ICRISAT Genebank Review 2020

Programme: Genebank Platform

Genebank reviewed: ICRISAT, Patancheru, India ICRISAT Regional stations at Niamey, Niger, and Bulawayo, Zimbabwe (Sept 2019)	**Site visit Dates:**	2-6 March 2020
	Review report Date:	20 April 2020
	Centre and Crop Trust responses:	18 September 2020
Genebank Manager	Dr Vania Azevedo	
Review Panel	Dr Brigitte Maass	
	Dr Bruce Pengelly	
Crop Trust staff	Charlotte Lusty	

No.	Observation	Recommendations for clearance	Due date	Responses
1	2 Major observations	Health and Safety: a. Install an emergency exit from the offices/ laboratories and seed stores as a matter of priority. b. Undertake a comprehensive analysis of risks associated with the recent switch to use of machinery in threshing and cleaning seeds in the genebank and implement changed practices to protect casual and non-casual staff.	1. Urgent. 2. End of 2020.	ICRISAT: Agreed. (a) Emergency exit from the offices/ laboratories and seed stores will be installed in consultation with Farm and Engineering Service (FES) and staff will be trained for emergency evacuation. Due to the COVID-19 crisis, lockdowns and restrictions in movement, we expect that a reform will be possible to occur around March 2021. (b) Risks associated with the new threshing machines are being evaluated and appropriate risk mitigating actions are being implemented and monitored. To be completed by September 2020. Crop Trust: Agrees with both recommendation and response.
2	1 Major observation, 2 Minor observations	Implement the safety duplication of all ICRISAT mandate crop species to be placed in other CGIAR centres (ICARDA, CIAT, IITA). Coordination with NBPGR is required in advance and throughout implementation to ensure timely processing of the seed shipments.	End of 2021.	ICRISAT: Agreed. • We recently updated the agreements since we now have a new DG. In CIAT, the decision to finalize genebank construction has been delayed, given the anticipated financial impacts of COVID-19, so they cannot sign the agreement yet. We are following up with IITA and ICARDA. The COVID-19 crisis and the restrictions in shipments and other things might delay this a bit more. • We will start the process by sending all accessions with good viability and seed quantity. Slowly we will substitute the old season seeds for fresh regenerated seeds. Once the agreements are signed, through ICRISAT management (DG and/or DDG) we will request Indian government approval. This may take a few months. We expect that we can at least start the shipments by December 2020. By the end of 2021 we will be able to achieve around 70% since we had to reduce field regeneration and seed lab monitoring due to COVID-19 crisis.

				Crop Trust: Agrees with the recommendation and understands the current situation may have slowed down progress. It will be wonderful to have achieved 70% safety duplication by the end of 2021.
3	See regional genebank review 2019 (Report attached as Appendix 1)	With other relevant CGIAR centres, World Vegetable Centre and Crop Trust, develop a plan to establish a 'One CGIAR' shared long-term storage and seed testing facility in West/Central Africa, possibly at IITA Nigeria. Such a centre would enable the ICRISAT-Niamey collection to be held in the sub-region of origin in a genebank that meets international standards of seed conservation and health in high quality facilities and with greater capability. Seed regeneration and characterisation would need to be undertaken at a site that is suitable for ICRISAT semi-arid crop species.	Concept plan be developed with other centres by December 2020.	ICRISAT: Agreed. • Discussion on "One CGIAR genebank in WCA" already started between ICRISAT, IITA and AfricaRice. Based on the conclusion of the discussion and ICRISAT management decision, this recommendation will be implemented as indicated in work plan 2020 and 2021 • ICRISAT Niamey station is ideal location for seed regeneration and characterization for at least pearl millet and sorghum • A meeting involving CG Centers and NARS in the region is already being planned and may occur by the end of 2020. Crop Trust: Agrees with the recommendation and recognizes ICRISAT's efforts to initiate discussions with the Centres in the region.
4	See regional genebank review 2019 (Report attached as Appendix 1)	The current Bulawayo genebank should be reduced to seed unit status with particular aim of supporting the East and Southern African ICRISAT plant breeding programs, e.g. the AVISA project. All germplasm held only at Bulawayo should be sent to HQ, and ICRISAT should work with the SADC Plant Genetic Resources Centre (SPGRC), Zambia to ensure regional germplasm continues to be held in the sub-region.	Unique accessions shipped to HQ by end of 2021.	ICRISAT: Agreed. • Agreed to regenerate and send all backlogs to HQ. • Discussion will be opened with ESA region partners and based on ICRISAT management decision, the recommendation of ensuring that regional germplasm continues to be held in ESA sub-region will be implemented Crop Trust: Agrees with the recommendation. For small outfits like the Bulawayo one, there is some benefit in being nimble. Projects are opportunities to set up better seed distribution but why should they be permanent? SPGRC has the mandate in the region for longer-term conservation.
5	1 Major observation	Urgently undertake refrigeration and door seal repairs of seed storage rooms which are the subject of frequent room condition alarms.	Urgent.	ICRISAT: Agreed. • We are planning to change all the old MT and LT doors to avoid such problem, being LT the priority. ICRISAT recently approved the request for investment to upgrade/fix the LT cold rooms doors. • Our Farm and Engineering Service (FES) department has already been informed to do the same and they are already on job. • Expected to be concluded by the end of 2020. May be delayed due to the covid crisis.

				Crop Trust: Agrees with the recommendation and is pleased to see ICRISAT's rapid response.
6	1 Minor observation	Delegate staff and resources to undertake the priority research to improve the efficiency and effectiveness of the genebank's operations and its contribution to world agriculture. The priority research areas are detailed in recommendations 7, 8, 9 and 10 below.	End of 2020.	ICRISAT: Agreed. • This is already being implemented. We are reviewing all our routine activities and implementing improvements based on those analysis. Examples: long term cold rooms improvements, seed processing modernization and mechanization, seed lab reform and upgrade, development of new subsets based on the characterization and evaluation data, longevity studies (SQM/Genebank Platform and NordGen 100 years project). GIZ Molecular characterization, Heterogeneity project (Genebank Platform), improvements in field operations. We understand that more can be done, as recommended, and we are, together with the implementation of the standards, implementing more routine research to improve and optimize the genebank work. Crop Trust: Agrees with the recommendation and the response. Clearly ICRISAT is tackling numerous action points at the same time. "Delgate" may be a key word in the recommendation. We hope that the team is able to tackle these issues through careful prioritization and appropriate assignment of responsibility.
7	2 Minor observations	Investigate the potential risks associated with distributing core and mini-core collections of accessions (see Distribution and User Satisfaction Area in the Review Checklist).	End of 2021.	ICRISAT: Partially agreed. • We distribute core or mini core diversity representative subsets when requested specifically. We also supply other accessions that are not in core/mini core collection based on the previous characterization and evaluation data generated by ICRISAT and NARS partners. Currently we are focusing on developing thematic subsets for different traits to enable distributing other diverse accessions as new subsets. In the past three years (2017-2019) we answered to 185 requests, being 51 of those subsets requests (46 mini core, 26 core, 7 composite collection and 2 reference set). The remaining 134 requests were not mini core or any other subset. Risk of distributing only subsets, while a potential risk, is low, since only 27.5% of the requested involved all kinds of subsets. Also, many times, other accessions are also requested with the subsets.

				Crop Trust: An interesting recommendation. Whether looking at risks or other information, tracking and critically analysing distributions, especially where requests are relatively high (as appears to be the case with mini-cores) is relevant to developing a more proactive strategy for use of the diversity in the collection. There are multiple benefits in using user surveys and tracing mini-core use. Also something to consider for an impact fellow when the opportunity arises.
8	5 Major observations, 1 Minor observation	Undertake a comprehensive analysis of the crop wild relative (CWR) collections with the aim of identifying priority, closely related species that should be conserved long term at ICRISAT, those warranting further diversity/ acquisition, and those that should be discarded altogether from the collection at ICRISAT because they are too remote from the crop species. The analysis should include consideration of relevant collections being reliably conserved in and made available by national and/or other international genebanks.	End of 2020.	ICRISAT: Agreed. • The primary, secondary and tertiary genepools are important to be conserved for all the 11 crops. • As suggested, we will make efforts to fill the diversity (taxonomical) gaps to enrich the genepools. • Considering the history of requests (if no request received), the highly distant genera particularly in pigeonpea (Rhynchosia – 303 acc., Flemingia - 16, Dunbaria - 12, Eriosema – 7 and Paracalyx - 3) and sorghum (Sorghastrum rigidifolium - 6) will be archived in long-term, and/or with support, they can be moved to other genebanks considering their mandate. • The field genebank of sorghum and pearl millet are the secondary and tertiary genepools, and *Arachis glabrata* are reported as sources for multiple disease resistance (rust, leafspot and viral diseases) and has high fodder potential. • During the past three years (2017-2019) we answered to 14 external requests of wild relatives and other dozens of internal requests. • Analysis to be concluded by end 2020. Crop Trust: Agrees with the recommendation. The new framework for dynamic curation, we hope, will make such strategic decisions easier.
9	7 Minor observations	Determine the key weaknesses in the processes from field to storage for all crops (including in the greenhouse and post-harvest dormancy), and enhance processes and equipment to improve the quality/ viability of harvested seed.	Report and map out changes in operations by end of 2020.	ICRISAT: Agreed. • We are in the process of implementing mechanized seed processing facility to reduce the time taken from harvesting to storage, including shade drying, threshing, cleaning, testing and transfer. A complete analysis regarding time, quality and cost is planned to be done once all improvements are implemented • As suggested, seeds harvested from glasshouse will be moved on the same day to short-term facility, and once harvesting is completed, then seeds will be processed to cold room. Glass house facility improvement is also planned (temperature, humidity and light control)

				• Experienced staff and quality manger are in-place to monitor the safety of personal and equipments, and quality of seeds. We have already developed instructions for handling and operating most of the equipment. • Being implemented. Report to be completed by end 2020 Crop Trust: Agreed. The changes already brought about at ICRISAT are striking. With these improvements and monitoring we look forward to seeing positive impacts on the viability of the seed.
10	1 Major observation, 3 Minor observations	Medium-term storage: a. Assess the benefits of different container options and how they can be used in MTS with special focus on management of relative humidity and improved seed longevity. b. Research should consider whether (or not) all accessions have to be stored in MTS as well as in LTS.	End of 2021.	ICRISAT: (a) Partially Agreed • We have already checked few accessions in MTS that were stored in cans ten years before with initial 8% moisture content and were never distributed/opened. We observed a decrease of ~1% moisture content in all of them which indicates that the environment inside the cans is not causing any increase in moisture, actually it is the opposite. • We, however, are developing a more scientific experiment, as recommended. Will test the feasibility of existing cans for seed storage in MTS and if any problem related to increase in seed moisture content of the stored seed is found, we shall explore other options for seed storage in MTS. • Complete comprehensive experiment requires more time, but we will generate significant date by the end of 2021. (b) Agreed. • Entire germplasm of 11 crops will be assessed statistically for similarity/relatedness considering passport and characterization data, and plan will be developed to phenotypically validate them, and archive possible duplicates in the long-term only. To be concluded by end 2021 with available data. More complete analysis can be done if new bilateral projects are approved for genotyping the genebank. Crop Trust: Agrees with the recommendation and highly supportive of the response. Only the empirical data will determine the best options.
11	4 Minor observations	Adopt the concept of seed numbers as being the primary measure of seed quantity and include seed number values in the database, to determine whether thresholds are met, and as a	End of 2020.	ICRISAT: Agreed. • We have already assessed seed numbers for legumes as these are more critical crops because of large seed size. We have identified critical accession based on seed number and regeneration plan is in-place for

		driver of conservation and management decisions.		achieving the standard. Concept is already being implemented for all crops. Regeneration to reach the standards for critical accessions will take longer, specially now with the covid COVID-19 crisis and significant reduction for a period of time in field activities. Crop Trust: Agrees with the recommendation and is pleased to see it is already being addressed.
12	3 Major observations, 6 Minor observations	Analyze the flow of germplasm during post-entry quarantine and acquisition with special reference to the roles of the key partners (NBPGR, ICRISAT-GHU and the genebank) in order to avoid both the loss of accessions and the genetic integrity of accessions as much as possible. The analysis, jointly developed with all partners, should focus on current seed treatments, options for viability testing before and after treatments, and alternative seed treatment options and be framed as a learning exercise to modify current practices where appropriate.	Improved processes in place by end of 2021.	ICRISAT: Agreed • We have already started having regular meetings with our GHU staff and are trying to improve and modify the current practices and procedures of germplasm acquisition and release in collaboration with NBPGR. • More emphasis is on removal of bottlenecks in germplasm acquisition and release so as to ensure timely and smooth flow of germplasm without losing accessions. • Improvements to be implemented by end of 2021 Crop Trust: This is an important recommendation and potentially complex to resolve. We are ready to provide support at the highest level should it be useful.
13	2 Minor observations	Fill passport and characterisation data gaps in the information system by checking diverse sources (national and international) including donor institutes for passport data.	Improved PDCI by end of 2021.	ICRISAT: Agreed. • Checking gaps in the passport data is a routine process and gaps will be filled by checking diverse sources including the donor organization, as well as other databases. • All the characterization data are generated at Patancheru location, and filling the characterization gaps is also a routine process if any data point are missing. This is already part of our routine work • As suggested, we will assess the completeness of data points of all the accessions, and will update missing data points. • In silico work will be immediately started. Field work however had to be reduced due to the COVID-19 crisis. • PDCI will be improved by end of 2021. Crop Trust: Agrees with the recommendation and the response.
14	2 Minor observations	Embark on a program to identify duplicates in the collections based on passport and characterisation data with the aim of removing duplicates from the collections	Remove/archive duplicates by end of 2021.	ICRISAT: Agreed • Entire germplasm of 11 crops will be assessed statistically for similarity/relatedness considering passport and characterization data, and

		(both primary collection and safety duplicates).		plan will be developed to phenotypically validate them, and archive possible duplicates in the long-term only. • To be concluded by end 2021. Crop Trust: Agrees with recommendation and response.
15	2 Major observations, 4 Minor observations	Train and encourage relevant genebank research and technical staff to upload and extract data from the genebank's information management system to avoid the current bottlenecks, which are created by having all entries and enquiries funneled through the data manager. An improved, simplified GRIN-Global data management system is already overdue with no firm delivery date. Therefore, ICRISAT should make whatever adaptations are required to their current system, and prioritise training of key staff to enable them to make maximum use it.	End of 2020.	ICRISAT: Agreed • We are in process of developing New Genebank information management system (GIMS). It will provide access to identified genebank staff to extract data. • Parallelly we are also working to streamline GRIN-Global. • GIMS to be concluded by end 2020. GRIN-Global only by end of 2021. Crop Trust: Agrees with the recommendation and the response.

Introduction

Commissioned by the CGIAR Genebank Platform, the review was carried out by Dr Brigitte Maass, a private consultant, scientist in agrobiodiversity, and former curator in the CIAT genebank and interim manager of the ILRI genebank, and Dr Bruce Pengelly, a private consultant with national genebank and institutional management background. The reviewers were supported by Charlotte Lusty, Coordinator of the Genebank Platform, Global Crop Diversity Trust.

The main phases of the review were short two-day visits to each of the ICRISAT regional genebanks at Niamey, Niger, and Bulawayo, Zimbabwe in September 2019, and a one-week, more comprehensive visit to the ICRISAT-HQ genebank at Pantacheru, Hyderabad, India (2-8 March 2020).

In addition to the discussions with Dr Vania Azevedo (Head of Genebank) and key genebank staff, the reviewers met with Dr Peter Carberry (DG ICRISAT) and Dr Kiran Sharma (DDG-Research ICRISAT) at the commencement of the review and again during the final meetings of reporting back to the genebank team. They also met with Dr Pooja Bhatnagar-Mathur (Theme Leader, ICRISAT); Dr Rajan Sharma (ICRISAT-GHU); and Dr B. Sarath Babu and Dr Kamala Venkateswaran (NBPGR-Hyderabad). Furthermore, they conducted a conference call with Dr Kuldeep Singh (Director NBPGR-New Delhi) and Dr Pratibha Brahmi (Officer in Charge of Chermplasm Unit, NBPGR-New Delhi).

The review was technical in nature and included a validation and review of the standard operating procedures (SOPs) for key operations, which were provided ahead of the visit along with other key documentation such as a self-assessment, previous review (2014), annual reports, a technical summary from the Genebank Platform online reporting tool (ORT), and distribution and acquisition data. A summary of the results of a user survey conducted by the Genebank Platform/Crop Trust assembled the feedback from 112 recipients of germplasm over the past 8 years (2012-2019).

A significant component of the review was inspection of the field, glasshouses, laboratory and storage facilities and, where possible, observation of practices as they took place. For example, the reviewers were able to observe post-entry plant quarantine operations in the isolation field, seed regeneration including harvesting of seed in glasshouses and the field, seed threshing and cleaning, pollination control in outcrossing pearl millet accessions, and glasshouse/shadehouse maintenance of sterile and shy-seeding accessions of crop wild relatives (CWR). The germplasm health unit facilities were visited and the unit's staff interviewed.

At all stages of discussion, the reviewers had the opportunity to explore the live GIMS (Genebank Information Management System) database with the help of the database manager, and extract passport, characterisation and seed inventory data from the GIMS as well as independently online.

Findings

Detailed observations and comments associated with the full range of activities of the genebank are provided in the attached checklist. There are 33 minor observations and 15 major observations, resulting in several suggested improvements and 13 recommendations. The overall findings were presented to ICRISAT genebank manager, the ICRISAT DG, DDG-Research and genebank staff on the final day of the review.

Under the new head of genebank, staff has been recently reorganized and responsibilities have been delegated further over the full hierarchy. Various trainings have been recently conducted, incl. staff from the Regional Centers.

The review found that Dr Azevedo, who has been the Head of Genebank for just 2 years, and her senior genebank science and technical team are responding impressively to a wide range of issues related to historical events, habits and processes that have been identified as requiring revision and correction. Significant progress has been made in filling gaps in characterization data, in addressing the backlog in regeneration and viability testing, and in key processes including a significant change in seed processing (e.g. threshing and cleaning) applying modern machinery for faster processes and more reliable quality control. A constant theme in the presentations from the Head of Genebank and from the discussions was that deficiencies in many areas of data, facilities and operation were recognised by the genebank team and that actions are either being carried out or are being planned to overcome some of the identified deficiencies. The progress has been achieved in part through a reorganization and allocation of responsiblites of the senior science and technical team – and that is applauded. In recognition of this progress, the reviewers assessed a number of issues as Minor observations in the Review Checklist, although without this progress, they would normally be considered Major observations.

The review recommendations are wide-ranging, from issues of how best to integrate the sub-regional ICRISAT genebanks, to seeking science-based solutions to improving genebank operations and the genebank's capacity to contribute to crop improvement. There are recommendations directly linked to SOPs and, certainly amongst the most important, a recommendation related to health and safety.

Strategic issues

The issue of the African regional genebanks, their future roles and their alignment with ICRISAT-HQ is especially important for efficient and effective conservation of the ICRISAT mandate crop collections and for crop improvement in sub-Saharan Africa and globally. There were strong arguments put to the reviewers by CGIAR scientists based in West Africa, national scientists and the private sector that this large and rapidly changing sub-region requires its own genetic resources centre. This view was strengthened by the argument that, for some species, a significant proportion of the world's germplasm originates from West Africa. The reviewers were sympathetic to that view and believe that a redesigned CGIAR

('One CGIAR') offers an opportunity to build a genetic resources centre of excellence in the sub-region that serves multiple crops from rice, vegetables, cowpea, to sorghum, millet and groundnut. It is the reviewers' position that, only through such a single well-resourced centre, the CGIAR could provide (afford) the quality of services, especially in relation to seed health and internationally acceptable phytosanitary protocols.

The recommendation for the genebank in Bulawayo is to terminate its genebank function. The reasoning for this is that the centre holds far less unique local germplasm, and that it is already poorly resourced in terms of facilities and staff (e.g. no LTS, no germplasm health unit, no database, no experienced genebank staff). In addition, the SADC Plant Genetic Resources Centre in Lusaka, Zambia, is the dedicated regional genebank that, with support, might be able to fulfil the sub-regional role. The seed storage and seed processing facilities at Bulawayo remain important to ICRISAT, especially as Eastern and Southern Africa plant breeding programs are being moved to Bulawayo for the AVISA project. That very large breeding program will require the sorts of facilities already in operation in Bulawayo.

For both the Niger and Zimbabwe ICRISAT stations, all unique germplasm should be backed up at ICRISAT-HQ. Most importantly, the regional genebanks in whatever form they take must be transitioned to integrated components of the ICRISAT genebank with uniform data management, conservation and management protocols, and not more or less separate entities as they have been in the past. The current Head of Genebank is making impressive progress towards such integration. Nevertheless, the reviewers consider that this issue had been brought up in the previous review 5 years ago and despite recommendations being made then, the lack of integration between HQ and the regional genebanks has continued to be a significant failure of ICRISAT delivering on its obligations for conservation of its mandate crops.

The lack of first level safety duplication of the collection in another genebank or genebanks outside India is a major gap in the genebank's practice and is a significant risk that must be addressed quickly. Although almost 90% of germplasm is now safety-duplicated at the Svalbard Global Seed Vault (SGSV), efforts to get agreement from other parties, on where else the collection could be conserved, have so far failed to progress to the actual shipment of seeds. The current plan for first level safety duplication in three CGIAR genebanks is sound and must be a priority for implementation in the genebank over the next 12 months.

Towards operational efficiency

The reviewers concluded that there are a number of research opportunities for the genebank team that will have direct benefit to the future operational efficiency of the genebank. These range from the review's recommendations on crop wild relatives, to those on viability/longevity and closer examination of passport data and consequent identification of duplicates. The genebank is a complex facility, has a large collection, deals with 11 crop species, operates on two continents and is expensive to run. It is imperative that the genebank's science leadership prioritise its research activities with an eye to both new science, and better practices for conservation and utilization. The priority to transition to the next "user-friendly" version of GRIN-Global as quickly as possible sits alongside these research priorities. This cannot be done by ICRISAT alone. The reviewers believe that the slow rate of development of a user-friendly GRIN-Global version led by the Crop Trust is a major impediment to efficient genebank operation.

One of the most pressing areas to be considered and tested are the medium-term storage (MTS) storage conditions and the processes involved. The reviewers agreed in principle with the overall concerns expressed by Dr Fiona Hay in 2017 regarding the storage of seed in the MTS. Dr Hay questioned the use of tins that cannot be assumed to be hermetically sealed and the conditions for relative humidity (RH) in the MTS rooms, but accepted that it was problematic to change the containers given the size of the collection. This review considered the same question, but suggests that the issue of MTS storage conditions needs to be

resolved with some urgency and should involve taking a different approach to control relative humidity.

In more detail, the MTS seed is now dried in the field or in the drying room to about 8% MC depending on which crop, and then temporarily moved to an environment of ca 25°C and 40% RH (in STS), where seed is put into containers, which are then placed in MTS rooms. However, our calculations (Figure 1) suggest that the ambient air at ~25°C and 40% RH has 9,200 mg/m^3 moisture content, which, when moved to the 5°C room, means that the air in the container would have a RH approaching dew point (>90%), assuming no exchange of air between inside the container and the room air. Storing seed at 5°C and >90% RH is inappropriate and will affect seed longevity negatively. This situation is even more deleterious when containers are only partly filled with seed (more air and, hence, more moisture). The reviewers agree with Dr Hay's observation that it would be difficult to change all MTS containers, but we consider that, if the lids could be perforated or exchanged with lids that enabled air to equilibrate between inside the container and the ambient environment, then the MTS seed would benefit from the dehumidified air. It would be even better if the ambient RH could be lowered below 30% RH.

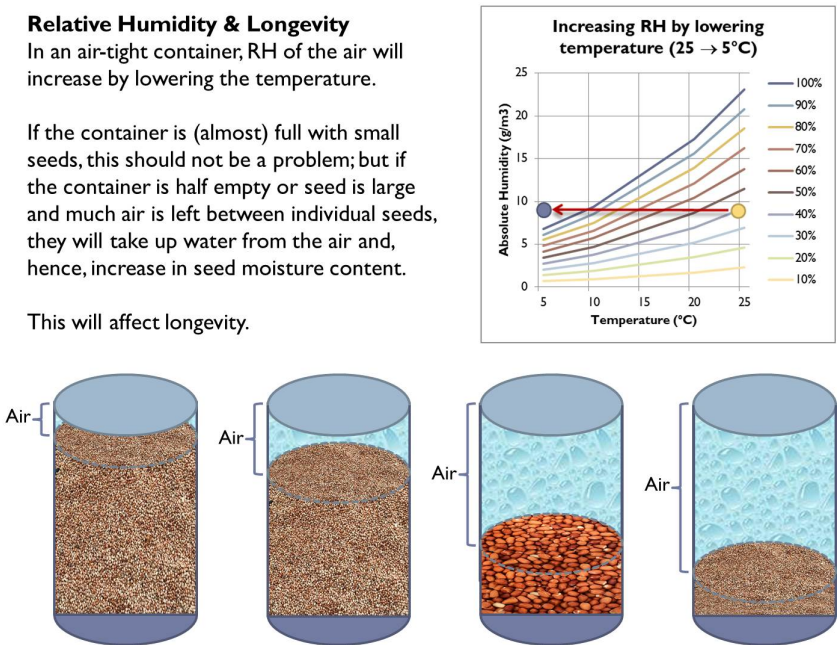

Figure 1. Illustration of the possible effect of cooling down relatively warm temperature with a certain relative humidity (RH) in airtight seed containers.

A further area where greater efficiencies can be achieved is by aligning seed regeneration practices and field plot size with expected requirements, particularly expected distribution frequency. The goal of regenerating accessions due to poor viability alone (accessions that are rarely distributed) should be to achieve a harvest that meets, but does not exceed, the minimum required for conservation. In most cases that goal could be achieved by smaller plots than are currently being used. Such a practice would be in accordance with the FAO Genebank Standards (2014: pp. 36-37), which state that "*high seed numbers are not needed for rarely requested accessions or species*". Conversely, larger-sized plots should be used for frequently distributed accessions so that their regeneration frequency is minimized.

Whatever the reasons for regeneration, all harvested seed should be dried in the best possible way and used to meet the need to have the desired seed numbers in LTS as the first priority. Seed going to MTS for ready-distribution must always be the second priority. This is the reverse of current practice where allocating seed to MTS is prioritized.

The reviewers recognize that differentiating accessions has already been applied at the ICRISAT genebank for some time by determining core and mini-core collections as well as other trait-based subsets. Further commonly agreed principles of “dynamic curation” should be applied. For example, once duplicates are identified, these should be destroyed or archived, whichever is appropriate. The genebank should have clear procedures on how different germplasm is managed depending on the priority of particular accessions.

Implementation

The timing of this review (2-8 March 2020) occurred at the beginning of the rapid spread of the COVID-19 pandemic across Europe, South Asia and beyond. The lockdown in India has been extended until 3 May; but it is expected that all or part of the national lockdown may well continue beyond that date. In late March, the ICRISAT genebank was reduced to a skeleton staff along with other ICRISAT units.

Given the current state of the pandemic in mid-April 2020, it is impossible to provide meaningful target dates for implementing recommendations, especially those recommendations seeking more or less immediate implementation. It can be expected that the ICRISAT genebank team will face considerable challenges associated with the pandemic over the next 12 months at least. The reviewers are aware that a number of genebank staff has volunteered to remain on campus during the time of the lockdown, when travel across India is very restricted. Those staff who have volunteered to put the function of the genebank at such a high priority in their lives have to be applauded and this occurrence only confirms the reviewers’ perception that Dr Azevedo and her team are exceptional in their dedication to the cause.

The reviewers thank Dr Azevedo and her team for their hospitality and their open and frank discussions. They hope the comments and recommendations that they have made assist them in improving the conservation and utilization of the ICRISAT mandate crops that are so important to agriculture and livelihoods in the semi-arid tropics.

Bruce Pengelly and Brigitte Maass
16 April 2020

Appendix 1: ICRISAT- regional genebanks in Niger and Zimbabwe

Review September 2019

Bruce Pengelly and Brigitte Maass

Introduction

This report describes the findings of a technical review commissioned by the Crop Trust on behalf of the CGIAR Genebank Platform of the ICRISAT Regional Genebanks in Sadore, Niger and Bulawayo, Zimbabwe. It was carried out by Bruce Pengelly and Brigitte Maass.

The reviewers were provided with a limited description of the processes in place in either location, since standard operating procedures are not yet documented, and with the ICRISAT Regional Genebank reports by the Crop Trust 2012-2018. Two-day visits were made by Drs Pengelly and Maass to each location, accompanied by the ICRISAT Genebank Head, Vania Azevedo, who is based in Patancheru, India, and by Charlotte Lusty in Niger.

Over four days, the reviewers toured the facilities and fields and interviewed the teams responsible for the genebank operations, and also with ICRISAT scientists and a few genebank users from the host countries. The reviewers gratefully acknowledge the cooperation and hospitality of the ICRISAT staff throughout the review.

It is our impression that the ICRISAT regional stations in Niger and Zimbabwe have held crop collections for several decades but have received little dedicated support for genebank operation until the beginning of 2012 and the initiation of the Genebanks CRP. The three stations (including one in Nairobi, Kenya) conserve collections of less than 20,000 accessions and function relatively independently of each other and ICRISAT-India in support of breeders and other scientists. Since facilities and operations have never been of the standard of an international genebank, the capacities of these genebanks are limited. The review follows up on visits undertaken on behalf of the Crop Trust in 2017, which provided suggestions to ICRISAT to upgrade operations and resulted in the development of a draft Sustainability Plan intended to provide a vision of the longer-term roles of the regional stations.

The current reviews aimed to answer the following questions:

1. Does the genebank currently have the staff capacity and facilities to provide an acceptable level of operation to ensure medium-term conservation and/or long-term conservation and distribution?
2. Is the collection value, size and use of a level to justify the existence of an independent genebank (given the context and existence of other Genebanks in the vicinity)?
3. Are there immediate issues that need to be addressed that, if not dealt with, would lead to (1) irrevocable loss of diversity or (2) major negative impact on reputation of ICRISAT.

Findings

1. Does the genebank currently have the staff capacity and facilities to provide an acceptable level of operation to ensure medium-term conservation and/or long-term conservation?

Niger

The genebank is doing a reasonable job in conservation, although there are questions about processing, especially from field to store in the genebank (evidence of loss of viability along the way). There is also a need to look more carefully at seed numbers, which are often well below what is required. Possibly the most challenging barrier to meeting FAO requirements is that of seed health. Most material has been sent for safety duplication to ICRISAT-HQ in India, except for most recent collections. The team has trained staff that are dedicated and linked to breeding programs and the regional seed industry at least in Niger.

We believe that the staff and operations in Niger are sufficient for medium-term storage, but neither for long-term management of unique accessions nor for the distribution of seed outside the country, at least not

without solid phytosanitary controls. The cost of bringing ICRISAT-Niger up to an international standard in seed health would be prohibitive and an alternative approach is needed.

Zimbabwe
There is no long-term storage, and medium-term storage is only running at 10°C and 30% RH. Most material ('unique accessions') has been transferred to ICRISAT-HQ for safety duplication, but still some backlog exists (2,303 accessions). There is a lack of seed health infrastructure and capability. The staff number is small. Despite the likelihood of increased demand for germplasm, it would be costly and difficult to raise the Bulawayo genebank to a higher standard as expected of a CGIAR genebank, and according to FAO standards.

2. Is the collection value, size and use of a level to justify the existence of an independent genebank (given the context and existence of other Genebanks in the vicinity)?

Niger
In the absence of strong national genebanks in the WCA region, it appears that the ICRISAT-Niger genebank is especially important in the region. This is more so in a sub-region where climate change is already impacting farming systems and where new invasive potential pests and diseases are likely to be prevalent given the region's exposure to increasing inter and intra continental trade. There are some excellent examples at ICRISAT-Niger of how the germplasm is being used by breeders to address challenges (fall army worm, downy mildew, head miner, striga, sorghum midge, nutrient density). These breeding and pre-breeding programs demonstrate the advantage of having material at hand in the sub-region. The access of material from ICRISAT-HQ in India is a significant problem. WCA "ownership" is an issue that has to be considered in any decision making.

Supply of material from ICRISAT-Niger to regional seed industry does not (might not) require the same health protocols, but this role of supply of elite material within the region is one that seed industry highlights as a priority of the centre. This might require a discussion with CORAF/WECARD and input from the industry. Certainly, this is not a genebank function and may not (probably does not) fit into the Crop Trust funding envelope.

Zimbabwe
Established in the 1980s, the station holds a large number of regional Southern Africa germplasm of the ICRISAT mandate crops. The most important being sorghum, pearl millet and finger millet. Less important and much fewer accessions of groundnut. Total accessions are c. 12,000. Major factors influencing the future of the genebank:

1. Existence of a functional SADC genebank in Lusaka, Zambia (SPGRC), which has capability to provide LTS.
2. B&M Gates Foundation-funded AVISA project resulted in moving ICRISAT-Kenya plant breeding capability to ICRISAT-Zimbabwe (5-year project) – increase in demand.
3. Political (Zimbabwe) "demand" that the ICRISAT genebank continues to be in Bulawayo.
4. Risk perceptions in accessing germplasm from ICRISAT-HQ because of Indian government tardiness in processing.

Consideration has to be given to the role of this station. It seems to have a host country demand that it keeps operating, but most of its activities are Zimbabwe-focussed (there are exceptions such as Namibia).

3. Are there immediate issues that need to be addressed that, if not dealt with, would lead to (1) loss of diversity or (2) negative impact on reputation of ICRISAT.

Niger
The ICRISAT-Niger station should consider focusing on medium-term conservation of a limited number of subsets and materials relevant for immediate use and evaluation in the region. In this context, the reviewers have highlighted a number of improvements below that should be carried out with a clear idea of the intended scope of the collection and the potential delegation of conservation or other activities to partner genebanks.

1. Given that a significant part of the collection appears to be held as samples below thresholds for seed number and viability, regeneration is needed ASAP but this should be done in a prioritized manner and in coordination with ICRISAT-HQ.
2. The roles of the ICRISAT-Niger genebank as a genebank should be carefully distinguished and heightened as opposed to the support role to sub-regional seed industry. Conservation activities should be a priority for a genebank where relevant, but targeted support to breeders and industry may be appropriate if the need is clearly identified and financial support is provided from other sources than the Genebank Platform. More effort is required in carrying out basic genebank management functions and, in particular, in interrogating the status of the collection and putting in place measures to ensure appropriate conservation measures are implemented.
3. Better practices from field to genebank have to be a high priority. Thresholds for seed number and viability need to be reviewed and clearly maintained. Reasons for failing viability should be determined ASAP. Practices need improving to avoid any risk of harvested seeds being exposed to adverse temperature or moisture for extended periods, even for a weekend. Train staff on the basics of seed physiology.
4. The database has passport and characterization data and, while not all accessions have been characterized, there is enough information available to make real progress in reducing numbers and workloads and inefficiencies. A critical review of the collection should also inform needs for future collecting, especially of sorghum.
5. Data from germination testing should be maintained for all tests over time so viability loss can be tracked. The database should be modified to accommodate this.
6. ICRISAT needs to take immediate steps to develop at least some phytosanitary capacity to test and/or treat seed for national and sub-regional distribution. High-risk distributions need to be identified and avoided. Collaboration with IITA is required here.
7. The genebank conserves safety duplicates and accessions on behalf of other institutes, in some cases only in MTS. The viability of these duplicates is unknown, and it is not clear whether these collections are being actively managed anywhere. ICRISAT should enter into conversation with the institutes involved and determine a plan to look at the viability of the duplicates and to place them in more secure long-term conservation conditions to avoid the eventuality that it is held responsible for any losses.

<u>Zimbabwe</u>
The Zimbabwe station should consider refashioning itself fully to support breeders and researchers, rather than to carry out a conservation role under the guise of a genebank. In this context, the reviewers have highlighted a number of improvements below that should be carried out with a clear idea of the modified role of the station.

1. Activities need to be focused on the accessions that are not yet at ICRISAT-HQ in India as these are most at risk. Keep regenerating all backlog ‘unique’ accessions and make sure they are safety duplicated in LTS ASAP.
2. Discussions with SADC should be carried out to build collaboration and, especially, for clearer role definition of ICRISAT in the sub-region.
3. Duplicate samples should be eliminated. Holding multiple “lines” (=lots) within accessions will only cause greater confusion (in regeneration for instance).
4. Elaboration and/or revision of SOPs need to have a higher priority than it has now.
5. An appropriate-sized drying room should be installed adjacent to the cold room to improve drying and overcome problems associated with periods of hot and/or humid conditions.
6. Train staff on the basics of seed physiology. The apparent low viability of a large number of accessions suggests that the seed is losing viability somewhere – probably in the process of getting it into storage. Seed processing is a key issue – the process between harvesting in the field to storing in the cold room urgently needs optimization.
7. Adopting the overall institutional GIMS has high priority.
8. Seed health testing needs should be reviewed and action taken to ensure that seeds with pathogens of quarantine significance have no possibility of being distributed.

Future Direction

Niger

IITA, Africa Rice, ICRISAT, ICRAF and WorldVeg are all taking roles of genetic conservation and germplasm distribution to varying capacities in West and Central Africa. This provides an opportunity to have a networked regional genebank, where the issues of long-term storage and seed health can be managed better by a centralized facility. IITA has a genebank and a fully functional health lab in Nigeria already that deals with seed and vegetatively propagated crops (yam, cassava, and banana/plantain). Africa Rice also has facilities in Cote d'Ivoire; and WorldVeg is operating out of Benin. Given the costs, especially in having capability to undertake seed health tests, there should be one, or at most two, well-resourced CGIAR/AIRCA genebanks in the subregion that have the capacity to ensure seed is clean and well processed for long-term conservation and distribution. Given at least one agreed well-resourced genebank(s), the "support" genebanks, such as the genebank at ICRISAT-Niger, should focus on distribution and interaction with users to encourage the use of pre-selected subsets and core materials rather than on acquiring accessions for long-term conservation, hosting black box duplicates, and processing and monitoring seeds for long-term conservation.

The ICRISAT-Niger genebank should have the following priorities:

1. Making available WCA germplasm in the sub-region.
2. Making available core or mini core material available for the three main crops (millet, sorghum and groundnut).
3. Characterization of sub-regional material and update the core-/mini core collections.
4. Upgrading and maintenance of its database of passport data, seed lot inventories, characterization data.
5. Developing a formal relationship with CORAF/WECARD.
6. Continuing its role as a partner with the Ghana-based sub-regional capacity building program WACCI (West Africa Centre for Crop Improvement) on plant breeding.
7. Collaboration with partners in the region especially IITA, Africa Rice and WorldVeg so that long-term storage and seed health can be addressed better.

In conclusion, ICRISAT-Niger should be further developed as part of a networked CGIAR genebank in the WCA region and actions taken to address the immediate issues identified above.

Zimbabwe

ICRISAT-Zimbabwe needs to focus on core material for breeders for AVISA and other future projects. It is not clear that it has a role as a genebank performing a medium-term or even long-term conservation role. If all the sub-regional (or regional) material at ICRISAT-Zimbabwe has to be held in Africa for optics, then the possible networked genebank in WCA could play that role. The recently built ILRI genebank (Ethiopia), which has health labs and capacity, could be an alternative. However, this second option for LTS in Africa has the issue of Ethiopia not allowing germplasm out of the country as a potential obstacle. The third option is to ensure all the locally collected material is placed in ICRISAT-HQ and in the SPGRC in Zambia, although we have no knowledge of reliability and quality control of the latter. All of these options enable long-term security and ready availability within the region.

Senior scientists at ICRISAT-Zimbabwe discussed the potential to move beyond mandate crops, specifically, using genebank practice (collecting and characterisation) to look at other species that are important in the context of changes in land use and livelihoods in the region. *Mucuna pruriens* is a legume being used with crop species to transform a crop system into a crop-livestock integrated system. However, this neither fits within the ILRI genetic resources priorities nor in those of ICRISAT-Zimbabwe.

In conclusion, the reviewers consider that the conservation of unique materials in ICRISAT-Zimbabwe be mandated to another location with options of a networked genebank in WCA, an alternative CGIAR Centre and SPGRC as hosts. ICRISAT-Zimbabwe is refashioned to service breeders and projects with support provided by those projects rather than from the Genebank Platform.

Area	Theme	Points to review	Evidence provided	Observations	Improvement
Value of collection	Numbers	What species and how many	Report from ICRISAT staff and searches of database – extracted map from the database showing where accessions have been collected from in the sub-region in the three main species: pearl millet, sorghum and groundnut.	Pearl millet, groundnut and sorghum are the most important collections. Pigeon pea has been introduced from ICRISAT-HQ because of local demand. According to searches on the database made during the reviewers' visit and excluding safety duplicates, there are 11,755 landraces, 3080 advanced varieties or breeding lines, and 36 wild species (mostly *Arachis*). Only 4215 accessions do not have an accession number from ICRISAT-HQ in Hyderabad, India. 3582 accessions have been recently collected in the sub-region.	
	Genetic repre-sentation	Is this collection significant regionally and globally	Presentation: The collection has been built organically. Initially, material was randomly brought by breeders. The breeding lines are now mostly separated from the genebank materials. Breeders (e.g. in Kenya) are still collecting and keep the materials. There may be a need to send back regional material held at ICRISAT-HQ to ICRISAT-Niger. Information was given on a survey in the region that 7 breeders responded to.	There is a need to prioritize the collection into material that is likely to have value sub-regionally in the short/medium term – value directly or to breeders in the ICRISAT-Mali centre, and also material that might support national breeding programs in the sub-region. Also of priority is material that has been collected locally. It is probably not politic to have these materials only at ICRISAT-HQ when recent experience is that getting materials back in a timely way can be difficult. The collection is sure to have material outside these two priorities and if this material is at ICRISAT-HQ then it does not warrant local maintenance in Niger. It was also stated that some partners have collections that are not well maintained and due to upcoming retirement, there is a risk of these getting lost. But these partners have trust in ICRISAT.	Undertake prioritization ASAP – doing so will relieve the genebank of the need to regenerate material of low priority.
	Duplication	What % of material is made up of duplicates of common - used landraces	Information has not been requested, but was also not presented directly.	Almost certainly, there are large numbers of duplicates. Given how this collection has been built up, it can be expected that breeders over the years have imported the same germplasm from ICRISAT-HQ. Just as importantly, the map of local collecting of the three main species points to the likelihood that local landraces have been collected more than once.	There are needs for a dedicated program of identifying duplicates. The database has passport and characterization data and, while not all accessions have been characterized, there is enough information available to make real progress in reducing numbers and workloads and inefficiencies.

Area	Theme	Points to review	Evidence provided	Observations	Improvement
	Gaps	Is there a need for more collection - why	The ICRISAT team believed so, but gave no evidence of why it was so (no mapping of passport data). The reviewers asked for this to be done, and maps were produced from the database quickly.	Maps of collections from west and central Africa of the three species show that pearl millet has been pretty well collected across the Sahel although nothing from Cote d'Ivoire or Mauritania, and not much from northern Ghana. Groundnut collections are heavily biased from Nigeria, Mauritania, Mali and Chad; very little from Benin, Burkina Faso, surprisingly little from Senegal, which is one of the major producers of the sub-region. Sorghum is almost entirely from Nigeria and Mali, with a sprinkling from other countries.	Based on the geographic mapping, there could be a case for collecting new groundnut and sorghum germplasm. Before deciding, it is essential to look at diversity data in existence. Likely to be the case for sorghum, given limited collecting so far. Would also need to look more closely at passport data before any decision.
	Users	Who needs it now and who needs it in the future	Discussions with seed industry representatives and breeders senior management discussions (Malick and Tabo)	Has a role is supplying seed in the region after periods of unrest in various countries. The importance of the genebank elevated as there is no national genebank in the sub-region. Seed industry representatives argued that the genebank is important to supplying germplasm of elite lines of all species. This seemed to be a Niger perception rather than a sub-regional view. ICRISAT breeders in Mali and in Niger request material for their programs. There is a case for locally collected material to be held in the sub-region rather than moved to ICRISAT-HQ only. Material is being now screened for resistance to fall army worm. Evidence so far is that there is more fall army worm damage in improved varieties than in landraces. A second large active program was in resistance to sorghum midge. The sorghum core collection was not available at ICRISAT-Niger. The challenges in accessing material from ICRISAT-HQ in India are important. In the midge program material could not be accessed from India and had to be sourced from Australia. A third breeding program accessing material is the Striga resistance screening in the millet core collection – 3-4 entries show significant resistance. Other programs have been screening for resistance to downy mildew in millet – 600 lines screened in early, mid and late maturing varieties, and in screening for	The genebank is being used and is important (vital) in the sub-region. The breeding programs in the Sahel depend on this genebank and, given the tardiness of India being able to supply material, its importance is even more so. A question that confounds the issue of role of the genebank is separating its important role as a genebank, as opposed to a role as a reliable partner and supplier of elite material for industry. Certainly the centre in Niger plays an important role with the Niger and sub-regional seed industry (in some countries at least) and that is important, but it's not really the role of a genebank.

Area	Theme	Points to review	Evidence provided	Observations	Improvement
				resistance to head miner in millet – a major problem across the Sahel. Or a PhD student is screening for high iron content or other nutrient density. Perhaps just as importantly are the optics of ICRISAT-Niger not holding the material in the sub-region it has collected it there (in collaboration with national partners of course). There is some kind of "re-regionalization" ongoing.	
SEED Regene-ration, multipli-cation and characte-rization	SOP	Is there a SOP and does it reflect what is happening?	2009 manual by Upadhyaya & Gowda is used; there is no location-specific SOP.	ICRISAT-Niger would benefit from reviewing, revising and consolidating the processes.	
	Equipment & infra-structure	Is everything able to be regenerated in the field site? How do you deal with accessions that are difficult to regenerate?	The review included a field walk. Land at Sadoré Station (~45 km South of Niamey city) is 500 ha; the genebank only takes up 24 ha. There is generous space, and facilities appeared to be adequate.	There are some accessions that cannot be regenerated in Niger (e.g. wild groundnut) or are regenerated with difficulty and sometimes using pots (e.g. accessions that are adapted to more humid conditions (Ibadan sorghum mentioned) or a different photoperiod)	
	Risk manage-ment	Adequate measures are in place to monitor and address pests, diseases and potentially other risks	Discussions with ICRISAT staff.	There was abundant evidence of fall army worm in the field and an evaluation plot for resistance to Striga. ICRISAT-Niger is certainly focusing its breeding programs on important pests and diseases relevant to the region (fall army worm, midge, head miner, Striga, downy mildew). There is an entomologist among the ICRISAT-Niger scientists. From this, we may suppose that there is monitoring of pests and diseases in the field.	
	Genetic integrity	Regeneration practices regarding number of seed planted, isolation of accessions and harvest of seed are appropriate to	We saw characterization plots in the field. Isolation of pearl millet using pollination bags. Labels are printed, but barcoding is only planned. No hand-held data-gathering devices. We did not see the temporary storage room in the field.	Identity of regenerated seed is verified with reference seeds. Fields looked well maintained and staff talked knowledgeably about diversity in the genebank and methods for characterization. Labels were printed with passport data on a plastic label attached to a metal peg. Labels are put both inside and outside bags of harvested seed. For accessions that must be harvested over a number of days, seeds are stored temporarily in an unconditioned store room near the	Better practices from field to genebank have to be a high priority.

Area	Theme	Points to review	Evidence provided	Observations	Improvement
		ensure genetic integrity is maintained		field. Reviewers were told that care is taken to maintain discipline with labelling. The processes look fine in getting seed from the field, but there has to be doubt on how efficient the processes are in getting seed from the field to the genebank and appropriate storage condition. Germination data extracted from the database shows huge variation in germination. Even for seed harvested and tested in 2018, germination varied from 0-100%. ICRISAT-Niger believes that this is because of the quality of the paper towels used in 2018 and that probably is correct. However the range in germination in material harvested in 2102, 2013, 2014, and 2016 from across the three species points to serious problems in practice. Pearl millet and sorghum, in particular, are easily stored species and should not be showing 70% or even 50% viability after just a few years.	
	Efficiency of procedure	Processes are efficient and scientifically sound When do you decide what to regenerate? How many regeneration cycles do you need to do to produce enough seed?	We viewed seed lab, STS, MTS and LTS and staff offices. We did not see temporary storage area and threshing area. ICRISAT use IPGRI descriptors but are also measuring traits requested by the breeders.	The fields look organized and there appears to be good capacity for characterization. The widely differing maturation suggested that soil fertility was uneven. Fall army worm showed high occurrence. Vania mentioned that certain traits, such as waxiness and aerial roots in sorghum, were being expressed in Niger but had never been evident at ICRISAT-HQ in India. Several questions arose in discussions with staff on the processing of seed.	See above – seed processing from field to genebank needs URGENT attention.
SEED Drying and storage	SOP	Is there a SOP and does it reflect what is happening?	2009 manual by Upadhyaya & Gowda is used; there is no location-specific SOP.	All seed processing is done manually.	
	Equipment & infra-structure	Environmental records for cold and drying rooms	Reviewers did not see the records for the conditions of the cold room. The genebank	At the time of the visit, the conditions and equipment seemed in good working condition. The panels of the cold room look like they've been resealed a few times.	

Area	Theme	Points to review	Evidence provided	Observations	Improvement
		(access, light, temp, RH) are monitored and no major deviations are evident? Storage and drying capacity are adequate for the collection.	as a whole was spacious; STS, MTS and LTS were not overcrowded. There were empty shelves. Seeds are dried in the field and then put in the cooled STS if they have unacceptable moisture content. There is no drying room.	The LTS freezers are more than 15 years old. One of the freezers dropped in temperature to -14°C after having been opened to show us the contents; it took several minutes to decrease one degree in temperature afterwards.	
	Risk manage-ment	Maintenance schedule and inspections are evident for key equipment Working backup equipment and generator in evidence	Reviewers did not see records. They were told that alarms and monitoring of equipment was in place. There was a telephone with an external line in the MTS.	Reviewers asked about the backup of compressors and the Lithium Chloride drums – there is no backup equipment. Someone checks the freezers every day. If one freezer breaks down, a spare freezer can be used (there are six spare freezers).	
	Genetic integrity	Thresholds of seed number per sample for long term storage and medium term storage are appropriate for the target crop(s)?	Data for seed weight and 100-seed-weight were viewed in the live database.	Seed number is determined by weight and 100-seed-weight is recorded. Reviewers were told that seed thresholds were 300 g for MTS and 100 g for LTS. However, the manual had higher thresholds. The database indicated that many accessions had low seed number – fewer than 100 seeds total in some cases, particularly groundnut. There is also a 90% viability threshold for accessions to enter LTS – so there are several accessions not in LTS.	Seed number needs to be looked at with some urgency. Numbers are too often so low that there is considerable conservation risk.
	Identity	Most original sample is maintained in LTS	Most samples are in LTS and MTS according to staff.	See above – 90% threshold means many accessions not yet in LTS at ICRISAT-Niger. It was not clear, whether they (part of them?) would have been sent to ICRISAT-HQ for LTS.	
	Seed quality managemen t	Appropriate containers are used and sealed for the crop and the conditions in the cold room	Reviewers saw containers in STS, MTS and LTS.	Seeds were moved from sealed aluminum bags into the standard ICRISAT tins in the past two years. The tins are relatively small and full. The lids are hard to screw on. This is a shame as the seeds would have been better stored in sealed aluminum bags. They have not yet moved groundnut to the tins so this practice should be reconsidered.	

Area	Theme	Points to review	Evidence provided	Observations	Improvement
	Data management	Inventory data are regularly updated in the database	Discussions with ICRISAT staff.	A complete seed inventory was carried out for MTS and LTS in 2016/17, and large-scale viability testing of all ~15,000 accessions took place in 2018/19 (e.g. 5000 groundnut accessions were tested, about 95% of them showing 85-90% germination). However, ~7000 accessions had <85% germination, some of them with very low seed stock. The results of these exercises were evident in the Access Database. However, these results do not seem to have triggered any particular action.	While the inventory and seed germination has been done, the red flags that are apparent from interrogation – seed number and viability need addressing. Data input is of no value unless the genebank looks to see what that data might mean. More effort in interrogation.
	Efficiency of procedure	Processes are efficient and scientifically sound Seeds to be processed for storage are not kept in temporary storage conditions for more than 12 months. No accessions are kept in limbo in terms of their conservation/accession status for long periods of time. Is seed tested for diseases before storage?	Observation of seed viability in the database and then a report (scatter plot) from the database showing wide variation in germination for seed grown in any one year.	The apparent low viability of a large number of accessions suggests that the seed is losing viability somewhere – on the way to storage and this ought to be a major concern re poor processes from field to store or poor storage conditions. The comments from Falalou in relation to the question of why so much 2018-grown seed had such low germination were that the paper towels used in 2018 did not absorb water properly. This might suggest that the germination testing procedures in that year, and perhaps in previous years, was not up to standard. Given that the same germination ranges are seen in all species shows that this is not a post-harvest dormancy. Post-harvest dormancy was said to occur, but in pearl millet, at least, lasts just a few weeks.	Processes need to be applied that keep seed cool, dry and get them into storage quickly. A deeper understanding of seed physiology is necessary.
SEED Viability testing	SOP	Is there a SOP and does it reflect what is happening?	2009 manual by Upadhyaya & Gowda is used; there is no location-specific SOP.		
	Equipment &	Equipment is regularly	Reviewers did not ask about equipment calibration and	There were balances and incubators in the seed lab that looked in order.	

Area	Theme	Points to review	Evidence provided	Observations	Improvement
	infrastructure	maintained and calibrated Are there important pieces of equipment missing?	information was not provided unsolicited.		
	Genetic integrity	Thresholds for % viability testing are appropriate Accessions below thresholds are prioritized for regeneration	ICRISAT staff informed that thresholds were 85% for MTS and 90% for LTS. From the database, the reviewers saw that 7407 accessions in MTS had germination <85%.	About half the collection appears to have unacceptable viability (2018-data only, historical data were overwritten in the records). Reviewers understand that viability testing has been under way since 2012, so it appears that this loss of viability may have happened in processing of seeds from the field into storage. The accessions with low germination are prioritized for regeneration, but have not yet been planted (while characterization appears to have taken precedence; and it was not clear why only characterization would be carried out and not regeneration on the same plot and year).	Data from germination testing should be held for each test over time so viability loss can be tracked. The database should be modified to accommodate this.
	Seed quality management	Decision making by staff in the process of viability testing is appropriate	Discussions with ICRISAT staff.	There was some confusion over thresholds and processes in general. Staff are relatively recently recruited and they were sent to ICRISAT-HQ for training. While they were impressive in their knowledge, the slight confusion in discussions suggests that the thresholds and various process issues are not entirely underpinned with sound thinking and understanding. Documenting SOPs and consolidating their thinking is needed.	
	Data management	Viability data are being entered appropriately into the database	Reviewers saw the viability test data in the Access database.	Database looked well managed and up-to-date. Vania mentioned a number of times that adopting GRIN-Global would make things more difficult. There is no historical record of viability that could help genebank managers evaluate their practices and their effectiveness.	Database must include historical germination data for each accession.
	Efficiency of procedure	Processes are efficient and scientifically	Reviewers visited the seed lab and heard from ICRISAT lab staff how they process	The understanding of thresholds and moisture control is limited. Processes have been dictated by the adoption of standards from the Upadhyaya & Gowda	Practices need improving to avoid any risk of harvested seeds being exposed

Area	Theme	Points to review	Evidence provided	Observations	Improvement
		sound The annual rate (% of collection) of viability testing is justifiable given the crop and status of availability of the collection.	the seeds upon entry from the field.	manual without more detailed thinking of local circumstances of where seed is held during processing, timeliness of processing, etc.	to adverse temperature or moisture for extended periods, even for a weekend.
Safety duplication	SOP	Is there a SOP and does it reflect what is happening?	2009 manual by Upadhyaya & Gowda is used; there is no location-specific SOP.		
	Risk manage-ment	Adequate legal agreement with secure terms and conditions available for safety duplication sites	Reviewers did not see the legal agreements, but black box duplicates and accessions from ICRISAT or national genebanks were well distinguished in the LTS.	It was rather expected that the ICRISAT-HQ genebank will provide relevant documents.	
	Efficiency of procedure	Processes are efficient and scientifically sound Is everything that is unique duplicated? How regular is the communication with the partners who donated the accessions?	Discussions with ICRISAT staff.	There are issues with the safety backup of all 'unique' accessions to ICRISAT-HQ. Previously, accessions collected in WCA were regenerated and sent to ICRISAT-HQ in India. This germplasm was declared non-FAO designated and, consequently, cannot leave India anymore. Currently, a relatively small number (about 600) of unique accessions remain to be sent to ICRISAT-HQ for LTS. Once this is completed, all accessions in ICRISAT-Niger should be available and conserved in ICRISAT-HQ with the exception of the most recently collected accessions and any ongoing new collecting activity that might happen. After passing quarantine in India, accessions are increase again for both LTS and MTS at ICRISAT-HQ.	
Distribution & user satisfaction	SOP	Is there a SOP and does it	2009 manual by Upadhyaya & Gowda is used; there is no location-specific SOP.		

Area	Theme	Points to review	Evidence provided	Observations	Improvement
		reflect what is happening?			
	Phyto-sanitary	Germplasm is adequately tested for quarantineable diseases before distribution	Discussion with ICRISAT staff.	According to Falalou, there is little capacity to carry out tests in the national agency and normally phytosanitary certificates are provided within a few days or a week, which suggests that there is little quarantine or controls.	
	Data manage-ment	Appropriate passport and characterization data is provided with germplasm	Reviewers did not ask this; and relevant information was not provided unsolicited.	It seems that passport and (some?) characterization data are available online and often consulted by users before requesting germplasm. Reviewers were not informed about internet stability in the region. No characterization data were observed from the existing Access database.	
		SMTAs available for all relevant distribution	Reviewers did not ask this; and relevant information was not provided unsolicited.		
	Efficiency of procedure	What is being distributed and who to? How much of the distributed materials are breeding lines? Who decides and how what to distribute?	Discussions with ICRISAT staff.	Elite germplasm is distributed to seed industry and WCA national agencies. Germplasm for breeding programs distributed to ICRISAT breeders working on the 3 major crops (sorghum, millet and groundnut). Breeders are in Mali and Niger. Mini-cores of sorghum and the millets are being made available to be able to screen for specific traits, such as pest/disease resistances. Commonly, 50-100 seeds/accession and request are distributed. Lately distribution has increased; they think this is due to better visibility of the genebank and interaction with potential partners, e.g. on field days.	
Data manage-ment	SOP	Is there a SOP and does it reflect what is happening?	2009 manual by Upadhyaya & Gowda is used; there is no location-specific SOP.		
	Equipment & infra-structure	Chosen software is effective and regularly updated	Reviewers were shown the Access database and were able to interrogate it with the help of staff.	The local documentalist was able to answer the reviewers' questions quickly and effectively. The data fields appeared to be well completed. In communications and posters, there is much	There needs to be numbers of accessions conserved that are repeatable, clear and understandable to the outside world.

Area	Theme	Points to review	Evidence provided	Observations	Improvement
				confounding of accession numbers in the genebank and numbers including safety duplicates and black box accessions, and mandate and/or non-mandate crops. Reviewers were told the data was entered into the system within weeks – not months.	
	Risk manage-ment	Data validation and quality control measures are in place Electronic and hard copy backups take place regularly	Reviewers were shown the Access database and were able to interrogate it with the help of staff.	Data is backed-up on site frequently, although the backup is maintained on the same site. Nevertheless, the server is located at TVC in Niamey City (at ~45 km North of Sadoré Station).	Need to ensure that the off-site backup works well (possibly one sent to ICRISAT-HQ each week).
	Identity	Passport data from donor institute is provided at acquisition How is characterization data gathered and how is it linked to the passport data	Discussions with ICRISAT staff and observing database.	Material is mostly either from ICRISAT-HQ or from local (WCA) collections. Both have passport data (reviewers were able to have maps of where local WCA collections had been made for all 3 major species). Reviewers were told that characterization data from the field is entered quickly into the database. Access is a relational database and passport and characterization data can be linked through the unique number for each accession.	ICRISAT-HQ needs to make decisions on what database is going to be used and how its design can incorporate the specific requirements of regional centres. Having an Access database at ICRISAT-Niger is fine, it works well and staff know how to use it. Better to have an institutional system – GRIN-Global or something else.
	Efficiency of procedure	There are no backlogs of hard copy or legacy data	Discussion with ICRISAT staff.	Some data is still to be entered, but this is from recent activities and could not be considered a backlog.	
Staff	Staff numbers and grade	Are there adequate experienced staff available to manage the routine operations of the genebank?	Observation and discussions with ICRISAT staff.	Staff were impressive; Falalou is well versed in most aspects of the operation and reviewers saw that other staff have particular skills in key areas such as seed germination, database management, field operations.	
	Staff compe-tences	Each team has all the necessary	Observation and discussions with ICRISAT staff.	Staff appeared confident and had received training at ICRISAT-HQ. Most operations reflected that training.	

Area	Theme	Points to review	Evidence provided	Observations	Improvement
		training and competences including staff in key positions		During peak working times, there are up to 30 casuals hired, receiving 2500 CFA/day (~4.20 USD).	
	Staff management	The teams in the genebank are in good communication with each other to ensure quality control and efficient workflow Succession or mentoring measures are in place The manager is enabled to make all necessary management decisions regarding routine operations of the genebank	Observation and discussions with ICRISAT staff.	All staff were quick to speak for themselves despite having to speak in English, and there was good rapport among staff members. It is apparent that the genebank is heavily dependent on Falalou and his leadership. Other staff have specialty areas that they lead (database and germination testing for instance), but the reviewers got the view that decisions on what is tested and what is distributed and characterized is largely decided by Falalou as might be expected in any similar genebank. On the other hand, Falalou keeps his technical staff changing from one job to the other in order to make them acquainted with all operations. This means that the genebank would be at some risk without him, although the closer links developed between the ICRISAT-HQ genebank (Vania) and ICRISAT-Niger since Vania's appointments alleviates that risk to a large degree.	
Acquisition		SMTAs provided for all relevant acquisitions	Reviewers did not ask this question, but got some information from Vania when they visited ICRISAT-Bulawayo.	According to Vania, SMTAs are used for all acquisitions and distributions and reports are made centrally from ICRISAT-HQ to the Treaty every year. Filed SMTAs for distribution from the region were not requested by the reviewers.	
		Clear policy on acquisition and scope of the collection	Discussions with ICRISAT staff.	There was no clear "policy" on new plant collecting, although there was an intention to collect more material in the sub-region (WCA). However, this did not seem to have advanced to priorities of what material where searched for. Mapping done at the request of the reviewers showed that pearl millet germplasm had been collected comprehensively in the sub-region, but the collecting of sorghum and groundnut left major geographical gaps.	

ICRISAT Genebank – Niger Review Report					
Area	**Theme**	**Points to review**	**Evidence provided**	**Observations**	**Improvement**
Phyto-sanitary		Pathogens tested for incoming materials	Discussions with ICRISAT staff.	No tests or capacity to test for viruses, fungi or aflatoxin.	
		Pathogens tested for outgoing materials	Discussions with ICRISAT staff.	No tests or capacity to test for viruses, fungi or aflatoxin.	
		Log of incidents or rejected shipments from genebank	Discussions with ICRISAT staff.	Not in the time since the Genebank manager has been in the job.	
		Documented agreement with host quarantine authorities on Genebank role and responsibilities	Discussions with ICRISAT staff.	Reviewers were informed that visible check was made including using microscope. They don't test for Aflatoxin, fungus, etc. All seeds leaving Niger are sent to the national Niger Phytosanitary Agency to get a phytosanitary certificate. NBPGR/ India detected several fungus spp. on materials obtained from ICRISAT-Niger.	

ICRISAT Genebank – Zimbabwe Review Report					
Area	**Theme**	**Mandatory points to review**	**Evidence provided (suggestions in green)**	**Observations**	**Improvement**
Value of collection	Numbers	What species and how many	Presentation	Pearl millet (4361 accs.), Finger millet (3155), sorghum (4347), and groundnut (68) are the most important collections; >50% are landraces or wild relatives from the region. There are no duplicates in these numbers. Another total was given as 12,182 accessions – there is some inconsistency in numbers. Of these, a total of 2303 (272 sorghums, 1763 pearl millet, and 268 finger millet) have not yet been sent to ICRISAT-HQ.	Processes below need to be focused on the accessions that are not yet at ICRISAT-HQ in Hyderabad as these are most at risk.
	Genetic represent-ation	Is this collection significant regionally and globally	Presentation: ICRISAT and IBPGR collected landraces in the sub region between 1980 and 1985. These were held at ICRISAT-Bulawayo. In ~1983, an ICRISAT breeding program commenced in Bulawayo, and during 1985-1987 large numbers of accessions were introduced from ICRISAT-HQ and from the USA (in the case of sorghum). This was germplasm that had an origin in the subregion or had been identified as having appropriate traits. There has been some collecting more recently (the latest in 2015).	The collection is significant regionally, although most accessions are also held at ICRISAT-HQ. There is no information on how many accessions are held in the SADC Plant Genetic Resources Centre (SPGRC). No plan appears to have existed at any stage to have a direct link to SADC and have duplicates or safety back up there. Politically, the genebank has been told that Zimbabwe (and perhaps) other national governments hold the existence of the genebank as high importance.	There is a plan to have discussions with SADC to build collaboration and, especially, for clearer role definition (especially for ICRISAT)
	Duplication	What % of material is made up of duplicates of common – used landraces	Discussions with ICRISAT staff – and the answer is 0%	The genebank has gone through all their data, looked for duplicates and reduced any confirmed duplicates to one accession. Reviewers discussed this at length and the team is confident that they managed to get rid of all duplicates. They do, however, hold multiple seed lots of accessions that were identified as duplicates.	Get completely rid of duplicate samples. Holding multiple “lines” (=lots) within accessions will only cause greater confusion (in regeneration for instance).
	Gaps	Is there a need for more collection – why	Discussions with ICRISAT staff	Gap analyses for individual crops in ESA have been based on geographically collected samples, climate probability of adaptation of	This needs more analysis on priorities.

Area	Theme	Mandatory points to review	Evidence provided (suggestions in green)	Observations	Improvement
				crops (by FloraMap) and a diversity index calculated on various traits shows is applied and mapped to identify possible areas of particular diversity. There are several publications with identifying zones for every mandate crop, where there is a high probability of occurrence based on FloraMap, and that have not been collected.	Also, a better understanding of distribution patterns of traits might be needed before the start of collecting.
	Users	Who needs it now and who needs it in the future	Discussions with ICRISAT staff	Users now are the national breeders of pearl millet, sorghum and finger millet in Zimbabwe. Sub-regional universities (Freestate Univ RSA, Univ Zimbabwe, Lupane University and Midlands University Zimbabwe. ICRISAT users in Kenya and seed companies are undertaking independent breeding programs in Zimbabwe, Namibia and Mozambique, and request genetic material for those programs. NGOs request material of elite landraces (not for any breeding program). Users very likely to increase significantly as the new AVISA project (BMG program) moves the ICRISAT-Kenya-based breeders to Bulawayo in the next months and recruits additional staff.	Appears to be more breeders on the horizon. The BMG-funded AVISA project has led ICRISAT to move breeders to Zimbabwe. Suitability as livestock feed and relevant traits will be more focused on in the context of crop-livestock systems becoming more prominent in AVISA project and under climate change scenarios.
SEED Regener-ation, multi-plication and characteris ation	SOP	Is there a SOP and does it reflect what is happening?	Discussion with ICRISAT staff	The 2009 manual by Upadhyaya & Gowda was used for some time. In early 2018, the ICRISAT-HQ team – without regional involvement – developed a "draft" comprehensive set of SOPs. These draft SOPs are now being reviewed and locally adapted to ensure, they are appropriate for implementing in the regional genebanks (Sadore/Niger and Bulawayo/Zimbabwe).	ICRISAT-Niger and ICRISAT-Zimbabwe would benefit from accelerating the revision of SOPs process. This need to have a higher priority than it has now.

Area	Theme	Mandatory points to review	Evidence provided (suggestions in green)	Observations	Improvement
	Equipment & infra-structure	Is everything able to be regenerated in the field site? How do you deal with accessions that are difficult to regenerate?	Field walk… nothing growing in the field at the time; observed glasshouses from outside only	The land leased by ICRISAT on the national government Matopos Research Station is >50 ha on several soil types and more than enough to enable field regeneration here, as well as near Harare (Muzarabani off-season site with irrigation). A few accessions with very limited seed for regeneration can be grown to maturity in glasshouses (n=4) at Matopos Station, also for handling wild species.	
	Risk manage-ment	Adequate measures are in place to monitor and address pests, diseases and potentially other risks	Discussions with ICRISAT staff	Seed increase plots are inspected twice during their growing period: during the vegetative phase and again post flowering. The inspection is carried out by a team of three technical staff from the Zim Quarantine service (covering entomology and pathology). They give advice on whether to destroy a block of plants (an accession) or to put extra effort into controlling a pest. These inspections enable Zim Quarantine to provide the Phytosanitary certificates.	Possibly need more inspections and advice, might depend on seasons.
	Genetic integrity	Regeneration practices regarding number of seed planted, isolation of accessions and harvest of seed are appropriate to ensure genetic integrity is maintained	Discussions with ICRISAT staff	ICRISAT-Bulawayo uses 4 rows of 4 metres length for seed increase except in groundnut, where 6 rows are used. In all but exceptional cases, over 100 plants are grown to maturity and harvested to gather equal seed from all. Target is about 200 g for cereals. Cluster-bagging is used in pearl millet and individual seed head bagging in sorghum. Finger millet is self-pollinated. Metal labels are hand written – no bar-coding is used. No hand-held data-gathering devices. Reviewers did not see the temporary storage room said to exist in the field during harvest.	
	Efficiency of procedure	Processes are efficient and scientifically	Site visits to glasshouses, labs, and discussions with ICRISAT staff.	Overall, the processes are ok. The aim is 85% germination before storing seed. It would be better if there was a 15 °C/15% RH drying	

Area	Theme	Mandatory points to review	Evidence provided (suggestions in green)	Observations	Improvement
		sound When do you decide what to regenerate? How many regeneration cycles do you need to do to produce enough seed?		room; but given the Bulawayo climate, that is probably not a priority. The seed testing laboratory is an old one made available to the genebank just recently. It looks good and there are two germination cabinets. Accessions have been regenerated based on urgency. There are many seed lots, where viability is poor: <20%. This situation is in part due to a fragmented history. The genebank was established to be a working collection for breeders. When Paula Bramel came to Bulawayo in 1996, there were constraints in having material sent to India so she implemented a plan to ensure material was not lost. But sufficient resources were not made available until 2012, 16 years later!! And no great evidence was given that viability was a priority. Hence, seed in the genebank dating back to the 1980s and 1990s are in such poor condition. Number of generation cycles required is usually one, but that depends on rainfall. Irrigation is a major problem because of unreliable electricity supply.	
SEED Drying and storage	SOP	Is there a SOP and does it reflect what is happening?	2009 manual by Upadhyaya & Gowda is used; there is no location-specific SOP.		
	Equipment & infra-structure	Environmental records for cold and drying rooms (access, light, temp, RH) are monitored and no major deviations are evident? Storage and	Discussions with ICRISAT staff and visit to conservation facility, entering one cold room.	There are two large cold rooms with capacity for 100,000 accessions. The store has adequate capacity, but is not overly generous. Rel. humidity and temperature are logged every 5 minutes, and data downloaded every week. ICRISAT security team checks temperature and RH after working hours; and if the temperature is outside the normal range (3-8°C) they should contact the farm manager	There is ample space for an adequate drying room adjacent to the cold room; this would improve outcomes and overcome problems when there are periods of hot and/or humid conditions.

Area	Theme	Mandatory points to review	Evidence provided (suggestions in green)	Observations	Improvement
		drying capacity are adequate for the collection.		(who lives on site) and the Genebank manager (Gapare). Drying conditions are not ideal. Current practice is to take seed to a large room that houses two drying cabinets that run at 28°C. Note that at the time of harvest, Bulawayo-expected ambient conditions would be about 11-26°C and RH only 50%; so, conditions are unlikely to be a major challenge throughout the seed harvest-to-storage process.	
	Risk manage-ment	Maintenance schedule and inspections are evident for key equipment Working backup equipment and generator in evidence	Observation of equipment and discussions with ICRISAT staff	Visual inspections are carried out regularly on refrigeration units and dehumidifiers but, maybe more importantly, there is a 4-month scheduled servicing by external technicians on these units. There are two refrigeration units – usually one can maintain conditions. The lead unit is switched regularly to ensure even wear. Refrigeration units at Bulawayo have a diesel backup generator, which has the capacity to condition the genebank unit. The room has a dehumidifier and there is a backup dehumidifier – but it is stored outside the refrigerated room.	Recommendation to have the LiCl drum stored in the refrigerated, dehumidified room if the drum is not sealed.
	Genetic integrity	Thresholds of seed number per sample for long term storage and medium term storage are appropriate for the target crop(s)?		Data for seed weight and 100-seed-weight were viewed in the live database	
	Identity	Most original sample is maintained in LTS	According to ICRISAT staff: MOS samples are in LTS and MTS – no evidence was provided.	There is no LTS in Bulawayo. MOS were said to be kept in small bags inside the tins. There was said to always only have one seed lot per accession in MTS.	

Area	Theme	Mandatory points to review	Evidence provided (suggestions in green)	Observations	Improvement
	Seed quality management	Appropriate containers are used and sealed for the crop and the conditions in the cold room	Reviewers saw containers in MTS (mostly tins and some aluminum-foiled bags).	ICRISAT just changed containers from aluminum-foiled bags to place all accessions in tins for easier handling. About 80% of the 'unique' accession backlog to be sent to ICRISAT-HQ have low germination and need regeneration first. The concern was not so much about appropriate containers, but rather about seed handling between field and storage room. Little understanding of seed physiology seemed to be available with staff.	Train staff on seed physiology. Keep regenerating all backlog 'unique' accessions and make sure they are safety duplicated in LTS.
	Data management	Inventory data are regularly updated in the database	Reviewers picked 2 accessions at random and easily located them in the MTS; the registered seed weight seemed ok.	Inventory is fine, but data is entirely in Excel in various unrelated spreadsheets. Data management and enquiry would be far easier and more transparent if the Excel sheets could be transferred to an Access system. Reviewers were told that the current Excel system can be migrated to GIMS (used at ICRISAT-HQ); said to be the preferred shift as GRIN-Global does not have the capability that ICRISAT requires. The aim to complete this transition is March 2020. Reviewers were told that data are up to date and regularly updated.	
	Efficiency of procedure	Processes are efficient and scientifically sound Seeds to be processed for storage are not kept in temporary storage conditions for more than 12 months. No accessions are kept in limbo		The apparent low viability of a large number of accessions suggests that the seed is losing viability somewhere – probably in the process of getting it into storage.	

Area	Theme	Mandatory points to review	Evidence provided (suggestions in green)	Observations	Improvement
		in terms of their conservation/accession status for long periods of time. Is seed tested for diseases before storage?			
SEED Viability testing	SOP	Is there a SOP and does it reflect what is happening?	2009 manual by Upadhyaya & Gowda is used; there is no location-specific SOP.		
	Equip-ment & infra-structure	Equipment is regularly maintained and calibrated Are there important pieces of equipment missing?	Reviewers did not ask and no evidence was provided unsolicited.		
	Genetic integrity	Thresholds for % viability testing are appropriate Accessions below thresholds are prioritized for regeneration	Discussion with ICRISAT staff and visit to germination lab.	100 seed x 2 reps are tested in Petri-dishes for cereals and between paper for legumes, placed in incubators. Full germination tests are being done for all unique accessions. Dormancy is said not to be an issue, except for some photosensitive sorghums. 85% germination is aimed at before storing, and also as trigger for regeneration. Best performers reach >90% germination, but there were many seed lots with poor viability, even <20%.	Seed numbers can be reduced for germination testing. Reps are more important than numbers. Seed processing is a key issue – the process between harvesting in the field to storing in the cold room urgently needs optimization. Training in seed physiology is a must.

ICRISAT Genebank – Zimbabwe Review Report					
Area	**Theme**	**Mandatory points to review**	**Evidence provided (suggestions in green)**	**Observations**	**Improvement**
	Seed quality manage-ment	Decision making by staff in the process of viability testing is appropriate	Discussion with ICRISAT staff and Excel spreadsheets demonstrated. Later scatter plots sent.	There was some confusion over thresholds and processes in general.	
	Data manage-ment	Viability data are being entered appropriately into the database	Discussions and spreadsheets	Reviewers saw germination test data in the Excel spreadsheets	
	Efficiency of procedure	Processes are efficient and scientifically sound The annual rate (% of collection) of viability testing is justifiable given the crop and status of availability of the collection.	Reviewers visited the seed lab and heard from the lab staff how they process the seeds upon entry from the field.	The understanding of thresholds and moisture control is limited. Processes have been dictated by the adoption of standards from the Upadhyaya & Gowda manual without more detailed thinking of local circumstances.	
Safety duplication	SOP	Is there a SOP and does it reflect what is happening?	2009 manual by Upadhyaya & Gowda is used; there is no location-specific SOP.		
	Risk managemen t	Adequate legal agreement with secure terms and conditions available for safety duplication sites	Discussion with ICRISAT staff. Reviewers did not ask for legal agreement, and no unsolicited document was shown.	The group aims at safety duplicating all ‘unique’ accessions from the region by 2020 in the ICRISAT-HQ genebank. Reviewers saw a workplan for this. Once in the central genebank, ICRISAT will take care of safety duplication in another (international) genebank as well as in Svalbard. In the region, national genebanks are responsible for safety duplication. LTS at SPGRC in Zambia is being used by member	

ICRISAT Genebank – Zimbabwe Review Report					
Area	**Theme**	**Mandatory points to review**	**Evidence provided (suggestions in green)**	**Observations**	**Improvement**
				countries that deal directly with SPGRC; ICRISAT is not a member. However, uncertainty ruled in ICRISAT about how many of the accessions collected in Zimbabwe would have been safety duplicated by the Zimbabwean national genebank at SPGRC.	
	Efficiency of procedure	Processes are efficient and scientifically sound Is everything that is unique duplicated? How regular is the communic-ation with the partners who donated the accessions?	There is still a backlog of 2,303 'unique' accessions; to be shipped to ICRISAT-HQ.	A certain number of unique accessions remain to be sent to ICRISAT-HQ for LTS. Once this is completed, all accessions in ICRISAT-Zimbabwe should be available and conserved in ICRISAT-HQ with the exception of most recently collected accessions.	
Distribution & user satisfaction	SOP	Is there a SOP, and does it reflect what is happening?	2009 manual by Upadhyaya & Gowda is used; there is no location-specific SOP.		
	Phytosanitar y	Germplasm is adequately tested for quarantineable diseases before distribution	ICRISAT-Zimbabwe depends on the national phytosanitary agency to test incoming/outgoing materials. Usually, there is a group of about 3 people with different backgrounds (entomology, phytopathology) coming to inspect the field, commonly twice during the growing season. If there are symptoms, they would take samples for further analysis in Harare.	There has been some discussion from the Zimbabwean side that they also need a plant health lab in Bulawayo due to the distance from Harare. From what the reviewers have heard, they cannot assess the national capacity. Even they did not follow up on how much time is needed to obtain a phytosanitary certificate. Gapare informed that if breeders' lines are introduced for field-testing, these do not need to go through quarantine, but will be grown in isolation.	
	Data manage-ment	Appropriate passport and characterisation	Discussion with ICRISAT staff.	Mostly requesters obtain data from the internet upon choosing the materials to be	

Area	Theme	Mandatory points to review	Evidence provided (suggestions in green)	Observations	Improvement
		data is provided with germplasm		requested. The normally do not need further information.	
		SMTAs available for all relevant distribution	Discussion with ICRISAT staff and a folder with filed and signed SMTAs (2017-2019).	According to Vania, SMTAs are used for all acquisitions and distributions, and ICRISAT-HQ reports centrally to the Treaty on an annual basis. Reviewers saw various filed and signed SMTAs from seed distribution to the region. Usually, these will be scanned at the end of the year and sent to ICRISAT-HQ, as they report to the Treaty for all subsidiary gene-banks.	
	Efficiency of procedure	What is being distributed and who to? How much of the distributed materials are breeding lines? Who decides and how what to distribute?	Discussions with ICRISAT staff and presentations.	Proportion of distribution is pearl millet (46%)/ sorghum (38%)/ finger millet (20%)/ groundnut + chickpea (6% because the collections are very small); much more landraces than breeders lines (e.g. 2256 vs. 998 for sorghum, 617 vs. 230 for pearl millet, 115 vs. 0 for finger millet, respectively). About 3g are distributed per accession; seed numbers were normally not considered. Users (see details above) have fairly good idea what they want and need, also from the annual field days held at Matopos Station in the peak season (February). Visitors to field days include mainly Zimbabweans but also partners from neighboring countries: Mozambique, Zambia, etc. Most requesters inform themselves on characteristics provided on the ICRISAT website. But some users request information on specific traits that will then be provided with the list of accession IDs.The bulk of distributed materials are accessions, only few breeding lines. Distribution mostly according to the requester. ICRISAT-Bulawayo may	

Area	Theme	Mandatory points to review	Evidence provided (suggestions in green)	Observations	Improvement
				suggest alternative materials according to users' needs; this happens mostly with universities. Very rarely users provide feedback on germplasm use and satisfaction.	
Data management	SOP	Is there a SOP and does it reflect what is happening?	2009 manual by Upadhyaya & Gowda is used; there is no location-specific SOP.		
	Equipment & infra-structure	Chosen software is effective and regularly updated	Discussion with ICRISAT staff and sighting Excel spreadsheets.	Reviewers were shown the Excel spreadsheets in use. There is no Access database, but HQ is helping to put the regional data into the GIMS. Cleaning up the database before adopting the overall institutional GIMS was said to be priority.	This is work in progress. Adopting the overall institutional GIMS has high priority.
	Risk manage-ment	Data validation and quality control measures are in place Electronic and hard copy backups take place regularly	Data validation and quality control have not been discussed.	Backup of data in a desktop and laptop; and there is also a cloud server of the Matopos Institute daily with backup taking place at 1.00 PM daily.	
	Identity	Passport data from donor institute is provided at acquistion How is characterisation data gathered and how is it linked to the passport data	Discussion with ICRISAT staff and sighting Excel spreadsheets.	Passport data have been shown in an Excel sheet and they looked quite complete. Some donated materials from a cooperation probably ICRISAT/ Bioversity International (donor cty ITA) were very incomplete. There are issues with inability to combine data and search for multiple criteria. The database is in process to be incorporated into the HQ-management system (GIMS). It's considered that the whole ICRISAT genebank system may migrate to GRIN-Global.	
	Efficiency of procedure	There are no backlogs of hard copy or legacy data	Discussion with ICRISTAT staff.	No data backlogs are known of; all passport and characterization data have been digitized. Except there may be some old reports in the library, where there are problems to connect	

Area	Theme	Mandatory points to review	Evidence provided (suggestions in green)	Observations	Improvement
				(characterization) information with today's accession ID.	
Staff	Staff numbers and grade	Are there adequate experienced staff available to manage the routine operations of the genebank?	Reviewers met and talked to all five genebank staff in the course of the 2-day visit to Matopos Station. 30 casual laborers are hired at peak seasons for harvest periods, etc. (c. 6.5 USD)	Staff seemed competent to handle technical questions. Except for the genebank manager (Gapare), all other staff were rather reserved and did not speak up unsolicited. Beyond Gapare, there has to be a question on who could run the operations completely in his absence.	
	Staff compe-tences	Each team has all the necessary training and competences including staff in key positions	Staff competences were not discussed.	Staff was built up again since 2018 after unrest period in Zimbabwe. The genebank manager (Gapare) did not raise any issue regarding staff needs.	
	Staff managemen t	The teams in the genebank are in good communic-ation with each other to ensure quality control and efficient workflow Succession or mentoring measures are in place The manager is enabled to make all necessary management decisions regarding routine operations of the genebank	Reviewers' observations from interaction and discussions with ICRISAT staff.	Except the genebank manager (Gapare), all other staff were rather reserved and did not speak up unsolicited. Perhaps they were only shy and respected the hierarchy. In the staff meeting held by Vania right after the discussion with the reviewers, good group communication appeared to be happening (only observed behind closed doors). The genebank manager appeared the lone person doing the decision making.	

ICRISAT Genebank – Zimbabwe Review Report					
Area	**Theme**	**Mandatory points to review**	**Evidence provided (suggestions in green)**	**Observations**	**Improvement**
Acquisition		SMTAs provided for all relevant acquisitions	Discussion with ICRISAT staff. Reviewers did not ask for acquisition SMTAs; and no documentation was presented unsolicited.	According to Vania, SMTAs are used for all acquisitions and distributions and reports are made centrally from ICRISAT-HQ to the Treaty. Reviewers say filed and signed distribution SMTAs (2017-2019), but no SMTAs for acquisition.	
		Clear policy on acquisition and scope of the collection	Discussion with ICRISAT staff.	Discussions with staff indicate that, in the past, acquisition has been driven by breeders and, perhaps, more in an ad hoc way. Today collecting will not be undertaken if the permits by countries are not in order. An example for this with Tanzania was given (sorghum, finger millet and pigeon pea), where collecting was about to start, but could not take place due to lack of signed papers. Collecting is guided by the existing and published gap analyses (by mandate species), but also based on traditional knowledge for particular traits available in certain geo-regions. Most recent collecting was in 2015 in Zimbabwe before Gapare was appointed. Samples are also stored in national genebank and supposedly in SPGRC, but not confirmed.	
Phytosanitary		Pathogens tested for incoming materials	Discussion with ICRISAT staff.	No testing is done at all by ICRISAT staff because no capacity exists. National inspection takes place.	
		Pathogens tested for outgoing materials	Discussion with ICRISAT staff.	No testing is done at all by ICRISAT staff because no capacity exists. National inspection takes place.	
		Log of incidents or rejected shipments from genebank	Discussion with ICRISAT staff.	Not in the time since the current Genebank manager (Gapare) has been in the job (=2.5 years).	

ICRISAT Genebank – Zimbabwe Review Report					
Area	**Theme**	**Mandatory points to review**	**Evidence provided (suggestions in green)**	**Observations**	**Improvement**
		Documented agreement with host quarantine authorities on Genebank role and responsi-bilities	Discussion with ICRISAT staff.	There is no formal long-term arrangement between ICRISAT-and Zimbabwe agency regarding phytosanitary controls, but it is all taking place and no mention of the arrangement being a constraint. .	

Appendix 2: Acronyms and abbreviations

CBD	Convention on Biological Diversity
CIAT	International Center for Agriculture in the Tropics, Colombia
CV	Coefficient of variation
CWR	Crop wild relatives
DDG	Deputy Director General
DG	Director General
DOI	Digital Object Identifier of individual accessions
ELISA	Enzyme-linked immunosorbent assay
Embrapa	Brazilian Agricultural Research Corporation
FAO	Food and Agriculture Organization of the United Nations
FETS	Farm, Engineering and Transport Services of ICRISAT
GGP	Genetic Gains Program of ICRISAT
GHU	Germplasm Health Unit
GIMS	Genebank Information Management System of ICRISAT
GRIN-Global	A scalable version of the Germplasm Resource Information Network
HQ	Headquarters
ICARDA	International Center for Agricultural Research in the Dry Areas, Syria
IITA	International Institute of Tropical Agriculture, Nigeria
ILRI	International Livestock Research Institute, Kenya
IPGRI	International Plant Genetic Resources Institute, now Bioversity International
LTS	Long-term storage
MA	Morpho-agronomic
MC	Moisture content (of the seed; in %)
MTS	Medium-term storage
NBPGR	National Bureau of Plant Genetics Resources, India
ORT	Online reporting tool of the Crop Trust
PDCI	Passport Data Completeness Index
PEQ	Post-entry quarantine
QMS	Quality management system
QR code	Quick response code, a matrix barcode
RH	Relative humidity (of the air; in %)
SADC	Southern African Development Community
SGSV	Svalbard Global Seed Vault
SMTA	Standard Material Transfer Agreement
SOP	Standard operating procedure
SPGRC	SADC Plant Genetic Resources Centre, Zambia
SQL	Structure query language
SSA	Sub-Saharan Africa
STS	Short-term storage
W-	West