Agenda item 7
For input

Issued: 4 December 2017

Inclusion of Common Bean in the CGIAR Portfolio

Purpose

At its 5th meeting, the System Council noted the need to address the absence of common bean in the CGIAR Portfolio. This document sets out the background to common bean research in CGIAR and provides potential options for establishing a Flagship Program as a part of the portfolio.

Action Required

The Board is requested to provide input on the potential inclusion of a breeding program for Common Bean in the CGIAR Portfolio.

The Board is further asked to consider the means for implementation of the approach and make a draft decision on one of the 3 options presented, or any other competitive options. If the Board wishes to confirm the next steps, this should include instruction to issue a request for program development with target date of May.

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Background

1. Common bean (*Phaseolus vulgaris*) was one of the mandated staple crops addressed by the CGIAR historically, largely through a breeding program established at CIAT. Global estimates of crop preference show an increasing focus on major staples and oil crops, and common bean has marginally declined against thee commodities in global terms. However, it remains a highly important crop regionally with key relevance for Latin American countries and Eastern and Southern Africa. For the poor in these parts of the world beans provide a key source of protein, calories and they are high in iron and folate[1]. CIAT's breeding efforts are amplified by adaptation and extension through regional networks (particularly ProFrijol in Latin America and the PABRA network in Sub-Saharan Africa).

2. The nutritional advantages of common beans have been further enhanced through the biofortification FP of A4NH (to produce high iron and high zinc varieties). Further, common bean has a broad temperature tolerance, making it an excellent climate-smart option for future agri-food systems. The existence of other species of *Phaseolus* adapted to different humid and hot environments means that the wider bean genepool is expected to yield additional advances in climate and nutritional resilience of common bean through research.

Programmatic developments

3. Despite the central importance of common bean to the higher goals of CGIAR, in the phases of evolution of the CGIAR portfolio the locus of common bean research has been moved in programmatic terms (it effectively resides within CIAT). Originally part of the Grain Legumes CRP, the continuing common bean work was re-located within the DCLAS (Dryland Cereal, Legumes and Systems Program) by the end of phase I. It was then envisaged as being part of the GLDC program planned for phase II led by ICRISAT. However, for reasons unrelated to the performance of the common bean breeding component, the original GLDC proposal was found weak by the ISPC and not endorsed for submission by the Consortium Board. The CGIAR portfolio, agreed to by funders in September 2016 (Mexico meeting), did not include the GLDC CRP, which had the effect of excluding the research on GLDC crops including common beans.

4. Recognizing this lacuna in the scope of the portfolio, the System Council Chair invited the System Management Board to consider how a program or programs to meet the need of the communities and agri-food systems of the Drylands might best be handled. In the interim, he invited USAID to act as a convenor of interested funders, as "friends of GLDC", to ensure that key crop breeding programs could be supported

[1] In the original prioritization of crops in the 2016 version of the Grain Legumes and Dryland Cereals CRP, in the crop prioritization exercise amongst dryland cereals and legumes, common bean was ranked first in its potential contribution to SLO1 (alleviation of poverty) and SLO2 (nutrition and food security).

during 2017. USAID have been the leading funder of the common bean breeding program in 2017.

5. The System Management Board Working Group convened (November 2016 to March 2017) to consider the issue invited an expert panel to provide an independent perspective as to how a Dryland program might be formulated. The expert panel under the Chairmanship of Peter Matlon reported at the end of February 2017, recommending that a new GLDC proposal be developed by ICRISAT but focused on the tropical drylands of South Asia and Sub-Saharan Africa. This recommendation was accepted by the SMB, to achieve greater focus for this research program. This meant that common bean, a crop predominantly of the humid areas, and the other cereal and legume crops of the temperate drylands (typical of the WANA region) were not included for consideration in the call for the new GLDC proposal (now submitted, reviewed and approved by SC5 in November 2017). The Matlon report also drew attention to the need to support work related to common bean separately, whilst suggesting that the WANA region might benefit from direct spill overs from GLDC, with support from regional funders in a later phase.

6. Two additional dimensions relevant to this discussion have been confirmed by System Council 5. The first is the additional flexibility for funders of the portfolio to be able to contribute funding to identified FPs (Flagship Programs) as well as CRP-level funding. Secondly, is the USAID-led funder initiative to support crop breeding programs in the CGIAR in a coordinated fashion. The details of this proposal are not yet finalized.

Possible means to accommodate a common bean breeding focal program in the CGIAR Portfolio

7. If the SMB supports the importance of the common bean as a key crop of the CGIAR Portfolio as outlined above and recommends its continuation as an element of the portfolio, a vehicle needs to be identified so that common bean breeding might be recognized as part of the portfolio. CIAT is expected to be the leader of any new common bean breeding hub/flagship because of past experience and network contacts. CIAT holds a substantial germplasm collection (including cassava and forages), is also lead Center for the CCAFS CRP and co-host of the Big Data Platform, providing important cross-portfolio linkages.

8. Three possible alternatives are proposed for Board consideration:

   a) Common bean breeding is re-incorporated as an FP into the GLDC CRP
   b) Common bean breeding is established as a hosted FP of the MAIZE CRP
   c) Common bean research is considered as a new small single-flagship CRP in its own right, allied to the new crop breeding initiative and linked to bilaterally-supported regional programs of ProFrijol and PABRA.

9. In each case the FP/program is expected to work to provide a supply of bean germplasm for poverty, nutrition and climate smart outcomes, linked to other AFS programs, the new breeding initiative (and the Excellence in Breeding Platform).

10. The three alternatives are not mutually exclusive, and there is some uncertainty given the final form of the funder support to (a selection of?) current crops in the planned new initiative, but the following observations may be relevant:

- **Alternative 1** (an FP in GLDC): Returns to earlier logic that all legume species would benefit from alignment in a single research program. However, it would contradict the specific crop and agroecosystem (and regional) choices that have led to the most recent revision and focus of a new GLDC. It would seem an inopportune time to reinvent this particular program. An alignment of more fundamental research would still be possible across CRPs and through the Excellence in Breeding Platform but the regional networks of most relevance to CIAT and common bean are different from those for GLDC.

- **Alternative 2** (an FP in MAIZE). Would be largely a hosting arrangement, and it is not suggested that common bean research and extension would be restricted or focused within maize farming systems. Food systems relationships between the two crops in Latin America and East and southern Africa would be advantageous, although it is noted that the current bean program is of particular importance to countries like Ethiopia and Rwanda where there is little overlap with maize farming or food systems.

- **Alternative 3** (a small[2] "single-flagship CRP" in which the breeding nucleus aligns with the new Crop initiative and links to 2 regional programs). This would re-establish the importance and visibility of common bean in the system (noting institutional links to nutrition and climate cross cutting outcomes) and enhance a means of working with regional program networks for the CGIAR. It is only different from Alternative 2 in scope and administrative independence (and if the new crop initiative is based entirely on the confirmation of other FPs within existing CRPs, then an FP alternative would be required to align with the initiative and this alternative may not be necessary). There are systemic implications of this approach, since it would be creating a new type of CRP. On the one hand, this could open up the portfolio to more flexible, smaller and potentially more fundable new programs. On the other, it would potentially complicate an already complex landscape and involve some challenges in the reporting and governance system.

[2] The maintenance of a bean breeding hub or nucleus at CIAT, Colombia and made relevant to Latin America and (eastern) SSA has been variously estimated at between USD 2 million to USD 3.9 million (see attached concept note in Annex1). The PABRA network is bilaterally funded by a group of funders currently to around USD 10 million. So, a very rough estimate would be for a total of USD 25 million annually for all elements together.

11. The above focusses on CIAT as the potential leader of any CGIAR breeding effort for common bean (paragraph 7, footnote 2, Annex 1). The Board may wish to confirm the assumption or consider competitive models for a call.

12. The SMB is encouraged to reach a clear rationale for inclusion, and the mode of inclusion, of common bean in the CGIAR portfolio, so that a swift alignment could be made with the any new call the funder initiative may make to align and update the crop breeding thrusts on key crops. If found appropriate, this would entail instructing the SMO to initiate a call for a proposal with a target date of May.

Suggested further reading:

- Annex to GLDC proposal (2016) https://cgspace.cgiar.org/bitstream/handle/10947/4384/3.%20GLDC%20-%20Annexes.pdf?sequence=1&isAllowed=y

- The Changing composition of Global Diets: Implications for CGIAR Research (CIAT Policy Brief, September 2014). https://cgspace.cgiar.org/bitstream/handle/10568/56788/policy_brief_global_diets.pdf?sequence=1&isAllowed=y

Annex 1 – The role of common beans in Global Food Security and Food Systems

Unpublished concept note, S. Beebe, CIAT (2017)

Mission Statement

1. To contribute to food and nutrition security and the alleviation of poverty in Africa and Latin America through bean-based technology that exploits the genetic diversity of the Phaseolus genus.

2. As the world's most widely consumed food legume, common bean (*Phaseolus vulgaris* L.) plays multiple roles in Global Food Security and Food Systems that serve both the poor and a growing middle class, as…
   a) A source of protein, complex carbohydrates, minerals and folate
   b) A source of dietary fiber
   c) A potent prebiotic for enhanced gut health
   d) A preventative measure for cardiovascular disease, colon and breast cancers, and type 2 diabetes

3. As with most other pulses, bean yields have not increased sufficiently to meet demand. For example, a study of consumption in Uganda and Tanzania indicates that the poor are unable to purchase beans to meet their needs, and can only consume about a third of the beans that higher economic strata eat. Bean prices in Central America similarly limit consumption. As crop programs in the CGIAR define themselves as Agri-Food System CRPs, the first priority of a bean research program must be to make beans available and accessible within the local food system, for both rural and urban consumers, through enhanced productivity that reduces prices. Technology that meets this goal must be cost effective for producers, ideally reducing production costs such that profitability is maintained when prices drop. A cornerstone of this goal is the development of germplasm resources and varieties that respond to needs and opportunities of bean users. SDGs are addressed by varieties with characteristics that in turn respond to sub-IDOs as formulated in the SRF.

SDG 1: End poverty in all its forms everywhere, is addressed by varieties that:

a) Enjoy ready market potential and meet consumer demands
   - Sub-IDO 1.3.2: Increased livelihood opportunities

b) Maximize the return on investment of inputs, especially through fertilizer efficient varieties
   - Sub-IDO 1.3.4: More efficient use of inputs.

SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture, is addressed by varieties that:

c) Display greater yield potential

- Sub-IDO 1.4.3: Enhanced genetic gain

d) Offer greater nutritional value and serve as raw products for processed foods
   - Sub-IDO 2.1.1: Increased availability of diverse nutrient-rich food

SDG 13: Take urgent action to combat climate change and its impacts, is addressed by varieties that:

e) Confront drought, excess rainfall, and/or higher temperatures, with accompanying biotic constraints
   - Sub-IDO 1.4.1: Reduce pre-and post-harvest losses, including those caused by climate change

4. While ambitious, this effort builds on forty years of experience, with some efforts already producing impact such as nutrient rich, drought tolerant varieties that improve hemoglobin and cognitive ability, and other activities with preliminary results that promise success in the mid-term. Furthermore, common beans enjoy vast genetic diversity in its two major gene pools and its multiple races for resistance to diseases, and for tolerance to some abiotic constraints. However, faced with extreme climates of the future, sister species of the Phaseolus genus offer far better adaptation that results from millennia of evolution in such environments. *P. coccineus* and *P. dumosus* evolved in extremely moist environments, while *P. acutifolius* evolved in hot, desert-like regimes. Pre-breeding with these species is a long-term investment in the viability of the bean crop. Furthermore, understanding their genetic systems will permit designing common beans through gene editing or genetic transformation when these methodologies are operational. We see the exploration of interspecific variability as a key to accelerating genetic gain. Our experience with breeding for abiotic stress has shed light on the physiological limitations on yield, especially with the issue of photosynthate transport to grain. Selection of remobilization traits under stress has had a positive effect on yield potential. *P. acutifolius* is especially efficient in this regard and can serve as a genetic model for yield improvement. A more effective root system as derived from *P. coccineus* can improve access to soil water and nutrients.

5. Staffing and functions for this ambitious plan include:

   a) Three applied breeders (Ph.D.): While eventually varietal development should be assumed by national programs, applied breeders will have a role in developing materials for strategic traits with direct potential for on-farm use. For example, even when sources of drought tolerance were available, a CIAT breeder needed to create a material with varietal potential as a proof of concept, and this variety was released in 2009 in Nicaragua. As a result, other programs have gradually introduced drought breeding into their activities. Breeding for high iron is approaching this state at present, while heat tolerance is a further behind in the pipeline. Breeders will gradually need to incorporate traits of consumer acceptance such as short cooking time. An international center will continue to have a role of providing elite parental material with good combining ability and a

generally acceptable phenotype to NARS breeders, while some countries may never have an effective in-house program and will need to be linked to other entities. The three breeders would be based in Colombia, Uganda and Malawi.

b) A molecular biologist/geneticist (Ph.D.): The availability of the common bean genome sequence, and sequencing of sister species and even cowpea and soybean opens new horizons and will give insights into opportunities at many levels, from the creation of more efficient markers for selection, to gene editing when this is feasible. Access to infrastructure and interaction with the breeder in pre-breeding makes it preferable to be based in Colombia.

c) A pathologist (Ph.D.): Extreme weather events and excessive rainfall will exacerbate intensity of several soil borne pathogens, and of Phoma foliar blight. While breeding for anthracnose and angular leaf spot resistance is well advanced, monitoring of pathogen variability is warranted in support of breeding. This person could be based either in Colombia or in East Africa.

d) A virologist (half time Ph.D. or full time M.Sc.): Important viral diseases are currently controlled genetically, but drier weather will increase vector pressure and new recombinants of gemini virus are already appearing. These need to be studied in relation to currently used resistance genes; the same can be said for variability of potyviruses. Work on gemini viruses requires the person to be based in Latin America.

e) A physiologist (Ph.D.): As part of a team for which abiotic stress is a priority, a physiologist is an indispensable component, focusing on drought and heat mechanisms of tolerance, and identifying which parental materials are contrasting in mechanisms that can be combined. Some attention should be directed toward fertilizer-efficient root systems, and to root penetration capacity, which will be increasingly important as soils degrade and become compacted. Access to infrastructure favors basing this person in Colombia, although a post-doctoral position in Africa would be welcome. Project proposals on physiology of bean have been developed with the University of Sydney, Australia, U. of Washington- Seattle and with Forschungszentrum-Jülich, Germany.

f) An entomologist (Ph.D.): While some pest issues remain in Latin America, bean stem maggot (Ophiomyia spp) continues to wreak havoc in Africa in dry years. Irregularity of early season rainfall that is brought on by climate change induces staggered planting dates and can generate insect populations that pass from farm to farm. Genetic differences in resistance are reported, possibly in P. acutifolius. This person could be based in Nairobi in the CIAT office on the ICIPE campus.

g) A Bioinformatician (quarter time, with a full-time research associate). We anticipate in the coming years, access to a great amount of sequencing data for Phaseolus species as well as other relevant legumes species. The expertise will be

needed for data mining to guide breeding and accelerate genetic gain. The position will be based in Colombia.

6. This team would need to be in direct contact with colleagues working in marketing (as the production-to-market corridor concept develops); with nutritionists; with seed experts; with gender experts; with professionals in Monitoring and Evaluation; and with regional coordinators who facilitate interactions with national programs.

Networking for Research and for Reaching End Users

7. Networking with other institutions both in Africa and Latin America, and with ARIs in North America, Europe and Australia makes for an effective and dynamic system for research and delivery. CIAT has a long history of creating regional networks with partners, first in Central America, and later in the Great Lakes region, and in Eastern and southern Africa. The Central American network has not functioned formally since the early 1990's, but collegial relations maintain interchange of germplasm and results, including regional trials, and with the support of the breeder at the Pan-American School (Zamorano). The annual regional agronomy meeting (the PCCMCA) facilitates face to face communication and information sharing.

8. The Pan-African Bean Research Alliance (PABRA) is a self-governing consortium under CIAT's administration that coordinates cooperation among twenty-nine countries and three regional networks. Annual meetings permit information sharing and joint decision making about priorities and governance. CIAT's two breeders within the region have a triple role of, 1) mentoring national programs including breeding activities where these exist; 2) carrying out breeding for locally important traits and distributing germplasm through regional trials; 3) bridging to CIAT headquarters to communicate needs and to coordinate introduction of germplasm from CIAT-Colombia. Some projects such as the bean component of the Tropical Legumes project funded by the Bill and Melinda Gates Foundation is co-executed between the breeder in Uganda and breeders in CIAT-Colombia.

9. The largest bean research community in the developed world is in the United States, where the genome sequence of common bean was developed. CIAT interacts both with colleagues in USDA and in universities there. One joint project focusing on breeding for abiotic stress tolerance is funded through USAID and is administered by Pennsylvania State University, facilitating interaction of CIAT researchers with those in three stations of USDA, the University of Puerto Rico, North Dakota State University and Zamorano, on topics as diverse as stress physiology, breeding, and genomics. A second project focused on developing sources of resistance to soil pathogens and was executed under the leadership of Michigan State University. Linkage funds supplied by USAID to the Grain Legumes CRP permitted interacting with Michigan State on processing characteristics of bean, and on photosynthesis research, and with UC Davis on physiology. Several of these partners are also active in the Legume Innovation Laboratory funded by USAID. CIAT's role is often though not exclusively the provision of unique germplasm resources, derived from its ample breeding program and its

tropical experience. Scientists on sabbatical leave are welcome to come to CIAT to work on topics of joint interest.

10. We foresee a particular role for legumes and specifically for beans in the area of health. While the nutritional benefits of beans are widely recognized, the additional benefits on health are emerging and are attracting ever greater interest as populations at every level of the economic scale suffer obesity and associated non-communicable diseases. We anticipate opportunities to develop cooperation with partners such as Michigan State University, Washington University, or potentially through them, with the National Institute of Health (NIH) that has identified beans as having a positive role in cancer prevention.

Budget

Position	Basic cost	Cost, assistants	Cost, technicians & workers	Operations	Institutional support	Overhead	TOTAL
Breeder, Colombia	150,000	120,000	120,000	160,000	121,000	73,810	744,810
Breeder, Uganda*	150,000	60,000	40,000	150,000	88,000	53,680	541,680
Breeder, Malawi*	150,000	60,000	40,000	150,000	88,000	53,680	541,680
Molecular biologist	150,000	120,000	30,000	140,000	96,800	59,048	595,848
Bioinformatician (0.25)	38,000	45,000		10,000	20,460	12,481	125,941
Pathologist	150,000	60,000	60,000	60,000	72,600	44,286	446,886
Virologist (0.5)	150,000	30,000	30,000	40,000	55,000	33,550	338,550
Physiologist**		90,000	60,000	110,000			260,000
Postdoc, physiology	80,000	30,000	10,000	50,000	37,400	22,814	230,214
							3,825,609

* Positions are currently financed by SDC, Switzerland, and GAC, Canada, with partial operational support.

** Position is expected to be funded by BMZ, Germany, without operational support.