Agenda item 5
For strategic input/endorsement

Issued: 19 October 2018

Modernizing CGIAR crop breeding programs: Draft 0 - 2019-2021 implementation plan

Purpose

As requested during SMB10[1], this document presents a 'Draft 0' implementation plan as a further demonstration of the System Management Board's strong commitment to support the Funders "Crops to End Hunger" initiative.

It is intended that the final endorsed plan serve as a coherent and system-wide response to enhancing capacity in this area critical to CGIAR delivery. Centers and CRPs for which crop breeding is an element will have accountability to the System Management Board, and through it, to the Funders for the enhancement of individual crop breeding programs. The Excellence in Breeding Platform will play a pivotal role in the process. The plan recognizes:

a. the need for commitment at all levels of the CGIAR, particularly from Centers' senior management and the breeding leads (with enhanced managerial "clout"); and
b. that the plan applies to all crop breeding programs; none will be exempted from the modernization drive.

This implementation plan should start immediately upon endorsement, such that it forms a key element of the CGIAR System 2019-2021 Business Plan.

Action Required

The Board is requested to review the 'Draft 0' implementation plan and provide strategic inputs and overall endorsement in advance of submission System Council for its inputs. The final implementation plan is envisaged to be formally approved by the System Management Board at its 12th meeting (13 December 2018).

Prepared by: CGIAR System Management Office

[1] Action point SMB/M10/AP2: The Board requested that the System Management Office put together a high-level (iterative) implementation plan on the modernization and prioritization agenda for discussion at SC7.

Background/Rationale

Crop breeding for improved varietal performance, and the agricultural and human welfare benefits which flow from such improvements, have been a mainstay of the historical success of the CGIAR system and a pillar of its theory of change. This should continue – despite the welcome increase in research by the private sector, there are still many crucial gaps that must be filled by public sector efforts for crops critical to the food security agenda of developing countries. Crop breeding has the power to provide varieties relevant to food productivity, human nutritional improvement and stability and resilience in the face of climate variability and pests and diseases. The focus of this plan should not imply that breeding is the only important area of CGIAR's work – these are addressed through many other parts of our portfolio and through similar strategies and special initiatives.

This initiative aims to accelerate a transition in crop breeding[2] in the CGIAR to address very different challenges from those faced in the green revolution. As set out in the CGIAR 2019-2021 Business Plan Forward from CGIAR Board Chairs: "The need for a global partnership to transform the food system while restoring our environment has never been greater. The task before us is momentous: a sustainable food systems revolution – as urgent as the agricultural revolution that launched CGIAR, yet exponentially more complex." One part of this challenge is for breeding in the CGIAR is modernize in terms of its objectives - to address the expanding demands for improved varieties to meet biotic and abiotic stresses such as climate change and environmental degradation, and to include a wider set of nutritional and market traits.

Another part is to modernize how it works - to keep up with the advances in all the contributory fields of genetics, experimental design, mechanization, methods of monitoring and data analysis so as to ensure that CGIAR is up to date and delivering on its promises; and to position itself squarely as one contributor to a value chain of innovation that works through others, often the private sector.

CGIAR addresses some 20 crops through a larger number of crop breeding and improvement programs. Funders have used an independent assessment tool, the Breeding Program Assessment Tool (or BPAT) to gauge the current quality and capacity of breeding programs. Whilst some of the system's historical comparative advantage is maintained in a few of the better-funded breeding programs, the assessments suggest that many crop breeding programs are below modern standards either in organization, skills, staff commitments or funding levels and quality to really ensure that the CGIAR can meet development goals. These reports collectively suggest that CGIAR is not where it needs to be on the threshold of a new phase of the portfolio and in the relatively short time towards the SDG targets of 2030. Funders have therefore taken the lead in defining a comprehensive modernization agenda for crop breeding in the CGIAR (see *Initiative on "Crops to End Hunger". Strategy and Options for CGIAR Support to Plant Breeding, vers. Oct 8 2018*).

[2] Funders chose to focus on 20 CGIAR crops (cereals, legumes, root crops and *Musa* spp.) for this breeding initiative, not including fodder species, livestock or fish which are the subjects of other work within the CGIAR.

This paper seeks to provide a comprehensive CGIAR agenda for the implementation of the changes occasioned by the funder demands for the modernization of CGIAR breeding. Our response acknowledges the seriousness of that challenge to the CGIAR, and for CGIAR stakeholders – the System Management Board, The Directors General of Centers leading the relevant Agri-Food System CRPs, their CRP Directors, DDG's Research and Breeding Leads – this is a moment of opportunity to identify the implementation steps of an ambitious modernization agenda.

What is meant by a "modern" breeding program?

A well-functioning modern breeding program is one that has a process of continuous improvement, which is always implementing ways to increase rates of genetic gains, and continually asking if there can be closer alignment between what will have maximum impact and the targeted and realized outputs. To be effective each crop breeding program will need to establish critical mass for product development and rigorous metrics for success: means to regularly measure genetic gains and the rate of varietal turnover in farmers' fields will be required. The system as a whole will be expected to seek efficiencies through better use of common services (shared and outsourced) and the use of shared infrastructure at CGIAR breeding hubs where appropriate.

A partnership approach

The modernization agenda is predicated on methods and practices which provide rapid and efficient varietal development in the private sector. Private sector experts are expected to continue to provide advice and best practice and opportunities for the provision of services to breeding programs through the EiB and potential partnerships. The Funder initiative views CGIAR crop breeding as taking place with national system breeding programs. This means that the planning of breeding programs, reflecting national demands and market considerations, and collaboration in phenotyping networks and identification of opportunities for seed delivery system alignment and improvement should all be considered. The Initiative highlights that to have effect, crop varieties need to perform demonstrably better in farmer's fields and to be desired commodities by farmers. CGIAR can and should promote its outputs but it does not control delivery pipelines. To this end, whilst the breeding initiative focusses on the modernization of breeding programs in the CGIAR, it invites a full collaboration with national programs as scientific and commercial partners to achieve the outcomes sought.

What will result?

By going through this process of improvement and modernization there will be multiple benefits. Firstly, for a given level of investment it is anticipated that each breeding program will achieve increased rates of genetic gain and scale of impact - what CGIAR breeding is all about. Secondly, there will be further opportunity to gather together allied crop programs in the CGIAR and to promote and work with standardized methodology across Centers. Thirdly, by adopting standardized ways of reporting needs, opportunities and progress this

will provide funders with a transparent view of where and how they are getting high rates of return for their investment. It is anticipated this will in turn lead to maintained and increased funding. Finally, by implementing current best practices and by utilizing latest technologies to their full advantage this can only provide funders, both current and potential, with increased confidence to continue, increase or start investing in CGIAR breeding.

Establishing commitment and the necessary staffing

The Funders' Strategy and opportunities document for the breeding initiative makes it clear that SMB and CGIAR Center management commitment to the modernization agenda is paramount and continued funding of breeding programs depends upon the successful implementation of the steps outlined below.

The System Management Board agrees that the underlying tenet of the modernization agenda is Center managerial and staff commitment to the process. The implementation plan is as much a managerial challenge as a scientific and logistical one. It will be necessary to galvanize all players, to treat the implementation plan as a stimulus to necessary change, and the opportunity to gain new skills and scientific excellence to underpin the programs of the CGIAR. Crop breeding programs encompass our colleagues in collaborating national programs. There is an opportunity to develop better approaches and facilities to benefit developing country agricultural research in a global manner.

This implementation plan therefore envisages Center leadership and development of new crop breeding plans by Center crop breeding teams. Modern programs are characterized by continuously looking to make improvements in each of the following areas:

a. Standardized product profiles (developed with NARS partners and with due regard to socio-economic and market demands) that describe germplasm that will have maximum impact
b. A formalized and documented breeding process with pre-defined requisites as found in a stage gate process, including clear plans for involvement of CGIAR clients (including NARS breeders) into the processes of testing, selection, release and commercialization
c. Optimized breeding schemes that routinely seeks to increase selection accuracy and selection intensity, maintaining sufficient levels of genetic diversity
d. Routine genetic gains assessment
e. Access to low-cost, well targeted genotypic data strategically integrated into the breeding process
f. Ability to generate low cost, well targeted and accurate phenotypic data
g. All breeding data is handled and stored in a way that supports automation, integration (at all levels), decision making and use of best-practice biometrics

A significant element of modernization can be done within existing funding envelopes and may even lead to cost efficiencies[3]. However, this is a skills-led process. Costs incurred by the breeding Centers associated with executing the improvement plans are likely to come in the form of personnel in the first instance, then access to services and capital and infrastructure:

a. To drive the modernization agenda within a Center from technical, logistical and administrative perspectives and to bridge support from EiB to the programs will likely require a dedicated person, perhaps a **Head of breeding**. This person should be technically highly skilled, including experience with modern breeding approaches and also have management skills.
b. To drive successful implementation of the improvement plan will require a **project manager**
c. To develop well informed product profiles and to be the bridge between the market (farmers and end users) and the breeding program may require someone to fulfill this role, perhaps a **product manager**.
d. To ensure optimal breeding schemes are being used and that new technologies are being applied optimally will require **access to quantitative genetics support**. This support will need to apply quantitative genetic principals to a functioning field breeding program considering all biological, logistical and resource constraints. These skills are difficult to attract. The person/people providing this support will need to spend considerable time on site with the breeding program(s) but may not need to be based at the center.
e. To ensure that maximum value is extracted from each data point **biometrics support** will be required. It is possible that this could be sourced together with quantitative genetics support. As breeding programs evolve to require these new positions other positions within the program should also be critically reviewed. As the program evolves there may not necessarily be an increase in the total number of positions, or, there may even be a reduction.
f. As programs require more sophisticated **data management systems** will be required with **data management and IT support**, which will need to be budgeted for.

The overall process to be taken to modernize CGIAR breeding programs:

The first step toward modernization of breeding programs is to identify the gaps - the areas that need to be addressed or improved. The Breeding Program Assessment Tool (BPAT) has been developed for this purpose. The deployment of BPAT has been funded by the Bill & Melinda Gates Foundation (BMGF) and administered by the University of Queensland (UQ) and has now been used to assess the breeding programs at more than half of CGIAR Centers. The process has involved use of a standard and detailed survey questionnaire about a specific crop breeding program run by a CGIAR Center. The survey is administered

[3] The Initiative focusses very specifically on improving the breeding element of crop improvement programs. In some assessments to date have noted that breeding has been surrounded by other activities which consumed breeding staff time or were of limited or competing value to the development of important new varieties.

by a small team of visiting experts with an on-site assessment. This is followed 3-4 months later by a formal written report by the BPAT team which includes descriptions of recommendations resulting from the assessment. This process has been rolled out across the CGIAR starting in early 2016 and is due to be concluded in 2019. A common gap identified from these assessments is that CGIAR breeding centers need access to tools and services, some of which cannot justifiably be developed for individual centers or crops but could be developed for common use if shared across the whole of the CGIAR. Examples include data management tools and access to low cost genotyping. To achieve many of the recommendations arising from the BPAT process and fill the identified gaps will require CGIAR breeding Centers to plan the future with access to high quality technical advice. Hence the Excellence in Breeding Platform (EiB) has been established to provide technical consultancy and access to shared breeding tools and services.

Table 1: Status of BPAT assessments of CGIAR Center hubs for crop breeding[4] (as if October 2018)

Center	Program	Status
ICRISAT	All except finger millet	Completed
IITA	All	Completed
CIMMYT	Spring bread wheat	Completed
IRRI	All	Completed
CIAT	Beans, forages	Completed
AfricaRice	All	Complete*
CIP	All	Complete*
CIAT	Rice, cassava	November
ICARDA	TBC	TBC
CIMMYT	All maize programs	Nov-18
CIMMYT	Durum, winter wheat, hybrid wheat	No plans

*Center awaiting final report

Only once the diagnosis has been made, a quality plan designed, and the necessary skills engaged, would it be appropriate to upgrade infrastructure, machinery and equipment at breeding hubs and as part of a shared strategy for breeding across all of the CGIAR. The Center breeding programs and Center hubs will need to establish the basis collaboratively for funder support on the scale required.

As programs take advantage of new tools and technologies this should not require additional resources as the value proposition of adopting new technologies should be such that a higher rate of genetic gain can be achieved for the same level of investment. Reallocation of resources may be required, however. To implement genomic tools may require investment in salaries or field nurseries to pay for genotyping conducted by an external laboratory. Much can be achieved with current infrastructure but to be truly "modernized" is likely going to require capital investment in infrastructure, machinery and

[4] It should be noted that BPAT assessments have been carried out on CGIAR Centers and a crop by crop assessment conducted for crop breeding programs led by that Center. The BPAT planning cycle will continue until all 20 crops considered by the Funder initiative have been included. This may introduce a naturally staggered development of new breeding plans per crop subsequently.

equipment. Examples include machinery for moving toward mechanized processes for trial packing, sowing, harvesting and post-harvest handling, equipment for seed handling, sample tracking, data collection, etc. and infrastructure for rapid generation advance and managed environment facilities (if and when required). Anticipated additional costs arising from modernization in the form of additional staffing, infrastructure and services beyond current levels will be set out in modernization plans.

Approach to Funding

On fundraising for the costs of the above, the System Management Board will facilitate a collective engagement with Funders attached to CGIAR's half-yearly System Councils to seek additional funding, where required, to support implementation of these costed modernization plans and any additional supporting shared services and infrastructure required.

Funding to breeding, like other areas of CGIAR's work, is fragmented and suffers from a proliferation of separate projects, leading to a fragmentation of efforts by Centers and leverage by funders, alongside inefficiencies from multiple reporting and weak core programs.

The System Management Board therefore urges Funders to provide funding:

- of sufficient volume
- through pooled funding arrangements of W1 and 2
- on a multi-year basis (even where through W1 and 2)
- coordinated among donors to reflect collective priorities
- through the agreed CRP and Platform portfolio

An aspect that will require monitoring is the capacity of the BPAT evaluation teams and EiB itself to maintain the review of breeding hubs and support functions to breeding programs (respectively) according to the schedule outlined in this plan with their current capacity. Should commissioning extra capacity be required to manage the simultaneous modernization of CGIAR breeding programs, these may require future additional funding.

Technical support for breeding plan development

EiB Platform is essentially constructed as a shared service to Centers (see Box). Once recommendations from the BPAT assessments have been made, and the EiB team is established together with the communities of practice, plans for responding to these recommendations will need to be developed. These plans will be crop-specific breeding program improvement plans or "improvement plans". One of the roles of EiB is to offer assistance to CGIAR breeding Centers to develop these plans, so that these plans will include recommendations made by both BPAT and EiB. As autonomous Centers, each CGIAR Center will choose how to prioritize these recommendations and will commit to their implementation.

For each of these improvements the plan will include:

- All action steps required to make each targeted improvement
- Each action step will need to have a deadline by which it will be completed
- Each action step will need to identify the person accountable for ensuring the action is completed, the people responsible for making the action happen and the people that need to be informed and consulted
- Methods for monitoring progress towards and completion of each action step.
- Expected costs or savings (if any) expected to be associated with any particular action

It is expected that each improvement plan will include the identification of responsibilities for each of, breeding team personnel, CGIAR senior management and the EiB Platform.

For the modernization of breeding programs, Center senior management (DG and DDG-R) will be accountable[5] both directly to funders and indirectly via the System Management Board. EiB is responsible for enabling CGIAR Centers to deliver against these plans by providing technical consultancy and access to shared tools and services and to report progress against the improvement plans. Shared tools and services (that pre-date EiB but will be supported by EiB going forward) are already being used within the CGIAR, for example access to high quality cheap genotyping through the High Throughput Genotyping Project or access to a Breeding (data) Management System through the Integrated Breeding Platform.

Across CGIAR there is an opportunity to aggregate demand for breeding services to create economies of scale for driving down per unit prices to access these services whether they're outsourced or provided from within the CGIAR for the whole of the CGIAR. EiB is tasked with achieving this wherever possible.

A key early step is for EiB to develop specific tools and templates to facilitate the process of developing the improvement plans. Examples of these might include tools and/or templates for the development of:

- The improvement plan itself
- Market informed product profiles that, for instance, include gender preferences, nutrition and climate resilience and mitigation traits
- A stage gate process for the development of germplasm
- Robust analyses of rates of genetic gains in farmers' fields
- Documented breeding schemes
- Documented use of (including usefulness of) specific molecular tools
- Documented approaches to and processes for phenotyping
- Breeding use cases and work flows currently supported by data management systems
- Breeding use cases and work flows still needing to be supported by data management systems

[5] This statement does not devalue the role of Center boards but rather identifies Directors General and their program leaders as being operationally responsible for program management.

Text Box 1: The Excellence in Breeding Platform

The Excellence in Breeding Platform (EiB) is designed to provide advice and access to services for the breeding programs of the CGIAR. Currently EiB is close to having its team established, at which point it will have an expert in each of the following areas:

1. Product design and management to ensure breeding objectives and processes are aligned for maximum scale of impact
2. Breeding pipelines, quantitative genetics and biometrics
3. Genotyping for breeding purposes including quality control (QC), forward Marker Assisted Selection (MAS) and Genomic Selection (GS)
4. Mechanization and automation of breeding process to increase quality and drive down cost of phenotypic data
5. Development of data management solutions for breeding

These 5 areas of expertise have been identified in consultation with all the Agri-Food System CGIAR Research Programs to cover the major technical areas of the breeding process. Sources of advice in these areas will be a resource for CGIAR breeding Centers, and will simultaneously lead a community of experts contributing to EiB to address issues such as what is current best practice and to develop plans for development of breeding tools and access to services. This community will be sourced from all areas of the broad breeding community globally including from CGIAR, National breeding programs, Advanced Research Institutes (ARIs) (including universities and government research organizations) and the private sector. From these communities, implementation and support networks can be developed. These networks will serve as a resource for the CGIAR community to make tangible advancements toward improved practices.

Some of these tools will be required for the development of the improvement plan itself, others will be required for the execution of the improvement plan. As the improvement plans are developed, additional tools and services that will be required to enable the plans to be executed may become apparent. Examples of such tools might include methods for assigning values to specific traits to determine their validity on a product profile, decision support tools for parent selection, cross combination, hybrid combinations or selections, or, simulation tools to simulate outcomes from alternative breeding schemes.

Once the necessary tools and templates are developed, for Centers wishing to utilize EiB to develop these plans, a process for both engagement and the development of the plans must be developed together by the Centers and EiB. The process of engagement is to be worked out and must balance commitment, funding and Center and EiB capacity. CGIAR Centers

choosing to be a part of the funders breeding initiative will develop a draft improvement plan by 31 March 2019 and a fully comprehensive plan by 30 September 2019[6].

These improvement plans will become a living document as they should continually be updated (which is why each is a "comprehensive" rather than a "completed" plan). The fluid nature of the plan does not diminish the accountability for any particular action point agreed to in the plan. The improvement plans will include many individual actions, some that could be actioned within weeks or months and others that will be part of a larger more complex outcome that might take up to 2-3 years. Improvements that are to be implemented over a longer timeframe than 2-3 years will be added later as the plan is updated. Plans will need to be formally updated every 6 months according to progress made during the first three years of the Initiative.

Accountability, Oversight and Monitoring of implementation progress.

Progress against the plans must be monitored and Funders expect some oversight to assess the quality of implementation. The modernization agenda for the CGIAR has to be a Center-led plan but to be framed with respect to the effective strategies of the CRPs. Breeding management is managed at the level of crops and Centers (or sometimes groups of Centers). CGIAR's existing governance arrangements and their principle of subsidiarity will apply.

Key roles are:

- Centers – to lead the detailed design and implementation of the initiative and their modernization plans
- CRPs - frame the work that encompasses varietal improvement research towards measurable outcomes
- System Council – in the form assessing implementation as reported on in the annual CGIAR Performance Report
- SMB – leading the overall design and oversight of the implementation plan
- Funders – to match the implementation plan with appropriative volumes and quality of funding
- EiB – to support the design and implementation of the plan

Key elements will include:

- Each individual breeding program will go through a BPAT process no less frequently than every two-three years[7]. The BPAT was used as the initial mechanism for assessing program quality and capacity and will likely be the best mechanism for routine assessment and for monitoring progress against improvement plans.

[6] This schedule is proposed for Centers for which a BPAT assessment report is currently available. Others would be expected to join in and develop draft breeding plans for individual crops approximately three months after the delivery date of the relevant BPAT assessment report.

[7] Two years is preferable; however, this will be influenced by the nature of crops (potentially slightly longer for root and tuber crops versus cereals) and the practical capacity of the BPAT assessment teams for such a re-review schedule – for instance if a full team assessment was anticipated, or re-reviews were conducted by only one member of the former assessment panel.

- Breeding programs will be assessed by common metrics, namely, extent of genetic gain and rate of varietal turnover in farmers' fields.
- Breeding Centers will report annually on implementation of their modernization plan [to the System Management Office] and this will be featured in a special section of CGIAR's annual performance report and accompanying dashboard.
- *An alternative* is that the EiB as part of its Annual Platform report is the channel for reporting on the modernization agenda (reports provided by Centers to the EiB through its contributor meeting or similar).
- CRPs will continue to report on planned programmatic outputs and progress towards outcomes from CRP research.
- EiB may be requested additionally by SMB to analyze and verify the reports provided, and where requested provide updates on the implementation of breeding initiative to SMB, SC and Funders.

Continuing interaction by EiB

In addition to working with CGIAR breeding Centers to develop improvement plans, EiB should also be providing technical consultancy and access to shared tools and services. Many of the ways in which EiB is expected to provide this have already been defined as a result of:

1. The BPAT reports
2. Surveys sent out by EiB
3. Feedback from CGIAR breeding teams and centers via the annual EiB Contributors Meeting
4. Engaging with CGIAR breeding teams and management during EiB visits to CGIAR centers

EiB's engagement strategy for assisting programs to develop improvement plans will be different from its strategy for providing technical advice or access to tools and services. Therefore, the priority and urgency with which EiB should allocate resources to assisting with the development of improvement plans should be clearly defined by the funders and senior management of the CGIAR Breeding Centers.

A philosophy of critical mass and sharing of services

A risk to a Center-by-Center process is that opportunities to invest in shared facilities and services are missed, even if these would be better value for money. Hence as key first step in this plan will be a request from SMB to EiB to facilitate a discussion among breeding Centers to identify the scope for such shared activities, where this makes sense to do so.

[This will be undertaken in Q1 2019 for submission to the SMB meeting in April 2019].

3-year Sequencing of Actions

- CGIAR breeding programs assessed with the BPAT (immediately, as per schedule)
- Draft Implementation Plan considered by DGs, breeding leads and the SMB in October
- Implementation Plan revised with stakeholder inputs and discussed with Funders at SC7 Seattle USA in November.
- Funder Initiative formally announced and commences January 2019
- CGIAR breeding Centers develop draft crop improvement plans (immediately)
- SMB request to EiB to identify emerging need for shared services (early 2019 for April 2019 review)
- EiB completes putting team together (by April 2019)
- EiB develops tools to assist development and execution of improvement plan (ongoing but significant progress by end of 2018)
- EiB assists CGIAR Centers wanting assistance to develop an improvement plan (immediately)
- CGIAR breeding Centers complete draft improvement plans (no later than by March 2019)
- CGIAR breeding Centers complete comprehensive improvement plans (no later than by September 2019)
- CGIAR breeding programs begin regular reporting through Annual report processes[8] in 2020
- Upgrade of breeding hubs begins 2020
- Improvement plans updated every 6 months
- BPAT assesses progress against the improvement plans no less than every 2-3 years

[8] See section on Accountability, Oversight and Monitoring for the alternatives