

CIAT Genebank Review 2013

Programme: Genebanks CRP

Genebank reviewed: CIAT	Site visit Dates:	08 Apr 2013 - 12 Apr 2013
	Review report Date:	03 Jul 2013
	Center and Crop Trust responses:	20 Nov 2013

Place: La Palmira, Colombia

Genebank Manager	Daniel Debouck
Review Panel	Theo van Hintum
	Luciano Nass
	Hugh W. Pritchard
Crop Trust staff	Charlotte Lusty
	Paula Bramel
	Anne Clyne



RESEARCH
PROGRAM FOR
Managing and
Sustaining Crop
Collections



CIAT 2013 Genebank Review: recommendations and responses

	Recommendation	Responses by CIAT	Responses by Crop Trust
1. Optimization of procedures	The genebank procedures in the GRP are in need of objective review. The Review Panel believes that given the nature of these procedures there is space for optimisation thus potentially creating capacity that can be used elsewhere in the GRP. These optimisations should be inventoried by an independent genebank expert within the next 18 months.	We have no problems with this recommendation, and would ask the Global Crop Diversity Trust to commission this independent expertise. As well noted by the Panel, growth and operation development have grown 'organically' in an infrastructure built for other purposes and with Staff trained 'on the job'. The independent expertise may provide elements along replies to Recommendations 2, 9 and 14 below. As an example, the case of three drying cycles in the Main Text might be misunderstood since one cycle of drying (called 'Pre-Drying' in the Handbook of Procedures) is necessary for threshing the fruits, and for drying seeds only Drying Room No. 3 has the appropriate technical conditions but it is too small.	The Trust appreciates CIAT's willingness to pursue the optimization of procedures. We are currently commissioning two consultants to assist in developing and strengthening Quality Management Systems. The initial focus will be on building a QMS for the cryobank but the workplan will extend beyond this. We envisage that one of the first steps beyond the cryobank will be to review Standard Operating Procedures (SOPs) of all the CGIAR genebanks, potentially taking place in 2014. If CIAT and the reviewers agree, this could be the first step in reviewing and optimizing the procedures in place at CIAT.
2. Health laboratory	Given the high quality and volume of work of the germplasm health laboratory, and the projected future demands likely to be placed upon this unit, solutions have to be created to accommodate the staff so that they are able to have dedicated desk space and maintain ample lab space.	Agreed. Action had been already initiated before the review, on the preparation of plans and lists of technical criteria for a new building for CIAT genebank, including a Germplasm Health Lab in the aisle of labs.	This is welcome news. The Trust will be interested to hear more about your plans as they evolve. No doubt fund-raising is a key part of those plans and we would be willing to lend our support where we can.
3. Risk assessment	Using the tools and capacity created by the GPG2 program, a complete risk assessment is carried out for the GRP within 18 months. This should be based on the advice of an external expert.	We concur, and we will ask the Global Crop Diversity Trust to coordinate this assessment. Perhaps CIMMYT and CIP genebanks may benefit of the visit of this external expert during the same period.	Indeed the Centres can benefit from working together on risk assessment and management, as they have already shown in developing the risk assessment tools and materials which are available on the Crop Germplasm Knowledge Base and as mentioned by the reviewers. (http://cropgenebank.sgrp.cgiar.org/index.php?option=content&view=article&id=135&itemid=236&lang=en). CIAT staff are able to access and work with these tools right now. The group of genebanks, together with the Trust, may agree minimum elements that should be included in the risk assessment, which would help to

	Recommendation	Responses by CIAT	Responses by Crop Trust
			address the reviewers' concerns that there are no major "blind spots" or gaps in risk management. Also the work on QMS will help us to keep a focus on risk assessment and management until a satisfactory outcome is achieved.
4. Documentation of procedures and quality management system	A proper and complete documentation of the genebank protocols, especially in the context of succession planning, is developed within two years. The protocols should cover all basic elements of the genebank operation and be published on the website. The protocols will form the basis of a QMS that is expected to be developed over the coming years.	We concur. Protocols about work flow charts, in vitro management and germplasm health are already published on the website (http://www.ciat.cgiar.org/urg , then "Handbook of Procedures"). The QMS for seed acceptance, conservation and distribution is the subject of a MSc degree of a member of Staff of the Program. The Audit Unit of the CGIAR has asked for the publication of norms for the distribution of in-trust germplasm, and GRP has started this writing, in addition to the policy already available on the website.	The Trust appreciates that CIAT is well on the way to the full documentation of the genebanks SOPS. The SOPS will form the backbone of the QMS and we hope that CIAT will be one of the frontrunners in having a solid QMS in place by 2017.
5. Med-term storage	A medium term operational plan is developed and implemented to assure within five years that >90% of the CIAT genebank accessions are available and remain available for immediate distribution.	The matter here is basically a financial one: we need to duplicate the acreage for seed multiplication in the stations of Quilichao for forages and Tenerife for beans, and accordingly the numbers of field workers during the 5-years duration of that plan. CIAT will provide by 4 August 2013 a budget so that this activity can be covered with one-off funds.	The reviewers' recommendation concurs with a need that has been expressed by the CIAT genebank manager for several years. However, the issue is not solely a financial one. Routine costs at CIAT have risen by 25% since the Costing Study. Until CIAT accepts that routine operations (involving the regeneration of c4,500 seed accessions per year) must be supported within the boundaries of the Costing Study, the Trust will not be able to disburse finances to support additional operations. A further point, which is relevant here, refers to recommendation #10, where the reviewers advise that CIAT reduces the size of the forage collection and the cost of maintenance. The Trust hopes to see a serious attempt to rationalize the forage collection and reduce the quantity of accessions requiring seed increase.
6. Mid-term storage	The duration of the temporary stay of seed material in the cold room at 7°C in	Agreed. The limit of two years (applicable to tropical forages and a few wild beans) is written in the	Again the QMS and SOPS come up here as they will track what is occurring in practice and not just what is in

	Recommendation	Responses by CIAT	Responses by Crop Trust
	preparation for long term storage is reduced considerably, preferably to a two years maximum. The Review Panel expects significant progress to be made in this direction within two years. This will require adaptations in the seed handling protocols currently used.	protocol already published on the website. A review of the seed materials kept in the Temporary Storage Room has been launched, sending materials with above 85% viability to the Long-term Cold Room, and those with lower viability to regeneration (along Recommendation #5).	the protocol. We are happy to see that CIAT is responding to this important recommendation. The Trust supports the reviewers' recommendation that all materials are stored at 7°C for no more than two years and hopes that this is fully actionable.
7. External services	Given the need for crop rotation, the unique eco-geographical circumstances of the regeneration sites and the demonstrated agronomic skills of the local staff, GRP should look at options for sharing these resources with other CRP genebanks (or other institutes) on at least a cost recovery basis.	We concur. As far as tropical forages are concerned, the options indicated by the Panel will be discussed with ILRI as part of the rationalization of collections. The proposal made to CATIE for cucurbits and other Central American vegetables will be re-visited, in consultation with the Global Crop Diversity Trust and the Asian Vegetable Research and Development Center.	The CIAT field sites offer potential locations for several CG Centres and national partners. The costs, feasibility and logistics of regenerating accessions from outside Colombia clearly need some examination before offering this service. Given the uniqueness and excellent management of these sites the various options are worth pursuing.
8. Safety duplication	The GRP takes urgent action to safety backup the entire seed collection at both primary and secondary levels, considering Svalbard as a secondary backup.	We concur. It is part of the same plan referred to in reply to Recommendation #5, by which seed stocks are equally refilled for the distribution and for the safety backups towards CIMMYT and Svalbard.	Agreed both to recommendation and response.
9. Succession plan	A succession plan for the key positions in the GRP is formulated within the next six months. The possibility of creating a deputy head position for the GRP should be explored.	We concur. A deputy head position in the GRP is possible, if funds are provided. If so, the two IRS positions would take a major part in the implementation of global outreach for the Global Crop Diversity Trust in the Americas, namely with partners such as Mexico and Brazil. The costing of the position will be included in the budget to be submitted on 4 August 2013.	Agreed. However, this, we understand, will be a new, permanent position, which should be considered part of routine operations. The costing for this position should be presented as an individual item and options for its financing considered and shared with the CRP Management Team.
10. Forage global strategy	A strategy is developed within a year, together with ILRI, regarding a rationalisation of the tropical forages collections with the aim of clearly prioritizing and distinguishing accessions for conservation and	Agreed. Action has been already launched on this, by sending an outline of a tropical forage strategy to ILRI.	We are glad to hear that this issue will be taken up by both CIAT and ILRI in coordination. We note that the reviewers are seeking not just rationalization between the two collections but reduction in the sizes of both collections. The different options should be considered, the community consulted and a plan presented to the

	Recommendation	Responses by CIAT	Responses by Crop Trust
	regeneration at ILRI and CIAT, clarifying and consolidating their individual roles and areas of collaboration, and enabling a considerable reduction in the sizes of the collections and the costs of the maintenance. This strategy should be implemented fully in the two following years.		CRP.
11. Collaboration with CRPs	In order to explore opportunities for more productive collaboration between the GRP and the commodity CRPs, a regular exchange between the GRP manager and senior staff of the relevant CRPs (3.4, 3.5, 3.7) is established, via participation in meetings and joint planning activities. This exchange and the resulting activities are reported annually to the Global Crop Diversity Trust (GCDT).	We concur, as time and travel budget permit. This collaboration is already taking place: for example, in the Root, Tuber and Banana CRP, there is a joint screening of cassava genetic resources for viruses of quarantine importance, as well as training for professionals from Uganda in in vitro techniques in summer of 2013. As another example, critical information for wide crossing in beans has been provided for the successful interspecific breeding in the legumes CRP.	The Trust recognizes that linkages exist. However, there are numerous cross-cutting areas (e.g. virus diagnostics research, international movement of cassava germplasm, use of research results to feed into collection management, gap analysis, impact studies, etc) that would benefit from closer collaboration between the GRP and other units within CIAT or research CRPs. We would like to see an active effort and mechanisms in place to ensure that the GRP is consulted in the development and execution of workplans involving genetic resources within the research CRPs in which CIAT is involved.
12. Capacity building	The Review Panel has substantial concerns about the quality of the work of the genetic quality laboratory (weak methodologies, lack of strategic direction), and recommends that the GRP explores and implements collaboration with other CIAT departments for this type of enabling research which should ensure publication in international journals.	Agreed. CIAT human resources is working on staff phase out that has to occur under Colombian laws. In the Staff succession plan, this part will be strengthened by close collaboration with Biotechnology.	We are relieved to hear that this issue is being addressed. We look forward to hearing the concrete plans for improving this area of work.
13. Data access	Information on germination testing over storage time of the wide range of species in the genebank is compiled and made clearly available online so that	Full agreement on this recommendation. Soon after the Review a set of experiments have been discussed with CIAT statistician in order to publish the seed storage behaviour of a first set of wild bean species,	We are very happy with this recommendation and response.

	Recommendation	Responses by CIAT	Responses by Crop Trust
	others may benefit from the findings of the long-term investigations.	and tropical forages will follow.	
14. Capacity building	The Review Panel observed that the capacity in the field of seed physiology and data analysis is below expectation and recommends that this capacity is enhanced through training to allow better interpretation of the seed quality results thus improving the quality of the genebank operations.	A postdoc trained at U. Reading in seed physiology through the Staff Capacity Development Fund was lost during one of the previous financial crisis. That capacity can be re-built. In line with Recommendation #9, one of the two technicians working in seed germination testing and retiring soon, will have a formal training at the Millennium Seed Bank.	We agree that this recommendation can be addressed through recommendation #9. It is good to hear about the connection with the Millennium Seed Bank and trust that the retiring technician will formally impart the training received to CIAT staff.
15. Cryopreservation	Given the attraction of cryopreservation for securely backing-up the cassava collection in the long term a proposal for the wide scale application of the developed droplet vitrification methodology is developed urgently by the GRP together with the CIAT cryopreservation experts for consideration by the Global Crop Diversity Trust (GCDT).	the proposal is being written, and will be sent to the GCDT; updating of the proposal will be done during the Annual Genebank Meeting of September 2013.	The Trust is supportive of this recommendation and will be working with CIAT this year at the AGM and afterwards to develop a cryobanking workplan for cassava within the framework of a QMS.

External Review of the CIAT Genetic Resources Programme Commissioned by the Global Crop Diversity Trust

Theo van Hintum¹, Luciano Nass² and Hugh W. Pritchard³

April 8 - 12, 2013, Cali, Colombia



¹Centre for Genetic Resources, The Netherlands (CGN), Wageningen University and Research Centre, The Netherlands



²Brazilian Agricultural Research Corporation (Embrapa), Brazil



³Royal Botanic Gardens, Kew, UK



Table of Contents

Abbreviations and Acronyms	9
Executive Summary	10
Background	11
<i>Aim of this review</i>	11
<i>Review methodology</i>	11
Review of Gene Bank Operations	13
<i>General observations</i>	13
<i>Specific observations and recommendations</i>	13
1 - <i>Optimisation of procedures</i>	13
2 - <i>Germplasm health laboratory</i>	14
3 - <i>Risk assessment</i>	15
4 - <i>Documentation of procedures & QMS</i>	15
5 - <i>Seed availability</i>	15
6 - <i>Medium term storage</i>	16
7 - <i>Capacity sharing / service provision</i>	16
8 - <i>Safety duplication of collections</i>	17
9 - <i>Succession planning</i>	17
10 - <i>Forages collection strategy</i>	17
11 - <i>Collaboration with CRPs</i>	18
12 - <i>Genetic quality laboratory</i>	18
13 - <i>Seed storage knowledge</i>	19
14 - <i>Seed quality testing</i>	19
15 - <i>Cryopreservation</i>	20
<i>Concluding remarks</i>	20
Annexes	21
Annex 1: Terms of Reference to the Review Panel.....	21
Annex 2: Biopics of the Review Panel members	23
Annex 3: Schedule for Review Panel	25
Annex 4: List of people the Review Panel met at CIAT	28
Annex 5: List of documents provided to the Review Panel	29
Annex 6: Flow chart of GRP activities (beans and forages)	30
Annex 7: Flow chart of GRP activities (cassava).....	31

Abbreviations and Acronyms

CG	CGIAR
CGIAR	Consultative Group on International Agricultural Research
CGN	Centre for Genetic Resources, The Netherlands
CIAT	International Center for Tropical Agriculture
CIP	International Potato Center
CRP	CGIAR Research Program
FAO	Food and Agriculture Organization of the United Nations
GPG2	The Collective Action for the Rehabilitation of Global Public Goods in the CGIAR Genetic Resources System – Phase 2
GRP	CIAT's Genetic Resources Programme
ICA	Colombian Institute of Agriculture
ILRI	International Livestock Research Institute
INIBAP	International Network for the Improvement of Banana and Plantain
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
LTS	Long term storage
MTS	Medium term storage
RP	Review Panel (as commissioned by the Trust)
QMS	Quality management system
Trust	Global Crop Diversity Trust
USDA	United States Department of Agriculture

Executive Summary

The Consultative Group on International Agricultural Research includes 11 genebanks in its CGIAR Research Programme (CRP). Responsibility for the genebank CRP resides with the Global Crop Diversity Trust (GCDT), which commissioned the Review Panel to assess the efficiency and effectiveness of the gene bank operation at CIAT for the conservation and use of collections of bean, cassava and tropical forages.

Prior to visiting the gene bank at CIAT the Review Panel* secured end-user feedback on the collections. Thereafter, the Review Panel spent five working days at CIAT (8-12 April 2013) specifically reviewing: 1) the operations and activities of the genebank; 2) the roles, services and use of the gene bank, and the linkages with users and partners both within and outside the CGIAR; 3) the status of the gene bank and individual collections within it, in the context of a global system for long-term conservation and use of the crop(s) in question; 4) any outcomes or impact specific to the provision of the long-term grant; 5) the general appropriateness of current expenditures for the routine operations of the gene bank with reference to the Costing Study estimates.

The Review Panel decided on a series of actionable recommendations relating to the genebank's: **Organisation** (four actions on: optimisation of procedures; expansion of the seed health laboratory; need for a complete risk assessment; and the complete documentation of protocols); **Operation** (four actions on: the vast majority of accessions being available for immediate distribution; reducing medium term storage to two years maximum; sharing regeneration site resources; and urgent safety duplication of collections); overall **Strategy** (two actions on: succession planning; and the development of a forage collections strategy with ILRI); and innovative **Science** (five actions on: more collaboration with the commodity CRPs; primary delivery of genetic quality research by collaborating with other CIAT departments; dissemination of existing seed germination and storage data; building capacity in seed physiology and data analysis skills; and implementing cryopreservation for the cassava collections).

The Review Panel acknowledges the high level of preparation by genebank staff and the leadership for the review. Beyond the recommendations above, the Review Panel notes the generally high satisfaction of users of the collections, the overall effectiveness of the gene bank operation, particularly documentation and seed health, the high standard of agronomy and the role of the gene bank's knowledgeable leader. The arrangements for touring the facilities at CIAT and the field sites, the scheduling of meetings and the general support were first class. The Review Panel is also grateful to the DG of CIAT and the senior management team for making time available to see us. Finally, the RP recognise the excellent interaction with three members of the GCDT (Paula Bramel, Charlotte Lusty and Anne Clyne), prior to the visit and on site.

*Theo van Hintum, Luciano Nass and Hugh W. Pritchard

Background

CIAT's Genetic Resources Program (GRP) is located in the CIAT campus in Cali, Colombia, and it hosts the world's largest genetic holdings of beans (37,302 accessions), cassava (6,632 accessions), and tropical forages (23,140 accessions), obtained or collected from over 140 countries. These accessions are maintained under an agreement with the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) of the Food and Agriculture Organization of the United Nations (FAO). As part of this agreement, CIAT has agreed (a) not to claim legal ownership over the designated germplasm, nor seek any intellectual property rights over germplasm or related information, (b) to manage and administer the designated germplasm in accordance with internationally accepted standards, including ensuring the material is duplicated for safety, and (c) to make small quantities of germplasm and related information freely available for the purpose of scientific research, plant breeding or genetic resource conservation, under a standard Material Transfer Agreement that is used by the CGIAR for all in-trust materials.

CIAT, and its GRP, can only function thanks to the support of all levels of the Colombian Government, including the productive collaboration with the Colombian Institute of Agriculture (ICA). This support and collaboration is not a natural fact, and should be highly valued.

In 2012 a CGIAR Research Programme (CRP) for the management of the CG genebanks was approved with the objective to "conserve the diversity of plant genetic resources in CGIAR-held collections and to make this diversity available to breeders and researchers in a manner that meets high international scientific standards, is cost efficient, is secure, reliable and sustainable over the long-term and is supportive of and consistent with the ITPGRFA". The Trust has accepted the responsibility of managing this CRP, as part of its leadership role in managing the funding of CGIAR genebanks.

This review of the CIAT GRP has been undertaken in the context of the monitoring mechanism of the CRP, but also of the longer term objective of creating sustainable genebank operations in the CGIAR.

Aim of this review

This review aims to assess the efficiency and effectiveness of the genebank operation as a whole, and the status of the CIAT genebank within the context of the global system for the conservation and use of the crops in question, i.e., bean, cassava and tropical forages. The terms of reference of the review included the following elements (for the complete text see Annex 1):

- Assess the operations and activities of the genebank;
- Assess the roles, services and use of the genebank, and the linkages with users and partners both within and outside the CGIAR;
- Consider the status of the genebank or individual collections within it, in the context of a global system for long-term conservation and use of the crop(s) in question;
- Assess any outcomes or impact specific to the provision of the long-term grant;
- Review the general appropriateness of current expenditures for the routine operations of the genebank with reference to the Costing Study estimates;
- Provide actionable recommendations related to all of the above.

Review methodology

A Review Panel (RP) was created consisting of three scientists with expertise in the fields of genebank management, seed storage, cryopreservation, research collaboration and research management (for

their backgrounds see Annex 2). With active support from the Trust and the GRP, the RP studied a large number of documents (see Annex 5), and approached a number of GRP users. On this basis, a review visit to the GRP facilities was made from April 3rd to 8th, 2013 (for the program see Annex 3, and for the people met see Annex 4). During this review visit the panel was accompanied by three Trust staff members, Charlotte Lusty (scientist, support person to the RP), Paula Bramel (assistant Executive Director) and Anne Clyne (director Director of Finance), who reviewed the financial affairs related to the CRP. On the last day of the visit the preliminary conclusions were presented to GRP staff and CIAT senior management. A report was drafted that, after a fact-check by the GRP, was sent to CIAT management for an official response, to which in turn the Trust responded. These responses are also reflected in this report.

Review of Gene Bank Operations

General observations

The Review Panel (RP) came to the general conclusion that Genetic Resources Programme of CIAT operates a very good genebank!

In preparation of the review, the RP approached 43 users of the CIAT genebank, based on a random list of users provided by the GRP. Responses of 16 of these users were received, and all of them were highly positive. To give an example, the respected US scientist Paul Gepts called the GRP "... one of the best organised units in the world, both CG and non-CG ..." and stated that "... operations of the collection, in terms of seed increase, viability and disease testing, etc., are a model for other PGR Units as to systematic conservation, rigour of operations ...". If there were points of criticism, they were mainly related to the (non-)availability of material, an issue that will be tackled in one of the recommendations (see recommendation #5). The feedback of these users, together with the outcome of a questionnaire-based survey of CIAT genebank users that was done in 2012, provided the basis of this review.

Visits to the GRP facilities gave an impression of a well-organised, clean and effective operation. However since the organisation has grown organically over the years, and the building was never intended for its current purpose. For example, the roof terrace was transformed into a meeting room. The building that initially was intended to be a slaughterhouse is rather old, and could be considered for renovation. The way the sections are separated make sense, i.e., the seed health separate from the cleaning of the seed that is in turn separated from the actual storage. The RP had some concerns about the safety provisions (see recommendation #3).

The genebank documentation is handled with care and knowledge, using an in-house developed, well-organised database management system based on Oracle. The data are published on the web in an accessible web-site. The RP feels confident that the documentation staff, in collaboration with the CIAT-IT department, is well on top of the job.

Another area where the RP was positively impressed was the agronomy at the regeneration sites. There was a remarkable ability to adapt methods and find solutions for the wide diversity of material from that immense array of species conserved mainly in the tropical forages collection. The highly skilled and dedicated staff was able to organise the operation very well as could be seen from the well maintained field plots.

Finally, the GRP benefits tremendously from the inputs of with a highly respected and exceptionally knowledgeable programme leader, Daniel Debouck.

Specific observations and recommendations

Recommendations 1-4 regarding the organisation

1 - Optimisation of procedures

The operational procedures of the CIAT GRP have grown organically as the need for them arose (for a flow chart of operations see Annex 6 and 7). Most of these procedures seem adequate. However, the

Review Panel identified a number of procedures that should be reviewed and rationalised, particularly regarding the technical details of some genebank methodologies. The procedures need objective review, critical or redundant areas identified and addressed so that processes are streamlined and fully justifiable. The documentation of procedures (as suggested in recommendation #4) might function as a basis for identifying these processes. However, if this documentation is not ready yet, a preliminary overview of procedures should be conducted by GRP staff, and the most likely candidates selected for full technical review. The Review Panel believes that improved procedures can be developed that will reduce the number of handling operations, for example:

- a) for the drying process, 'why have three cycles of drying?';
- b) for viability testing, 'why do tests in years 0, 5 and 10?';
- c) for the *in vitro* management, 'why use 5 tubes of 3 plants each?'

It is expected that rationalisation of procedures will result in savings that can be employed elsewhere in the GRP.

Recommendation 1: The genebank procedures in the GRP are in need of objective review. The Review Panel believes that given the nature of these procedures there is space for optimisation thus potentially creating capacity that can be used elsewhere in the GRP. These optimisations should be inventoried by an independent genebank expert within the next 18 months.

2 - Germplasm health laboratory

The Review Panel was impressed by the careful planning to protect the seed accessions from any risk of cross contamination by pests and diseases, by locating the germplasm health laboratory (GHL) in a separate building to both the viability testing and the long term store (LTS). The GHL is full part of the genebank, and provides the technical information on which the plant quarantine authority of Colombia, of the Colombian Institute of Agriculture (ICA) can issue the phytosanitary certificates. The GRP provides for the secretary, office space, services and operations for the CIAT-ICA agreement in relation to plant quarantine; ICA pays the salary of the plant quarantine officer. The GHL is populated by nine staff with a wide range of expertise, e.g., in fungal biology, virology, bacteriology and molecular characterisation. Using various methods (polymerase chain reaction [PCR], polyacrylamide gel electrophoresis [PAGE], *in vitro* culture), staff assess seed health, and inspect plant growing areas for plant disease. In the five year period 2008-12, staff tested c. 34,000 plant / seed samples, including 15000 bean samples for the GRP and 6000 samples for other CIAT projects. During this interval about 80% of bean accessions tested were given a clean bill of health. Cassava certification represents a significant part of the work, running at about 200 molecular tests per week. The innovative development and application of a new test for the viruses responsible for Frogskin Disease (FSD) in cassava has reduced the disease detection time from 72 weeks in the field to 5 days in the laboratory. In addition to the predicted annual throughput of cassava samples to be tested, health evaluation is needed on c. 400 *in vitro* samples from wild species, and the whole cassava collection needs screening for FSD. In addition to a tour of the facilities and meeting the staff, the Review Panel met with the ICA Plant Quarantine Officer, who confirmed that working relations with the Germplasm Health Laboratory under the ICA-CIAT letters of agreement were excellent, and expressed the wish to strengthen collaborative research under the agreement. The Panel were left in no doubt as to the quality of the work in this laboratory, but identified significant risks from the co-location of staff desk space and the laboratory work.

Recommendation 2: Given the high quality and volume of work of the germplasm health laboratory, and the projected future demands likely to be placed upon this unit, solutions have to be created to accommodate the staff so that they are able to have dedicated desk space and maintain ample lab space.

3 - Risk assessment

Plant genetic resources conservation relies on secure storage of the germplasm. One of the elements of this security is a proper analysis of the risks that threaten the collection, including fire and earthquakes, but also the sudden loss of key personal, political unrest or other undesired and often unexpected circumstances. The second Global Public Goods programme (GPG2) that was, inter alia, aimed at developing tools for a better management of the CGIAR PGR collections developed an elaborate tool for risk assessment in plant genebanks (<http://www.sgrp.cgiar.org/?q=tool>). The risk assessment prepared by the GRP and presented to the Review Panel was unsatisfactory since it failed to address the full spectrum of risks as identified by the GPG2. Therefore, the Review Panel recommends that a new risk assessment is carried out on the basis of the tools developed in GPG2. To avoid the blind spots of the GRP staff, it is furthermore advised to involve outside expertise, possibly the scientists involved in the development of the GPG2 tools. Given the availability of the tools and the urgency of the matter, the results of the assessment, including the necessary plans for mitigating actions, should be presented to the Trust within 18 months.

Recommendation 3: Using the tools and capacity created by the GPG2 programme, a complete risk assessment is carried out for the GRP within 18 months. This should be based on the advice of an external expert.

4 - Documentation of procedures & QMS

As described in the first sections of this report, the Report Panel observed a genebank operation of very high quality, with generally very good staff. Most of the procedures applied are of high quality. However, the Review Panel observed that only very few have been documented on a level that would allow an outsider to understand how 'things are done'. Documenting procedures has a number of advantages. 1 - New staff members can study and apply the procedures. 2 – Outsiders can study the applied procedures, question them and propose improvements. 3 – A quality management system (QMS) - including audits - can be easily set up. 4 – Other institutions can learn from the experience that has been build up. Since it can be expected that in the near future the CRP will demand at least a minimal QMS, all efforts in describing the procedures can be considered an investment in the future. By publishing the procedures on-line, transparency is improved and based on the facilitated feedback, an increase in the quality of the procedures and thus the cost effectiveness and reliability of the operations can be expected.

Recommendation 4: A proper and complete documentation of the genebank protocols, especially in the context of succession planning, is developed within two years. The protocols should cover all basic elements of the genebank operation and be published on the website. The protocols will form the basis of a QMS that is expected to be developed over the coming years.

Recommendations 5-8 regarding the operation

5 - Seed availability

A genebank must be, in general and especially those in the CGIAR system, a reliable repository of germplasm for conservation and access, i.e., all germplasm should be conserved in a sustainable way and be accessible for use. According to the current procedures, the GRP is clearly failing in delivering on the second commitment as approximately one third of the material is currently not available, even though it is presented as genebank material on the GRP's website. This situation is highly undesirable

and has the potential to generate damage in terms of public relations for both the CIAT genebank and the entire CGIAR. The lack of sufficient material for distribution is caused by a continuing backlog in regeneration stretching back a decade, caused by a lack of capacity and the high standards set in terms of minimally required seed quantities. To resolve this problem several solutions are available, including an increase of the regeneration capacity with the associated costs, a reduction of the required number of seeds or a reduction of accessions listed as part of the collection. The solution of this problem will consist of a combination of these options, and should be implemented in a responsible but also rapid fashion.

Recommendation 5: A medium term operational plan is developed and implemented to assure within five years that >90% of the CIAT genebank accessions are available and remain available for immediate distribution.

6 - Medium term storage

The genebank accessions at CIAT-Genetic Resources Programme are extensive, and comprised of the following materials in the Multi-Lateral System of the ITPGRFA: 37,302 (40 taxa) of beans; 6,632 (33 taxa) accessions of cassava; and 23,140 (734 taxa) of tropical forages. In total, this amounts to 67,074 accessions held in the GRP. The broad objective is for all accessions to be of sufficient quantity and quality of seed to meet the five conservation needs (i.e., long term storage, viability monitoring, distribution (over the 30 years to come), country of origin, and safety backups, currently CIMMYT and Svalbard). To meet these objectives, a threshold number of high quality seed is required. Until this seed number is achieved, seeds are held in plastic bottles under medium term storage (MTS) conditions at c. 7°C. Although the seeds at this stage have been pre-dried (at c. 17°C) to 25% relative humidity, the MTS conditions will permit the start of seed ageing much sooner than storage at -20°C (in foil laminate bags). Based on information in the 2012 reports, the GRP is holding 12,188 bean accessions (i.e., 33%) in MTS. Similar datum for forage seed is 8,756 accessions (i.e., 38%) held in MTS. Moreover, 8,842 bean and 3,537 forage accessions have been in the MTS for 6 – 35 years since the last regeneration. The Review Panel believes that the holding of seed accessions in MTS for such times is unnecessary, will compromise long-term storage performance, reduce the time interval to regeneration (at 85% viability) and thus increase genebank handling costs (human resource and consumables).

Recommendation 6: The duration of the temporary stay of seed material in the cold room at 7°C in preparation for long term storage is reduced considerably, preferably to a two years maximum. The Review Panel expects significant progress to be made in this direction within two years. This will require adaptations in the seed handling protocols currently used.

7 - Capacity sharing / service provision

The origin of the accessions maintained in *ex situ* collections can affect the level of difficulty in seed regeneration, since the accessions will have different needs in terms of climate and soil conditions, temperature requirements (e.g., daily maxima and minima). Consequently, the regeneration of significant quantities of high quality seed can be a serious challenge. Passport information and/or personal knowledge of the most suitable environment of each accession are fundamental to the delivery of successful and efficient regeneration processes. Genebanks usually have limited areas (hectares and environments) to conduct their regeneration activities. However, this is not the case for the GRP, which has access to numerous growing sites including Quilichao (c. 1000 m a.s.l.) and Tenerife (c. 2200 m a.s.l.) – two sites that the Review Panel visited. Based on the need for crop rotation and the area available for the regeneration of high numbers of accessions, the Review Panel

see considerable opportunity for the GRP to collaborate with other CGIAR Centres and other scientific institutes in the production of seeds of high quality and quantity. The identification of possible partners to regenerate the accessions is highly desirable.

Recommendation 7: Given the need for crop rotation, the unique eco-geographical circumstances of the regeneration sites and the demonstrated agronomic skills of the local staff, GRP should look at options for sharing these resources with other CRP genebanks (or other institutes) on at least a cost recovery basis.

8 - Safety duplication of collections

Based on the 2013 self-assessment document produced by the GRP, the safety backup contains 65.2% and 53.5% of the beans and forages accessions, respectively. For security reasons, safety backup, which was initiated in 2004 at CIMMYT, must be a priority to any genebank. The Review Panel recognises that considerable effort has been put into sending seed material to the Svalbard facility in the past few years. However, it should be remembered that Svalbard is to be considered only as a secondary backup.

Recommendation 8: The GRP takes urgent action to safety backup the entire seed collection at both primary and secondary levels, considering Svalbard as a secondary backup.

Recommendations 9-10 regarding the strategy

9 - Succession planning

GRP has a team of staff who are very well trained, motivated and committed with their responsibilities. Nowadays, there are 66 persons enrolled with the Unit, including technicians and 13 researchers. Genebanks are involved with several activities, such as collecting, introduction, characterization, evaluation, documentation, and conservation. Another important service provided by them is the availability of accessions of high quality. Specific knowledge is required in relation to the species maintained. The GRP has a highly respected and exceptionally knowledgeable leader with an international scientific reputation. However, the Review Panel believes to it to be necessary to appoint a Deputy Head of the GRP in order to avoid discontinuity in the leadership of genebank activities, and to be involved in decisions regarding strategic options for the future since the GRP leader is approaching retirement. A Deputy Head with significant scientific knowledge in keys areas, such as use of genomic techniques and seed physiology, would contribute considerably to an improvement in the quality of the research. In addition to the Head of the GPR, the Review Panel note that other very experienced staffs are approaching retirement age.

Recommendation 9: A succession plan for the key positions in the GRP is formulated within the next six months. The possibility of creating a deputy head position for the GRP should be explored.

10 - Forages collection strategy

CIAT has been responsible for the maintenance of the tropical forage legumes and grasses collections, which are of value in adaptation to low fertility soil with high aluminium. Another forage collection is held by ILRI, which consists of accessions – mainly of African provenance - adapted to high and mid-altitude tropical and subtropical forages. Despite some differences between the two collections in respect to the agro-ecological aspects of maintaining and regenerating the accessions,

there is enough information to indicate that redundancy of collections between the two is high. For example, previous reports on ILRI's collection identified about 3000 duplicated accessions with CIAT's materials. Accordingly, the Review Panel considers it to be essential that a strategy is developed to rationalise these two collections. It is also crucial that redundant accessions are removed, thereby reducing the costs of both collections.

Recommendation 10: A strategy is developed within a year, together with ILRI, regarding a rationalisation of the tropical forages collections with the aim of clearly prioritizing and distinguishing accessions for conservation and regeneration at ILRI and CIAT, clarifying and consolidating their individual roles and areas of collaboration, and enabling a considerable reduction in the sizes of the collections and the costs of the maintenance. This strategy should be implemented fully in the two following years.

Recommendations 11-15 regarding the science

11 - Collaboration with CRPs

CGIAR has recently experienced major changes in the way the Centres operate. Since the *modus operandi* changed the Centres have been interacting among each other in a more intensive manner, leading to the development of the new CGIAR Research Programs (CRPs). Considering that the CIAT genebank (GRP) includes cassava, beans, and forage, it is natural to expect a significant collaboration with CRP 3.4 (Roots, Tubers and Bananas), CRP 3.5 (Food Legumes), and CRP 3.7 (Forages). However, based on the discussions and observations the Review Panel had during the review of CIAT's genebank, a lack of interaction between GRP and these CRPs was detected. Since the objectives of any genebank are to provide materials and to promote utilization, the Review Panel sees an important opportunity for collaboration between CIAT's genebank and related CRPs.

Recommendation 11: In order to explore opportunities for more productive collaboration between the GRP and the commodity CRPs, a regular exchange between the GRP manager and senior staff of the relevant CRPs (3.4, 3.5, 3.7) is established, via participation in meetings and joint planning activities. This exchange and the resulting activities are reported annually to the Global Crop Diversity Trust (GCDT).

12 - Genetic quality laboratory

The genetic quality laboratory of the GRP is intended to give answers on a scientific basis to questions regarding the quality of the genebank operations. These questions can be related to the genetic integrity of regenerations, occurrence of soma-clonal variation in *in vitro* or in cryo-maintained material, optimisation of the composition of the collections, etc. The Review Panel had the strong impression that the current genetic quality laboratory is not able to do this at an appropriate scientific level. It appeared not to be able to define detailed experiments, or to critically assess and interpret the results. The lack of outputs in the form of scientific papers supported this impression. This fact, combined with the availability of high quality state-of-the-art facilities and scientific capacity elsewhere on the CIAT campus, urged the Review Panel to propose that the GRP considers reallocating the funds for this type of research to other facilities on the campus. GRP staff should formulate the questions, and in collaboration with other CIAT research groups design and perform experiments using the research infrastructure of these groups. These experiments should result in both answers to the pertinent questions, and in joint scientific papers. Collaborations of this type are also important in regards the foreseen 'digital future' of the genebank in which sequence-based information will determine the genebank services. Further investments in the current inferior biotechnology laboratory of the GRP are therefore strongly discouraged.

Recommendation 12: The Review Panel has substantial concerns about the quality of the work of the genetic quality laboratory (weak methodologies, lack of strategic direction), and recommends that the GRP explores and implements collaboration with other CIAT departments for this type of enabling research which should ensure publication in international journals.

13 - Seed storage knowledge

Seed quality assessments through germination testing are an essential part of genebank operations. A test made during the early stages of storage, often after the final drying step, provides the evidence of whether the seed accession is tolerant to drying, and thus not 'recalcitrant' in storage behaviour. Thereafter, germination testing at relatively regularly intervals during long-term, dry storage indicates the longevity properties of the accessions ('orthodox' seed response). The Seed Testing Laboratory of GRP tests about 11,000 accessions per annum, through the work of two or three staff members. Forage accessions are tested on germination test papers in temperature-controlled incubators operating at 35°C (day) / 20°C (night). In contrast, bean accessions are sown in trays in a sand-compost mix and maintained in an outdoor growing area under ambient conditions. Overall, about 28,000 and 14,000 germination tests have been carried out on bean and forage accessions, respectively, in the last five years (2008-12). Since the establishment of the GRP, about 36,000 accessions, across 255 species, have been shown to be orthodox and other evidence is emerging on the storage response of 543 forage species. The Review Panel recognise that the information on germination and storage performance generated so far on a wide range of species represents a very significant contribution to seed banking knowledge.

Recommendation 13: Information on germination testing over storage time of the wide range of species in the genebank is compiled and made clearly available online so that others may benefit from the findings of the long-term investigations.

14 - Seed quality testing

As stated above, the Seed Testing Laboratory of GRP is engaged in the large scale testing of seed quality during the storage of accessions. The time interval to regeneration (at 85% viability) is dependent on an accurate estimate of the pattern of viability loss in time, which at GRP is assessed initially after 0, 5 and 10 years. The precision of the longevity prediction is not only a function of the regularity of generating storage data but also the number of seeds used to assess viability at each time point. Of equal importance is the need to quantify the proportion of seeds that are dormant, particularly in the forage species, as the presence of this trait will mean that the determined germination value may not be equivalent to the viability of the accession (at any moment in time). Laboratory staffs have some experience in applying the triphenyl tetrazolium chloride (TTC) vital staining method to seeds that have not grown in the germination test, which can give an estimate of the dormant seed fraction. However, the Review Panel were not convinced that the most robust protocols were in operation for the assessment of seed viability or the interpretation of seed viability loss curves, which would impact on decisions about when to regenerate a seed sample.

Recommendation 14: The Review Panel observed that the capacity in the field of seed physiology and data analysis is below expectation and recommends that this capacity is enhanced through training to allow better interpretation of the seed quality results thus improving the quality of the genebank operations.

15 - Cryopreservation

Although the history of seed cryopreservation stretches back to the 19th century, the application of low temperature science to the conservation of plant genetic resources is a modern construct of about the last 30 years. During this latter period, plant tissue cryopreservation (especially of shoot-tips) has advanced through innovations in the development and use of highly concentrated cryoprotective agents (CPA), in particular the so-called vitrification solutions. Via the application of various methodological systems, more than 100 species have now been shown to survive cryopreservation with vitrification solutions. Consequently, genebanks in the USA (USDA), Peru (CIP) and Belgium (INIBAP) have committed to using this technology for the *ex situ* conservation on clonal crops in particular. The Review Panel was impressed by recent progress within CIAT in the development of droplet vitrification for the cryopreservation of cassava *in vitro* shoot-tips from accessions initiated from different eco-geographical regions. Since cryobanking ensures long-term security of the clonal collection, eliminating the need for cumbersome safety duplication of *in vitro* cultures, and because of this 'proof-of-concept' of methodology and the success of similar work on other cassava accessions at IITA, the Review Panel is convinced that the time is right for the establishment of a programme to systematically cryopreserve the >6000 cassava accessions currently held in the *in vitro* core collection. These cryobanking activities are to be carried out as a safety back-up of the efforts to conserve the accessions as they are currently maintained *in vitro*.

Recommendation 15: Given the attraction of cryopreservation for securely backing-up the cassava collection in the long term a proposal for the wide scale application of the developed droplet vitrification methodology is developed urgently by the GRP together with the CIAT cryopreservation experts for consideration by the Global Crop Diversity Trust (GCDT).

Concluding remarks

The Review Panel believes that the current GRP is operating at high technical and scientific standards, relative to most other genebanks in the CG and the rest of the world. The users of the CIAT genebank notice this and appreciate it very much. However, given the history of the GRP and the lack of a proper technical review in the past, there is quite some space to further improve the quality of the operations. For this reason the Review Panel formulated 15 recommendations that, with varying urgency, should be implemented over the coming years.

The Review Panel realises that the current genebank staffs are already very busy running the operation, and does not feel inclined to add further burden to the staff with these new activities. However it believes that the recommendations will be important for the rationalisation and optimisation of the current operations.

The Review Panel trusts that implementation of its recommendations will allow the GRP to move into a sustainable and reliable future.

Annexes

Annex 1: Terms of Reference to the Review Panel

Center Genebank review – Guidelines and Terms of Reference

The Global Crop Diversity Trust commissions the five-yearly review of the CGIAR Center genebanks in its role as Project Manager of the CGIAR Research Programme (CRP) for Managing and Sustaining Crop Collections and also as donor of long-term grants. This review aims to assess the efficiency and effectiveness of the genebank operation as a whole, and the status of the genebank within the context of the global system for the conservation and use of the crops in question.

The objectives of the review are to:

- Assess the operations and activities of the genebank;
- Assess the roles, services and use of the genebank, and the linkages with users and partners both within and outside the CGIAR;
- Consider the status of the genebank or individual collections within it, in the context of a global system for long-term conservation and use of the crop(s) in question;
- Assess any outcomes or impact specific to the provision of the long-term grant;
- Review the general appropriateness of current expenditures for the routine operations of the genebank with reference to the Costing Study estimates;
- Provide actionable recommendations related to all of the above.

Additional specific areas of focus for the review will be identified in phase 1 of the review.

In 2010, a comprehensive Costing Study was carried out of the genebank operations, which resulted in the publication of cost estimates for routine operations for each Center crop collection. These now form the basis of the funding allocations of the CRP and also of the Trust's endowment target. The current level of operation and operating costs may be an important consideration of the review if there are significant differences from the Costing Study. This will be clarified during the interactions with the Trust in phase 1 of the review. The Trust Finance Director will also undertake a two-day financial audit, during the review, and will provide any relevant findings to the panel. The overall responsibility to resolve financial and budgeting issues will remain with the Trust.

The review will be facilitated by a Trust member of staff, who will provide background information, coordinate the development of the agenda and the execution of the review on site. The Trust facilitator will participate in all review sessions unless requested not to, and will assist the Chair in any aspects of the review and the completion of the final report. However, the Trust will not take part directly in the formulation of the review report and recommendations.

The review will be undertaken in three phases:

Phase I: General background and literature review

Reviewers will be provided with the following documents:

Long-term grant agreement(s)

Annual long-term grant reports

Genebank Costing Study

Genebank CRP proposal

Genebank manuals, website and related materials

Relevant past donor or internal reviews of the genebank as given by the Center

Any other materials given by the Center as background for the review

All review panel members and the genebank manager will be involved in the development of the agenda for the site visit. This is an important process during which specific issues and questions are identified for review and relevant stakeholders and users within and outside the Centre are identified for consultation. Usually the site visit will involve interactions between the panel members and Center or CRP senior management and germplasm users, as well as the full genebank staff. There will also be at least one visit to field stations and, if feasible, national partner institutes. The panel members should determine the scale of these interactions. Any issues for clarification should be raised with the facilitator.

At least one interaction will take place in advance of the site visit between the panel members and Trust staff either through a visit to the Trust HQ or by conference call.

Phase II: Site visit and review of Centre gene bank

The panel members will conduct a site visit of the genebank following the agreed agenda. Given that discussions during the review are usually intensive, panel members may wish to review together the findings at the end of each day. There may also be a need to make adjustments to the agenda in order to pursue certain issues in greater detail. The draft recommendations will be presented to the Center staff and management on the last day of the site visit.

The Trust Finance Director will work with the Center financial staff in parallel to the panel review. Initial findings of the financial review will be shared with the panel members in order to inform discussions on general management, the appropriateness of genebank and institutional costs in relation to the Costing Study estimates, and any needs for investment in infrastructure or equipment. If necessary, the Finance Director may provide a recommendation for inclusion in the review report.

Phase III: Completing the report and presenting the recommendations

The review panel will produce a report of no less than 5,000 words in which actionable recommendations are clearly stated and justified. The report should be submitted to the Trust for initial review to ensure that the recommendations are clear and actionable. A response will be solicited from the Center by the Trust. Specific actions or workplans to respond to individual recommendations may be requested.

The Trust will, finally, provide its own response to the recommendations. In the event of a lack of endorsement by the Center or the Trust to a recommendation, further discussions may be necessary between the Trust, panel members and the Center staff. If necessary, the CGIAR Consortium Office or other bodies may be consulted.

The Trust Executive Board and the CGIAR Consortium Office will review the completed report. The report will also be made available on the Trust web site and circulated to the CGIAR genebank managers and presented at the Annual Genebanks Meeting.

Terms of reference of Review Panel members

The specific responsibilities of the Review Panel Members are to:

Review background documents and data

Participate in developing the site visit agenda

Conduct any background research, ground-truthing or informal consultation concerning the review crops or Center in preparation for the site visit

Participate in discussions with Trust staff to form an understanding of past interactions and experiences between the Trust and the review Center, and of future workplans for the Genebank CRP.

If required, present the aims of the review to the Center staff

Participate and/or conduct interviews with participants of the review

Contribute to the formulation of the review recommendations and the written report

If required, present the findings and recommendations of the review in subsequent relevant meetings.

In addition, a chair will be appointed by the Trust and will be required to take overall responsibility for:

- Organizing and conducting review presentations and interviews (unless otherwise delegated)
- Leading the panel members in formulating the recommendations and writing the review report
- Ensuring that the feedback from the Trust or review institute is adequately incorporated into the review report
- Ensuring that the formulation of the recommendations is based on principles of scientific and political objectivity, and that the interests or opinions of any one interviewee or panel member do not override this need for objectivity
- Ensuring that the final report is of an acceptable standard to the Trust.

Annex 2: Biopics of the Review Panel members

Theo van Hintum (Panel Chairman)

Theo has been with the Centre for Genetic Resources, The Netherlands (CGN) since its start in 1986. He started, still a student as database administrator, continued as scientist and later, senior scientist. In this capacity he is currently responsible for the documentation and methodology of the CGN.

Theo received his BSc in Plant Breeding (with honours), in 1986, from the then called Wageningen Agricultural University. In 1994 he received a PhD from the Swedish University of Agricultural Sciences, with the thesis : 'Drowning in the genepool, managing genetic diversity in genebank collections'.

His career at CGN included a five year period, January 2004 – June 2008, during which he was made available to the CGIAR Generation Challenge Programme (GCP) to act as Sub Programme Leader for Bioinformatics and Crop Information Systems, and in 2005 for a short while as Interim Director.

At CGN his research covered a wide array of topics related to plant genetic resources management. This included the application of new technologies, such as molecular markers or information technology, to genebank management, but also quantitative genetic approaches to the composition of genebank collections, so called core collections, and quantitative studies of genetic erosion.

Theo is active on several international platforms related to plant genetic resources management, did reviews and consultancies and has published over fifty papers in scientific journals.

Luciano Nass

Luciano received his BSc in Agronomy, in 1985. He got his MSc. (1989) and PhD. (1992) in Genetics and Plant Breeding. He has been with the Brazilian Agricultural Research Corporation (Embrapa) since 1989. Luciano spent about 10 years (1991 – 2001) as a visiting scientist at the Department of Genetics (Esalq/USP), teaching and working with several pre-breeding projects. In 2001-2002 he took a sabbatical leave at University of Wisconsin, Madison and was involved with the Germplasm Enhancement of Maize Project (GEM). Back to Brazil and Embrapa (2003 – 2005) he was the manager of the genetic resources team at Embrapa Genetic Resources and Biotechnology.

In 2005, he was selected to participate in the Embrapa's Virtual Laboratory Abroad (Labex Program) with a focus in Genetic Resources, at NCGRP/ARS/USDA, in Fort Collins, USA. He spent three years in this position, which gave him the opportunity to understand better the United States genetic resources program and also to interact with the American curatorship system.

In 2009, he joined the Secretariat for International Affairs as a Knowledge Exchange Coordinator. He is responsible for all scientific interaction that Embrapa has abroad, including the coordination of the Labex Program Labex implemented in the United States, Europe (France, UK, and Germany), South Korea, China, and Japan. From 2010 – 2013 he was a member of the CGIAR Fund Council, representing the Latin America and Caribbean countries.

Luciano has published several books focused in genetic resources activities, pre-breeding efforts, and plant breeding. He also published over thirty papers in scientific journals.

Hugh W. Pritchard

Hugh is Head of Research (Seed Conservation) at the Royal Botanic Gardens, Kew and a member of Kew's Senior Science Group. He has a PhD in plant cryobiology and 30 years' experience in genetic resources preservation, including as a member of the senior management team delivering the Millennium Seed Bank Project / Partnership. His research specialities include seed cryopreservation, germination modelling and stress biology. He has published >150 scientific papers (c. 50% in international peer-reviewed journals), including in the *Proceedings of the National Academy of Sciences* and *Trends in Plant Science*. His research work is multidisciplinary in approach and his research group has global connections, publishing with co-authors from >30 countries (from Brazil to China) in the last 10 years. He has been leader of three Darwin Initiative (UK) projects and currently leads for Kew on two EU Framework 7 projects on 'climate and seed quality' and 'native seed biology'.

In addition to being a publisher of the low temperature science journal *CryoLetters*, he has been chairman of the Society for Low Temperature Biology (2008-11) and a governor at Writtle Agricultural College (partner to the University of Essex; 2008-12). He is chairman of the Seed Storage Committee of the International Seed Testing Association. He holds honorary professorships from the University of Sussex and the Chinese Academy of Sciences, is a fellow of both the Linnean Society and the Society of Biology, UK and is an elected member of the Academy of Sciences of South Africa. He was a Senior International Visiting Professor with the Chinese Academy of Sciences in 2011.

Annex 3: Schedule for Review Panel

Monday 8th April (Day 1) to Friday 12 April 2013 (Day 5)

	Item	Participants involved	Objectives
Day 1			
07.30-09.30	Brief presentation by the Review Panel Chair and presentation of the genebank by GRP Head. Q&A	Senior management, CIAT staff, GRP staff. Review panel and Trust staff	To introduce the review panel and Trust staff to CIAT staff, to hear the highlights and plans of the GRP work in past 5 years and to understand the objectives of the review.
Break			
09.50-10.50	Linkages between CRPs and use of the GRP	CRP leaders (3.5 Food Legumes, 3.4 RTB, 3.7 Forages) and CIAT staff who use GRP, Review panel and Trust staff	To assess and discuss past, current and future use of the collections. To develop an understanding of the impact pathway from genebank to user and to explore current and potential entry points for the GRP into CRPs and vice versa.
10.50-12.00	Regional cooperation (Mexico, Brazil, USA and Colombia)	CRP leaders (3.5 Food Legumes, 3.4 RTB, 3.7 Forages) and CIAT staff who use GRP, Review panel and Trust staff	To assess and discuss past, current and future use of the collections and cooperation with national partners
Lunch			
13.00-15.00	Genebank: General presentation and tour Acquisition Conservation Distribution	Daniel Debouck, GRP staff, Review panel & Trust staff	To get to know the genebank and the people who work there. Introduction to all genebank operations and review of basic operations and main activities of the past 5 years
Break			
15.30-17.30	Time out	Review panel	Reviewers may chose to discuss further with Trust staff and/or GRP staff
15.30-17.30	GRP staff interactions with Trust staff	Paula Bramel, Charlotte Lusty, GRP staff	To discuss staff and administrative issues
Day 2			
07.30-12.00	Visit to field station Tenerife and Palmira (site of CIAT HQ)	GRP staff, Review panel, Paula Bramel and Charlotte Lusty	To view screenhouse, facilities in Palmira and seed production of bean and forages at Tenerife.
Parallel session 07.30-12.00	Financial budgeting and reporting	Anne Clyne & CIAT Finance staff	To review details of 2012 reporting and general costing procedures

Lunch			
13.00-15.00	Visit to genebank and laboratories: Viability testing, germplasm health, genetic quality	GRP staff, Review panel, Paula Bramel and Charlotte Lusty	To get to know the laboratories and the people who work there. Introduction to and review of basic operations and main activities of the past 5 years
Parallel session 13.00-15.00	Financial budgeting and reporting	Anne Clyne	To review details of 2012 reporting and general costing procedures
Break			
15.30-17.30	Time out	Review panel	Reviewers may chose to discuss further with Trust staff and/or GRP staff
Day 3			
07.30-12.00	Visit to field station at Sandander de Quilichao	GRP staff, Review panel, Paula Bramel and Charlotte Lusty	To view seed production of forages and field collection
Parallel session 07.30-12.00	Financial budgeting and reporting	Anne Clyne, Charlotte Lusty & CIAT Finance and Administrative staff	To review general budgeting and reporting procedures for the Trust long term grants and Genebank CRP
Lunch			
13.00-14.00	Data management issues/internet services	Documentation/IT staff, GRP head, review panel, Paula Bramel	To review GRP accession databases and online services
14.00-15.00	Cryoconservation	Cryopreservation staff, GRP head, review panel, Paula Bramel, Charlotte Lusty	To review the long-term conservation strategy for cassava and, if relevant, seed crops
Parallel session 13.00-16.30	Financial budgeting and reporting	Anne Clyne, Charlotte Lusty	To review details of 2012 reporting and general costing procedures
Break			
15.30-17.30	Time out	Review panel	Reviewers may chose to discuss further with Trust staff and/or GRP staff
Day 4			
07.30-09.00	Risk management, implementation and impact of the QMS	relevant CIAT staff, GRP Head, Review panel, Paula Bramel, Charlotte Lusty	To review the status of the risk management strategy for the genebank, the documentation of procedures & implementation of the QMS
09.00-09.30	Meeting with Human Resources and	relevant CIAT staff, GRP Head & staff,	To address any issues regarding staffing, staff retention and training, etc

	GRP staff	Review panel, Paula Bramel, Charlotte Lusty	
Break			
09.50-10.30	ICA Plant Quarantine	ICA staff, GRP Head, Review Panel, Paula Bramel	To review procedures and linkages between CIAT and ICA Plant Quarantine
10.30-11.30	Crop global system: international collaboration	Review panel, GRP Head, Paula Bramel & Charlotte Lusty, IITA, ILRI or ILRI genebank reviewers	Interactions with IITA, ILRI
11.30-12.00	Issues concerning the management of the grant and the Trust	GRP Head, Review panel	To discuss and highlight management issues regarding the Trust long term grants, management of the Genebanks CRP and raising funds for the endowment.
Parallel session 07.30-12.00	Financial review	Anne Clyne & Trust staff as possible	
Lunch			
13.00-15.00	Review of finance and administration	GRP Head, Review panel, Trust staff & CIAT staff as necessary	To summarise the findings of the financial review, consider the appropriateness of the operating budget and costs.
Break			
15.30-17.30	Time out	Review panel	Reviewers may chose to discuss further with Trust staff and/or GRP staff
Day 5			
07.30-08.30	Preparations by review panel	Review panel and others as requested	Reviewers to prepare recommendations and presentation to GRP staff
08.30-10.00	Presentation of draft recommendations to GRP staff followed by Q&A	GRP staff Review panel, Trust staff	Reviewers to provide findings of the review and draft recommendations
Break			
10.30-12.00	Meeting with Senior Management	GRP Head, Review panel, Trust staff	Reviewers to provide findings of the review and draft recommendations. Trust to provide findings of financial review
Lunch			
13.00-17.30	Drafting of the review report	Review panel and where necessary Trust staff	To prepare first written draft of the review report

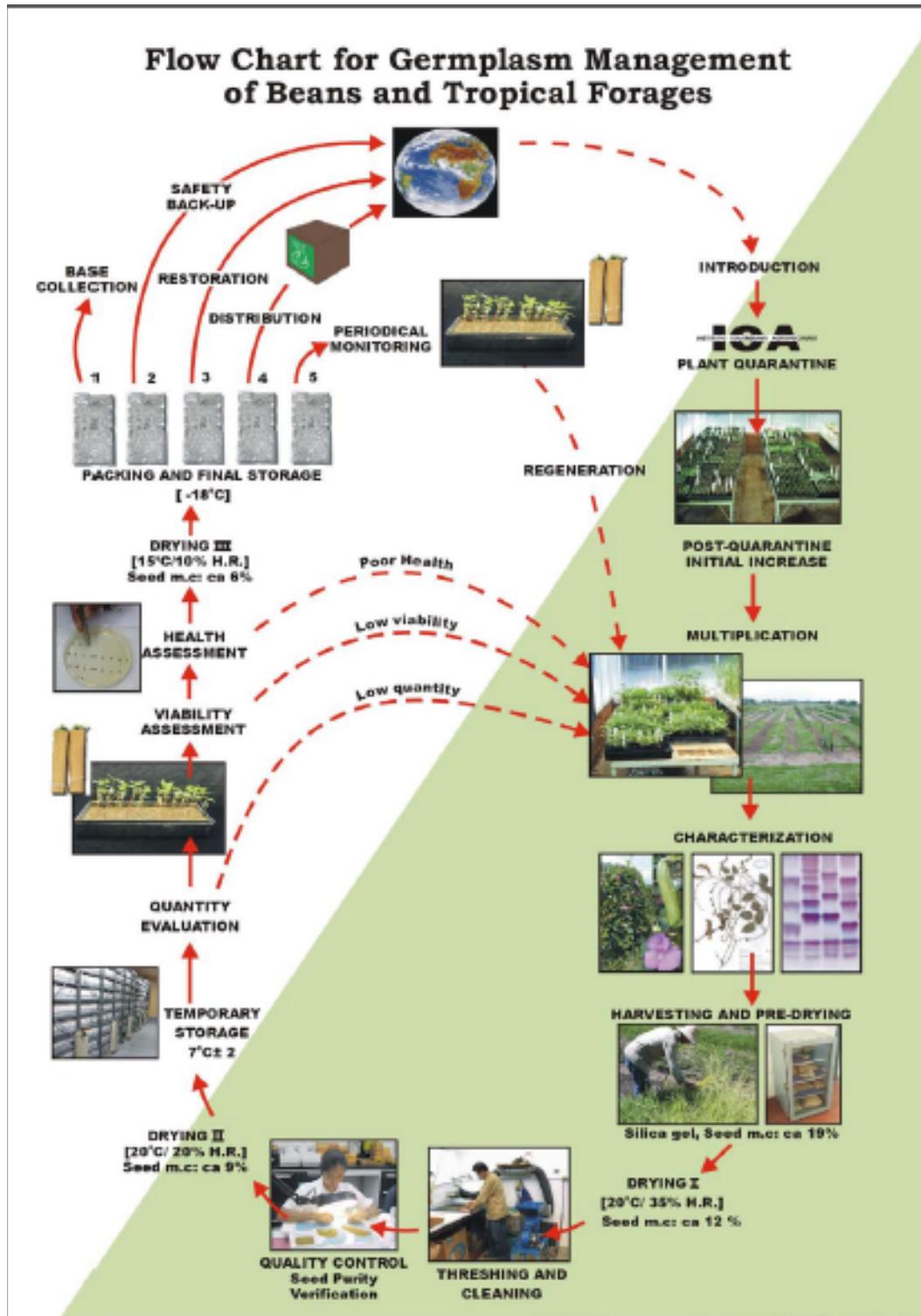
Annex 4: List of people the Review Panel met at CIAT (8-12 April 2013)

Name	Role and affiliation
Ruben G. Echeverria	Director General, CIAT
Albin Hubscher	Deputy Director General, Corporate Services, CIAT
Maya Rajasekharan	Program Office, CIAT
Carlos Meneses C.	Information Technology Manager, CIAT
Manuel Arturo Franco Duran	Head of Databases and Web Applications, CIAT
Joe Tohme	Agrobiodiversity Research Area Director, CIAT
Clair H. Hershey	Leader, Cassava Programme
Mario Bernal	Head of Human Resources, CIAT
Steve Beeby	Leader, Beans Programme
Roosevelt Escobar	Biotechnology Research Assistant and Cryobiologist
Isabel Natalia Salas T.	Coordinator, Quarantine Office, ICA-CIAT Agreement
Daniel G Debouck	Leader GRP
Josefina Martinez	GRP Administrative Assistant
Eliana Urquijo	GRP Clerk and Information Support
Angela Marcela Hernandez	GRP Information System Analyst
Luis Guillermo Santos	GRP Seed Conservation Coordinator
Ericson Aranzales	GRP <i>In Vitro</i> Conservation Coordinator
Jaime Roberto Guzman	GRP <i>In Vitro</i> Conservation Specialist
Orlando Toro	GRP Bean Germplasm Production Specialist
Arsenio Ciprian	GRP Forage Germplasm Production Specialist
Cesar Humberto Ocampo Nahar	GRP Germplasm Quality Specialist
Martitza Cuervo	GRP Germplasm Health Coordinator and Virologist
Maria del Socorro Balcazar	GRP Germplasm Health Bacteriologist
Julio Cesar Ramirez Pretelt	GRP Germplasm Health Pathologist

Annex 5: List of documents provided to the Review Panel

Year	Item
2006	Report CIAT GRU Review, October 2006
2007	Technical Report – GRU
2007	Report of the Sixth External Program and Management Review (EPMR) of the Centro Internacional de Agricultura Tropical (CIAT). Eduardo Venezian et al.
2007	Final signed long-term grant (LTA) between CIAT and the Global Crop Diversity Trust
2008	Technical Report – GRU
2009	Technical Report – GRU
2010	Technical Report – GRU
2010	A Global Conservation Strategy for Cassava and Wild Manihot Species. Clair Hershey and Daniel Debouck
2011	Technical Report - GRU
2011	Proposal to the Fund Council. Submitted by Consortium Board of Trustees for 'Financial Support to the CGIAR Center Genebanks in 2011'
2012	Annual Report, Beans
2012	Annual Report, Forages
2012	Annual Report, Cassava
2012	Baseline performance indicators, Cassava
2012	Baseline performance indicators, Beans
2012	Baseline performance indicators, Forages
2012	Development of a CIAT Strategy for Integrating Tropical Forages into Smallholder Mixed Crop-Livestock Systems in Sub-Saharan Africa Report of a mission to Kenya and Rwanda (18-30th July 2012) Jonathan Robinson, Jean Ndikumana and Werner Stür, 23 August, 2012
2012	CIAT Genebank Survey Users
2012	Cryobanking strategy CIAT cassava
2012	In Trust for the International Community. Plan and Partnership for Managing and Sustaining CGIAR-held Collections. CRP Research Support.
2012	Receipt and Distribution of Germplasm Audit at CIAT Headquarters. Terms of Reference.
2012	ILRI External Review, Final Report
2012	Risk Matrix Genebank 20 June 2012
2012	Report about the Risk Matrix for CIAT genebank
2013	CIAT Genebank External Review – self assessment
2013	Conservation of <i>Phaseolus</i> beans genetic resource – a strategy. D. G. Debouck
2016	Baseline performance indicators, Institute
2016	Target performance indicators, Beans
2016	Target performance indicators, Cassava
2016	Target performance indicators, Forages
2016	Target performance indicators, Institute

Annex 6: Flow chart of GRP activities (beans and forages)



Annex 7: Flow chart of GRP activities (cassava)

