashes breeders’ time - M5](#)
9. [Developers unite around a common platform to liberate breeding data - M5](#)
10. [National breeding programs prepped to measure – and boost – genetic gains - NARS](#)

Overall

6

Funder requests seeing results

Breeding needs to constantly replace currently grown varieties with new and improved ones. To achieve this, [Crops to End Hunger](#) (CtEH) funders have [six requests to CGIAR breeding programs](#). EiB leads and supports efforts to respond to these. This report shows how EiB and partners are making progress on the following six requests, including:

1. **Develop pipeline investment cases:** Working with breeding programs, EiB identified [320 unique sub-regional market segments and 120 breeding pipelines](#). By better aligning breeding pipelines, market segments and product profiles, investments can better impact food security and livelihoods in priority areas.
2. **Incentivize management and staff to deliver higher genetic gain:** CGIAR centers are adopting more formal advancement systems, partners have started developing KPIs for staff, and new KPIs are tracking breeding program performance across the CGIAR.
3. **Develop strategic plans for delivery to farmers and varietal turnover:** EiB supported Centers across CGIAR to begin development of specific, targeted plans. Programs are working with socio-economists, EiB's market economist, and local partners to strengthen strategies.
4. **Quantitatively optimize pipelines for higher genetic gain:** Through EiB-supported [practices and technologies](#), CGIAR breeding programs have been improving parent selection, enhancing accuracy, shortening breeding cycles, and standardizing data management.
5. **Implement shared services:** Services such as [EiB's newly launched genotyping](#), [EBS shared data platform](#), and [operations](#) and informatics networks are pushing CGIAR toward standardized services.
6. **Build NARS breeding networks and capacity:** An effective CGIAR-NARS collaborative breeding networks model was developed, with ongoing EiB [support](#) and [mentoring](#) provided to NARS.

1.5%

Increased rate of genetic gain is within sight

Two major goals have been broadly adopted by CGIAR and NARS breeding: increased rates of genetic gain ($\geq 1.5\%$ p.a.) and reduced area weighted average age of varieties in farmers' fields (<10 years).

Throughout this report, you will find evidence of processes that are beginning to transform CGIAR breeding into a cohesive program targeted toward genetic gain increases, through:

- Refocusing breeding networks on distinct [market segments and product profiles](#)

- [Modernizing breeding approaches](#) to shorten breeding cycles, increase selection accuracy and selection intensity, and pursue value from genetic resources
- Applying best practices and partnership models across teams and crops

This transformation will result in crop varieties that are more likely adopted by farmers and consumers, driving down the age of varieties in farmers' fields. This means greater impact on incomes, nutrition, gender equality, and climate adaptation.

EiB has captured some progress on this goal through its [Stories of Excellence](#), delivered at [Virtual Meeting 2020](#).

12+

Grants overseen to ensure Crops to End Hunger impact

EiB is realizing the full potential of Crops to End Hunger (CtEH) investments by overseeing funds to help CGIAR and NARS breeding programs implement major improvements to meet the [six requests from CtEH funders](#).

These funds are laying the groundwork for a successful transition to the One CGIAR model. 12 projects are underway with others set for implementation. Highlights include:

- Support to IRRI on improved seed handling, implementing centralized trait augmentation with AfricaRice and NARS, development for rice product profile and marker segmentation, and creation of a biotic stress monitoring tool.
- Creating a charge account to support CGIAR and NARS for low and mid density genotyping.
- AfricaRice's refurbishment of short-term seed storage, land prep machinery, data capture system and threshers
- Supporting CIMMYT to improve irrigation and drought screening capacity at three key NARS locations in Zimbabwe, Ethiopia and Kenya. And improved seed drying capacity to expedite harvest processing.
- Support for IITA to recruit and implement integrated management of breeding and operations and develop regional bioinformatics and biometric capacity.

EiB will continue to determine where funds are most needed and oversee grants to help partners meet the six requests.

5

Modules expanding services & catalyzing change

EiB's success depends on the best technical skills and the strongest relationships. Indeed our greatest asset is our people. [EiB's expertise](#) supports partners through five interlinked modules:

Product design & management, Breeding scheme optimization, Genotyping & sequencing, Operations & phenotyping, Breeding informatics.

You will find numbers and success stories throughout this report showing how they are teaming with partners to catalyze change.

EiB's expertise now includes a Crop Market Economist, Quantitative Genetics Specialists, and Mechanization Support Specialists for Africa. [EiB teams](#) collaborate to work across our talented partners to boost capacity for delivering CGIAR's promised results. And partners expressed high trust in the team's mandate, skills and expertise in an EiB partner survey. With real talent, comes real results!

50

Best CGIAR innovations includes gender-responsive breeding approach

Vital to EiB's goals is making it easier for CGIAR to develop the right product for the right customers. And [understanding](#) gender-differentiated trait preferences is critical to ensuring priorities are demand-led and investment decisions are smart.

[CGIAR celebrates its 50th anniversary](#) by naming its top 50 innovations in 50 years. The [G+ approach for gender-responsive breeding](#) is among them. These tools offer an integrated, systematic and evidence-based approach for breeding new crop varieties with desirable traits.

EiB is supporting the [CGIAR Research Program on Roots, Tubers and Bananas'](#) (RTB) [Gender & Breeding Initiative](#) (GBI) to validate the tools and deliver data to improve them. GBI are [also developing](#) a Guide to Gender Responsive Product Profile Development and a training program.

[Breeding for better gender equity](#) is a priority for EiB, and CGIAR breeding programs are including gender in product profiles through the G+ tools and other methods.

"Historically breeding programs didn't properly consider gender, or included it late in the process," says EiB Director Michael Quinn. "But now we are ensuring breeders develop gender responsive product profiles up-front so we know the varieties developed will be adopted."

Product design & management

320

Market segments identified

To [better target investments](#), EiB and partners set out to understand the characteristics and needs of the markets in their low- and middle- income target regions. By collecting and analyzing data from CGIAR programs, national partners, and international bodies, EiB identified and described [320 'market segments'](#) across 26 crops. Each market segment reflects a unique combination of grower and consumer needs, including gender considerations.

EiB calculated the value of each market segment based on data such as number of hectares, average crop yield, and average selling price. Potential impact was then calculated using numbers of people, of people in poverty and of undernourished people in each segment.

Existing target product profiles will be updated based on this analysis. This work will allow clear metrics to be established for monitoring and reporting progress.

120

Breeding pipelines identified

In order to maximize investments and impact, CGIAR needed to identify and describe all of its current breeding pipelines. Working with partners at all CGIAR Centers, EiB characterized [120 breeding pipelines in 2020](#).

The analysis found that not all market segments were being served by a breeding pipeline, and many breeding pipelines aligned to several market segments. The team then turned to aligning these pipelines to market segments, as not all market segments were associated with a pipeline and some pipelines were associated with multiple market segments.

“This data uncovers potential to reorient some pipelines for greater impact and efficiency,” explains EiB’s [Peter Coaldrake](#), EiB’s [Product Design and Management](#) module lead. “As we move toward a [One CGIAR](#) model, the data puts us in a good position to make sure breeding programs can target less well-served farmers and consumers.”

12

Metrics being used to develop investment cases

CGIAR breeding efforts have a [record of high ROI](#). EiB is enhancing that by working to ensure [donor investments](#) are targeted toward crops and regions that will show the most impact on food security, poverty reduction and nutrition. The team has begun developing pipeline investment cases that compare the current level of investment with the [potential to make an impact](#).

The analysis looks at the level of investment per person, per person in poverty, and other breakdowns. This helps us see if the way today's dollars are allocated are appropriate to the potential impact. Or if investments should be shifted to target one market segment over another.

Pipeline investment cases are developed based on current pipeline investment and the 12 values used to describe market segment/s served by the pipeline. These values include: total population, rural population, number of people in poverty, number undernourished, hectares, tons of production, value of production.

The work means decision-makers can look at the data by crop or region, and act to [achieve the greatest impact per dollar](#). It sets the groundwork for breeding pipeline investment cases to become the new unit of investment in breeding.

Breeding scheme optimization

45

Simulations run

EiB ran [45 simulations](#) to test ways in which breeding programs can optimize their activities. In 2020, EiB partnered with the Roslin Institute, University of Edinburgh to bring computer simulations to breeding programs. EiB's dedicated optimization team worked with breeders to map their programs and identify areas that could be improved on. Simulations were then used to predict the impact of these decisions on breeding program performance over time.

12

Optimizations implemented in breeding programs

Ten CGIAR breeding programs have implemented 12 optimizations as a result of [collaboration with EiB](#). This includes optimizing the size of breeding programs to attain the highest performance over time, finding the best strategies to select varieties that have the most potential for farmers, or deciding whether to invest in genomic selection or hybrid breeding. Another 36 optimizations remain to be implemented by the 17 breeding programs.

32

Breeding optimization resources shared

The EiB [breeding optimization toolbox](#) contains [9 manuals and guidelines](#) to manage genetic diversity, evaluate and select promising materials, and track the performance of breeding programs by calculating predicted and actual genetic gains. Libraries of [breeding program simulations](#) and [software](#) are also available for breeding programs to optimize their operations.

These were the most actively used and shared resources within the [Toolbox](#), which saw a 55% increase in users over 2019.

Genotyping & sequencing

12

1st KASP marker platform covering 12 crops and fish

EiB maintains a reliable collection of marker data for varieties that are key to meeting UN development and sustainability goals. This data is a key resource for breeding programs and a step towards centralized genotyping services aligned with OneCGIAR.

2.4 million

Sampling capacity of new Mid-density SNP Genotyping Service

The new Mid-density SNP Genotyping (MDSG) service has the capacity to analyze 2.4 million samples per year. The service offers a low cost (as low as \$10 per sample) and highly scalable genotyping service for applications such as DNA profiling and routine genomic selection. Users can expect reliable results, fast turnaround time, zero equipment setup costs and data compatibility with various genotyping platforms. The service is rapidly expanding to many crop and animal species.

25%

Annual growth of Low-density SNP Genotyping Service

The number of samples processed and overall business volume of the Low-density SNP Genotyping (LDSG) service is increasing at an average of 25% each year. Contingency plans were made to ensure the robustness of the LDSG service to meet demand and maintain marker-assisted selection and genetic quality control activities in breeding programs affected by COVID-19. This meant that LDSG maintained the level of business volume required to remain a self-sustaining service with no external funding.

5

New ways EiB expanded genotyping adoption

In 2020, EiB found five new ways to increase the adoption of shared genotyping services.

1. A CGIAR-wide trait and marker development working group to maintain genetic knowledge as a public good.
2. Transition towards a centralized crop genotyping network that will enable rapid deployment of genotyping tools across CGIAR and national breeding programs.
3. Access to technical expertise on marker design and operation provided to breeding programs with limited internal genomics capacity.
4. Expansion of genotyping services to new use cases such as the use of DNA tools for varietal monitoring and impact assessment, seed chain purity assessment, as well the genomic selection application in orphan crops. Some new collaborators include the United States Department of Agriculture (USDA) Breeding Insights project and the Feed the Future Innovation Lab for Crop Improvement (ILCI).
5. Building low- and mid-density genotyping adoption capacity within national agricultural research systems in Africa, enabling faster development of new varieties with available resources.

Breeding Operations & Phenotyping

26

Operations assessments finalized

EiB assesses agronomic practices, seed processing, planting and harvesting, phenotyping and continuous improvement practices for partners. EiB finalized the last of these [Breeding Operations and Phenotyping assessments](#), and several partners began implementing recommendations. For example, the EiB team finalized assessments with visits to stations, and delivered final assessment results to AfricaRice (two stations in Senegal and Ivory Coast) and Crop Research Institute (two NARS stations in Ghana).

Assessing the current capacity of CGIAR/NARS breeding operation supports centers and breeding programs helps prioritize improvements. This deep-dives into high-level recommendations developed through the Breeding Program Assessment Tool ([BPAT](#)).

Many improvements were implemented by Centers / programs based on the EiB assessments, e.g.:

- AfricaRice started improvements in their seed storage area.

- CIMMYT purchased and installed a weighing system in three combines and improved HSE procedures at a food processing lab.
- CIAT established an agronomic committee and adopted a farm management system
- IITA defined a strategy to improve soil quality and optimized their irrigation management

4

Programs receiving technical support

EiB made progress in supporting technical initiatives for priority crops in 2020. Technical support provided by EiB to CGIAR/NARS breeding programs in 2020 included:

- CIMMYT Maize: Support for irrigation design for three key stations (Kenya, Zimbabwe, Ethiopia), drying capacity for Kenya and Zimbabwe sites, biotic stress screening facility in Eastern Africa, provision of soil management recommendations for the Kenya site.
- IITA: Irrigation design in three key stations in Nigeria, technical recommendations and phenotyping techniques for nutritional traits for the cassava program, initiation of a project to define the requirements for improving efficiencies of the clonal multiplication process.
- ICRISAT: Irrigation design for Kenya, Zimbabwe and Mali stations, GPS recommendations for Mali station, soil management recommendations for the Kenya station.
- AfricaRice: Engineering services to design the seed process infrastructure improvement.

170

New Continuous Improvement champions

EiB is supporting partners to improve operations through embedding the use of the [Continuous Improvement \(CI\) methodology](#) in their work. The goal is to assure implementation of the breeding programs' improvement plans. This aims to reach the operational staff as an important support component.

In 2020 EiB worked with the IRRI breeding team to create a CI system that can potentially be deployed in other CGIAR/NARS centers. This first round included some key progress:

- Selection of three projects by IRRI, aligned with their breeding program improvement plan.
- Training for 25 IRRI staff in lean methodologies, who applied the learnings to deliver on their expected projects. This includes their hybrid rice team, with a plan to optimize management to reduce the level of pathogen contamination of rice seeds produced.

In total, EiB trained 50 CGIAR staff in lean methodologies, and over 120 NARS staff participated in a [continuous improvement webinar](#). With these new champions, adopting continuous improvement could mean a cultural transformation that brings CGIAR to the next level.

393

Digitization devices distributed

EiB is providing breeding programs with equipment to help speed up and enhance the accuracy of various breeding processes including seed preparation, data collection, data analysis and inventory management. With Crops to End Hunger support, EiB acquired and organized the distribution of nearly 400 digitization devices to 24 breeding programs. These included:

- 17 Package printers
- 21 seed counters
- 22 label printers
- 48 printers
- 285 handhelds

This support for mechanization and technology upgrades [will continue in 2021](#). "We want to do more to support centers to improve their operations so they can achieve the most effective and cost efficient phenotypic processes - agronomic practices, seed processing and other areas," says Operations and Phenotyping module lead Gustavo Teixeira. "We aim to expand to more programs and partners."

EiB will continue to support NARS across Africa and beyond to digitize their operations, and is working with partners to secure more equipment, training and resources. With this Digitization project, EiB has targeted 24 breeding programs in 14 countries in Africa.

4

Programs piloting digital phenotyping

In collaboration with ICRISAT, CIMMYT and CGIAR's Big Data platform, EiB coordinated the pilot effort to deploy digital phenotyping as a service for breeding programs. The aim is to federate efforts across CGIAR centers, in the scope of an "Asia hub." The first phase of this project started at ICRISAT-Patancheru where a wide array of CGIAR crops are currently represented. The work started with four crops before scaling up to more: maize, sorghum, chickpea, and pigeonpea.

The project has delivered:

- SOPs [published in EiB toolbox](#)

- Training for CIOT (Crop Improvement Operation team) at ICRISAT
- List of priority traits assessed using digital phenotyping tools

The second phase aims to deliver a streamlined process and implementation plans for considering other crops and regions.

Breeding informatics

51

Users of breeding management software developed under EiB

The [Enterprise Breeding System](#) (EBS) is available to 61 users in the CIMMYT Wheat, CIMMYT Maize, IITA Maize and IRRI Rice breeding programs. These power users and early adopters support development by providing input into the functions needed by breeders. More users and crops will be added as EBS development progresses; meanwhile, EiB is supporting breeding programs with training, data curation and integration of digitization equipment.

2.1

Version of EBS breeding software released in 2020

EiB released [Enterprise Breeding System](#) (EBS) version 2.1 in 2020. This version, which was deployed by CIMMYT with maize and wheat germplasm databases loaded in, includes experiment design and management features allowing breeding programs to run their experiments within the EBS software.

EBS connects, merges and builds upon existing breeding software and data solutions to offer a single powerful data management tool to manage and support breeding workflows across the CGIAR and beyond. It can help breeders [harness the power of data, save time](#), and make the best breeding decisions. And an even faster, more feature-filled 2.2 version launched in 2021, with more upgrades to come.

30

Participants in the breeding informatics network

The Breeding Informatics Network (BrIN) is a community of around 30 implementers that includes includes biometricians, quantitative geneticists, bioinformatics, the EBS Analytics Framework development team, and external partners from Bayer, ILCI, BreedBase, Breeding Insight and VSNI. BrIN creates working groups to address topics of common interest for CGIAR

breeding programs, with the results being incorporated into development of the EBS software. In the future, BRIN will become a global team serving One CGIAR.

NARES

National Agricultural Research and Extension Systems (NARES)

11

Customized improvement plans underway

As part of EiB's [support for national breeding programs](#) to modernize practices, EiB completed baseline assessments and [developed](#) customized improvement plans for 11 NARES breeding programs for CtEH priority crops in Africa and South Asia.

With support from Crops to End Hunger and EiB's technical teams, partners have begun implementing improvement plans. Efforts are underway to implement product profiles (for seven breeding programs), [access and apply genotyping data](#) for quality control / quality assurance (QC/QA) and profiling of elite parents, [improve program costing](#), adopt [data management platforms](#) and more.

For example, Kenya's [KALRO](#) highland maize program carried out its first-ever [full program costing](#), is expanding early stage testing, [developing product profiles](#), [digitizing](#) operations, and switching to a double haploid breeding scheme, supported by EiB and [AGG](#) / [CIMMYT MAIZE](#).

300+

NARES breeding experts building skills

EiB launched resources and a new webinar series to support NARES and improve collaboration toward a One CGIAR-NARES network.

Over 300 NARES partner participants engaged in webinars on [genetic gain](#) enhancement and calculation, data management platforms, the [continuous improvement methodology](#) and more. The efforts will continue on key issues such as [program costing](#), market segment definition, and product profile development. Webinars are open to broad audiences, but EiB also provides in-house consultancies and resources for core NARES partners to implement these best practices.

When this knowledge is applied, we can see impressive results, such as those in [Ghana](#). The rice breeding program at [CSIR](#) have developed product profiles, identified their target market segments, costed out their program, digitized their operations, and have even deployed molecular markers for selection.

1

Model for One CGIAR/NARES collaboration

EiB and their partners co-developed a new model for CGIAR/NARES collaboration. It provides clearer definitions of roles and responsibilities in breeding, along with a network of regionally based specialists that will directly support the modernization of NARES breeding.

EiB works with 28 NARES breeding programs in 11 countries, and the model will help streamline processes and relationships across the CGIAR. Collaborations are already supporting NARS to [apply genotyping services](#), access [digitization equipment](#), improve knowledge about best practices, and other improvements.

CGIAR-NARES networks are complex, with crop specific challenges and myriad partners at different stages. The model will help these networks define a route to delivering sustained [genetic gain](#) in public breeding programs.

20

EiB resource highlights

6 Top Tools:

- [Breeding scheme optimization manuals](#)
- [Breeding scheme simulation library](#)
- [SOPs UaV phenotyping](#)
- [Field applications, data management software and molecular breeding tools](#)
- [Low-density genotyping services](#)
- [Mid-density genotyping services](#)

4 Top Webinars:

- [Enhancing and measuring Genetic Gain in crop breeding](#)
- [The Continuous Improvement \(CI\) approach for breeding programs](#)
- [Breeding Insight - Breeder centric software & integrated data management](#)
- [Genotyping services tutorials](#)

6 Top Blogs:

- [How can I optimize my breeding scheme?](#)
- [Here's how to embed continuous improvement in your work](#)
- [Crop breeding and soil management must go hand in hand](#)
- [CGIAR breeding programs need more than just tech upgrades. They need change management](#)
- [Plant breeders could let women farmers guide them](#)

- [Four ways One CGIAR breeding programs can walk the talk on innovation](#)

4 Virtual Meeting 2020 Highlights:

- [Best practices for modern breeding? CGIAR-EiB coalition shares excellence, innovations, opportunities](#)
- [Opening plenary \(Asia\) EiB Virtual Meeting 2020](#)
- [The EiB mandate and progress with Director Michael Quinn](#)
- [Stories of Excellence: Rice breeding modernization in Ghana, Gender in NextGen cassava, Highland maize breeding optimization in Kenya, Marker design in yams BrAPPS and more](#)

Thank you to our funders and partners:



[And all other EiB funders & partners](#)



Thank you!

excellenceinbreeding.org/annual-report/2020/