3.14Broadening the genetic base of nature-positive production systems

a. What, in brief, is the solution?

The relatively narrow genetic base underpinning many of today's agri-food systems makes them vulnerable to climate change and limits dietary choices and livelihood opportunities of stakeholders. A rich source of crop biodiversity has been assembled at genebanks around the world during the last half-century. This resource has yet to be systematically deployed at scale to broaden the genetic base of agri-food systems for reasons such as (1) the scarcity of information available for many genebank accessions, (2) a perhaps too exclusive focus on genetic-improvement programs as the principal genebank users, and (3) inadequate tools for effective two-way communication between genebanks and their clients. We propose to rethink and broaden the role of genebanks by reaching out to technology innovators to enrich collections with more actionable information and engaging with a broader range of genetic value chain actors through digital-networking tools to better understand and address their needs. Over time, this should lead to a more systematic testing of crop genetic resources by a broader range of actors to broaden to genetic base of nature-positive production systems.

b. What was/were the source(s) from which this solution emerged?

The idea to encourage a broader use of crop genetic resources for food production has led to the decision by the Alliance of Bioversity Intl. and CIAT to build Future Seeds, a 21st-century genetic-resources hub for tropical food systems based in Colombia.

c. What problem is it trying to address within food systems?

The vulnerability of agri-food systems to climate change; the need to maintain/increase per-ha yield to respect planetary boundaries; the urgency to promote more diverse and nutrient-dense diets better aligned with human physiology; and the pressing need to create more income opportunities for disadvantaged agricultural communities.

d. Why is addressing that problem important for achieving the goal of your ACAI?

The genetic base of crops substantially determines the flexibility, adaptability and robustness of agricultural production systems when it comes to meeting challenges such as climate change or diet-related chronic diseases.

e. How can this solution address that problem?

Crop biodiversity can be used in a variety of ways, including (1) a more effective deployment of genetic diversity in the improvement of 'mainstream crops', (2) 'off-the-shelf' deployment of traditional varieties or landraces with desirable traits, (3) diversification across a broader range of currently underutilized or neglected crops, and (4) fast-tracking the domestication of new crops. All four of these impact pathways (IP) critically depend on information about features of crop genetic resources, such as the presence of desirable traits like disease resistance or heat tolerance (IP 1, 2, 3), traditional knowledge about uses and traits (IP 1, 2, 3), and the genetic makeup and relationships among germplasm materials (IP 1, 4). The *de novo* domestication of novel crops based on knowledge about the molecular events that led to the domestication traditional crops (IP 4) has only recently become a possibility (Tassel et al. 2020). To this date, IP 1 has probably been the dominant impact pathway for many crops, particularly those with long breeding histories.

A common denominator (and current bottleneck) of all four impact pathways is the limited availability of actionable information linked to genetic resources. Technology advances in the areas of DNA-sequencing, image-based phenotyping, robotics and machine learning offer opportunities for characterizing genetic resources at an accelerating pace and decreasing cost. On the other hand, COVID-19 has accelerated a

trend towards digital social networking, which is empowering people to assemble virtually to promote common interests. Although agricultural citizen-science tools such as ClimMob already provide platforms for somewhat related crowdsourcing purposes (Van Etten et al. 2019), Decentralized Autonomous Organizations (DAOs) which are governed via tokens on public blockchains owned by community members, may emerge as a particular powerful organizational model for men, women and young farmers and other genetic-value-chain actors to gather and promote agreed-up research priorities or policy measures.

Genebanks, sometimes considered as mere 'seed warehouses', should stay abreast of these developments. They should proactively attract technology innovators to better characterize their collections and use digital communication channels and platforms to more effectively reach out to emerging networks of germplasm users such as farmer organizations, breeders, seed companies, nutritionists, 'foodies', etc. In this way, genebanks such as the new Future Seeds genetic-resources hub in Colombia, which was explicitly designed to support a broader deployment of genetic resources, could more effectively identify and make available genetic resources that address the needs of a broad variety of germplasm users, thereby becoming a driving force to 'bio-diversify' production systems.

f. Why does this solution align to the definition and criteria for a 'game changing solution' developed by the Summit?

New funding would be required for genebanks to better characterize germplasm collections and to more proactively engage with germplasm-user networks through novel digital social networking tools and platforms. Genebanks are situated in the upstream part of genetic value chains. The potential multiplier effect on downstream actors, therefore, could be substantial, and comparatively small investments could create large returns, albeit not immediately. Over time, the funding required is likely to decrease as per-unit costs for characterizing genebank accessions are bound to decrease as technologies advance.

g. What is the existing evidence supporting the argument that this solution will work, or at least that it will achieve the initial outcomes described above?

There are numerous examples demonstrating the use of crop genetic resources to improve mainstream crops (Bailey-Serres et al. 2010), to identify 'off-the-shelf' landraces that outperform mainstream varieties (Mancini et al. 2017), and to diversity cropping systems, for example by incorporating cash crops (Feliciano 2019). Also, proof-of-concept work has demonstrated the feasibility of fast-tracking *de novo* domestication of new crops using gene-editing (Tassel et al. 2020).

h. What is the current and/or likely political support for this idea?

Several genebanks have started characterizing their collections at greater depth, both on a genetic and phenotypic level. However, the role of genetic data or Digital Sequence Information (DSI) in the context of Access and Benefit Sharing (ABS) is subject of intense discussions between the Global South and North (Hiemstra et al. 2019) and could potentially derail efforts to expand the 'digital dimension' of crop genetic resources to encourage their broader use in agri-food systems.

i. Are there certain contexts for which this solution is particularly well suited, or, conversely, contexts for which it is not well-suited at all?

Marginal and more heterogeneous agroecosystems may require more context-specific, non-standard crop germplasm and may benefit most from a broader range of genetic options to test and choose from.

j. Who are the key stakeholders to be further involved in the process of developing and refining the solution idea?

International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)*,* CGIAR Genebank Platform*,* CGIAR Big Data in Agriculture Platform*,* Seeds 4 Needs project*,* Word Farmers' Organisation*,* Crop-specific seed system networks such as PABRA*,* SeedSystem.org

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