Bioversity Genebank Review 2013

Programme: Genebanks CRP		
Genebank reviewed: Bioversity	**Site visit Dates:**	14 Oct 2013 - 17 Oct 2013
	Review report Date:	21 Jun 2014
	Center and Crop Trust responses:	29 Sep 2014
Place: Leuven, Belgium		
Genebank Manager	Nicolas Roux	
Review Panel	E. R. Joachim Keller	
	Gordon Prain	
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CGIAR RESEARCH PROGRAM FOR Managing and Sustaining Crop Collections

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Bioversity 2013 Genebank Review: recommendations and responses

	Review recommendations	Bioversity response	Crop Trust Response
1	*Infrastructure: We recommend the urgent installation of an oxygen alarm system for the cryo-storage room as well as a separate nitrogen level-sensing warning system for each container connected to a central alarm system and emergency service*	The equipment for the oxygen alarm will be installed (by a specialized company in collaboration with the technical services of the University) in late 2014. The nitrogen level sensing alarm in the cryo-tanks will also be connected with the central services in late 2014.	The Crop Trust supports both recommendation and Bioversity's very concrete response.
2	*Staff: The RP identifies the need to appoint a more senior staff (above technician) as assistant to Ines Van den Houwe. At the same time ITC should ensure that there are a minimum of 2 members of the technical staff dedicated to cryopreservation, meaning the addition of 1.5 staff members for this area of the genebank. We are thus suggesting the addition of 2.5 new positions to make 4 persons/year as the minimum technical staff needed to adequately manage the genebank in the long term, including cryopreservation. This level of staffing should constitute the basic requirements for routine genebank management and the necessary resources should be requested from the Trust to ensure this staffing level*	We agree that 2 cryo-technicians are needed for the routine operation of cryopreserving 70 accessions/year. This is 40 accessions/year for a routine technician and 30 accessions/year for technician funded by the genebank CRP. The latter devotes 25% of this time to other activities related to the cryobanking. This will be the case for the next 7 years in order to cryopreserve the rest of the MTS collection (about 500 more accessions). From that point, 2 cryo-technicians will still be needed to cryopreserve incoming accessions. The routine cryo-technician started in May 2014 (paid by Cryo-banking proposal of the GCDT). However, he has a contract of only 3 years. After which we will fall back again to one technician, so funds will be raised for another "routine" cryo-technician after April 2017. For MTS, in October 2013, a genebank research assistant (MSc degree) was hired who is responsible for daily activities related to MTS and requests for and distribution of germplasm. As she grows in this role, she will take on other tasks more closely with the genebank curator providing support managing the genebank. However, additional support in obtaining feedback from germplasm users is	The Crop Trust appreciates the nature of this recommendation and the comprehensive response. Bioversity has obviously responded positively and rapidly. We recognise fully that staff, once trained in cryopreservation, should be retained. The longer-term needs of 2 cryo-technicians should be periodically reviewed. The recruitment of a liaison officer is not a direct recommendation of the review. As Bioversity's strength lies in its networking capacity and experience, the specific role and functions of a liaison officer would need to be justified within the complement of existing staff.

	Review recommendations	Bioversity response	Crop Trust Response
		needed and could be provided by a liaison officer, who will enhance communication and exchange of information among the ITC, external users and the Montpellier office.	
3	*Content of the* Musa *collection: The RP recommends that a clear multi-faceted strategy be developed to enable the genebank to address gaps in the collection, especially cultivated and wild types in areas under threat from climate change or deforestation, but also in underrepresented genomic groups of the cultivated banana and plantain. This might include fund-raising for organization of collecting expeditions and new types of agreements with field genebanks.*	We see this as a high priority and one that is central to the workplan of the Global Musa Conservation and Use Strategy. We are committed to developing a strategy for gap filling of the ITC collection together with partners such as IITA, and we will raise the necessary funds to do this.	The Crop Trust supports the recommendation and the response. Gap-filling is, by its nature, a never-ending task. The gap analysis and collecting under the Crop Trust-coordinated Crop Wild Relatives project will hopefully contribute importantly to this task. A comprehensive assessment of gaps and prioritisation of gap-filling is not a minor undertaking and we will be keen to support and learn from Bioversity and partners' strategy and approach.
4	*Medium term storage: We recommend labelling all test tubes in the collection, but this should be facilitated with labels that can be more easily detached for washing that those currently used. The use of street shoes in the MTS and laboratories should be avoided.*	We are now adapting the barcoding and printing system of MGBMS in order to handle and manage individual replicate accession samples (test tubes) in MTS. Labelling individual test tubes will be started in September 2014 and will be funded by the current operational budget. By the end of 2015 we will adapt lab practices to increase cleanness of the labs and reduce contamination sources including the use of overshoes or lab shoes for those entering and working in the labs.	The Crop Trust supports the recommendation and the response and recognises the significant investment of time and resources that these actions imply.
5	*Cryopreservation: Virus-positive material, which is cryopreserved, should be separated gradually over time from other cryo-preserved material. In the case of very valuable material that is virus-positive, ITC should find ways to cryopreserve this material in special tanks that are separate from other*	We are committed to separating virus positive material from virus negative material and also for ensuring that two repetitions per accession are stored in separate tanks. For executing this activity, funds will be raised for 3 extra tanks in Leuven and 1 extra tank for the black box in Montpellier. Separating the material by physically transferring the tubes	The Crop Trust supports the recommendation and response, and appreciates the details provided and again the investment of time and resources to making this change.

	Review recommendations	Bioversity response	Crop Trust Response
	materials.	while still in liquid nitrogen is time consuming and it will require staff time of 20% full time (1 day per week) for one year. Additionally, 1 to 2 weeks staff time for a technician is required to separate the cultures in Montpellier. Funds will also need to be raised for this staff time. Otherwise less time will be dedicated to cryopreservation of the MTS collection.	
6	*Partnering in virus elimination and virus indexing: The RP recommends that a backup option for virus indexing should be identified.*	We are committed to identifying and entering into agreement with a backup VIC. The possibilities are: Australia (not possible for the moment, but maybe in the future), CIRAD (to be investigated), SPC (but problem in introducing infected material) and IITA.	The Crop Trust supports the recommendation and response.
7	*Setup of a virology strategy: The RP recommends that Bioversity/MusaNet together with ITC proactively seeks to convene a task force of virologists to clearly assess the risk and impacts of different viruses and to educate quarantine officials and provide clear recommendations to the ITC on its management and distribution of virus infected accessions. This is currently important for BSV. Criteria need to be formulated concerning viruses of low impact with the aim at excluding them from unnecessary quarantine limitations*	We have a Task Force comprising Virologists from CIRAD, DAFF and other research centres that currently advise the ITC on the management of virus-infected material. They published the safe movement of germplasm guidelines and recently held discussions on BSV at the ProMusa symposium in August 2014. ITC does not distribute BSV infected material, however in the framework of RTB we screened some accessions that are BSV positive but not infectious (will never show symptoms). We will clarify with the Task Force if these accessions could be distributed.	The Crop Trust supports the recommendation and response. Bioversity have already a Virology Task force and are pursuing a recommendation from the Task Force on non-infectious BSV affected germplasm. It will be useful to know what approach is agreed as this is relevant to IITA and other crops. It will also be important for Bioversity to strengthen its procedures and criteria for determining when materials should be quarantined through its QMS, if this is not already sufficiently clear.
8	*User analysis: The RP recommends that ITC develop user profiles based on a detailed analysis of the reasons for different users' requests, the types of germplasm requested, their distribution of*	We will carry out a more detailed user analysis in order to develop a partnership strategy. It is proposed that feedback from users is obtained by conducting surveys and/or through direct and more intensive interactions with	The Crop Trust supports obtaining more feedback from users and using that feedback to feed into developing and building on existing strategies for promoting the use of the collection

	Review recommendations	Bioversity response	Crop Trust Response
	this material etc as a means to reassess the germplasm distribution. On the basis of this analysis and as part of the currently revised genebanking strategy, the RP recommends that ITC develop a partnership strategy to improve the flow of information and the establishment of closer collaborations towards promoting wider use of germplasm from the collection.	users. This would be one of the roles of a dedicated liaison officer, for which funds will be raised as a high priority for 2015.	and developing partnerships. These strategies need to link ultimately to other elements of the collection management, information management and staff capacity. We appreciate the spirit of this recommendation and the response.
9	*Collaboration with other CRPs: The RP recommends strengthening the partnership between ITC and IITA, which is a key actor in Musa conservation and use and the leader of the Humid Tropics CRP which is identified as one of the CRPs with which ITC hopes to engage.*	We are now working in collaboration with IITA (Humid Tropics CRP leader) in the area of Field Verification, the evaluation for specific traits such as drought, the collection of plantains and matoke bananas and in situ conservation work.	The Crop Trust supports the recommendation and the response. Collaboration with IITA at numerous levels can only bring mutual benefits.
10	*Distributing accessions for field verification: The RP recommends that the process of verifying accessions for trueness-to-type is critically reviewed and that other means of authenticating accessions are considered so that a standardised method is deployed that will ensure results are available within a reasonable timeframe.*	We are committed to the process of verifying and putting accession information online, however this has been hampered by the slow feedback from partners. This will improve as we are working only with the mostly reliable partners. In addition, more intense follow up with partners will be undertaken by a liaison officer. We are also complementing the existing data with molecular (SSR markers) and cytological (ploidy) data which are also accessible on MGIS.	The Crop Trust supports the recommendation and appreciates Bioversity's optimism that the process of testing trueness-for-type may be improved by relying only on trusted partners and with more intense follow-up. However, we endorse the reviewers point to critically review the present procedure: is it necessary to check trueness-to-type of all accessions in the field every 10 years? A period of 10 years has not proved feasible so far, where are the shortcuts or what are the alternatives given the availability of complementary methods? Working on the SOPs with Janny van Beem will help you to

	Review recommendations	Bioversity response	Crop Trust Response
			review this procedure further.
11	*IT procedures: The 18 recommendations made in a special IT assessment of the genebank carried out by an expert review team should be implemented, especially the consolidation of all data in the MGBMS database, the assignment of globally unique identifiers for accessions and measures aimed at reducing risk of data loss (Annex 10).*	Part of the recommendations (recommendations 1,2,4,5,6,8,13,15,16) are already being addressed as part of the 2014 planning by the two part-time IT consultants that take care of the routine maintenance of the ITC database system. For the migration of MGBMS to a web-based system, introduction of cheaper mobile platforms, a middle tier and QR codes (recommendations 5, 7,9,10,11,17,18) investments will be required. In 2015, one full time programmer will be recruited to address recommendations 9,10,11 and 18.	The Crop Trust supports the recommendation and the response.
12	*Characterization and evaluation information: It is recommended that ITC take a more proactive approach to obtain characterization and evaluation data from users. Existing IT efforts to make MGIS more user friendly should continue and intensive information campaigns should be launched, both directly to field genebanks, but also through use of ProMusa on the value and importance of the data and the use of MGIS. Feedback from users indicates that lack of data can decrease potential use of accessions.*	We need to gather more information as priority on accessions (both acquired and distributed). The Field Verification project is partially contributing and the SMTA sent with all accessions includes a request for information. It would be very helpful to have a liaison officer appointed to make connections to users to gather more characterization and evaluation data. Funding will be raised for a liaison officer that could be charged with collecting more data from users.	The Crop Trust supports the spirit of the recommendation, although the details are not entirely clear. There is some implication that capacity building in the NARS field banks is needed and further sources of data pursued by working through ProMusa, which corresponds with R#14. Bioversity has been working on MGIS, field verification and other characterisation activities for many years now but there remains a real paucity in good quality accession level data. Some reflection at the institute level as to what is needed to make real change happen here would be very useful.
13	*Passport data: The RP recommends that ITC revise passport data structure to incorporate specific fields for indigenous knowledge and contextual ecological information (to avoid leaving this*	Indigenous knowledge (where possible due to legal constraints) and ecological information will be integrated in 2015 as part of the upgrading of the MGIS user interface. This information will be provided in specific	The Crop Trust supports the recommendation and the response.

	Review recommendations	Bioversity response	Crop Trust Response
	information in hard to search "comment boxes").	fields or on maps.	
14	*Musa web resources: The RP recommends that ITC strengthen the interconnectedness of cultivar information on MGIS and in Musapedia and other information sources on ProMusa (e.g. Musalogue) and considers providing information on main news items on the home page, with a one liner and picture and more information at the News tab.*	Links to Promusa and MusaNet are already in place. These will be strengthened and complemented as the new MGIS interface will include more information on cultivars, including links to other sources.	The reviewers make a specific recommendation here on MGIS links to Musapedia and information available on the ProMusa website. Bioversity's response is very general. The Crop Trust endorses the reviewers' perspectives that the interconnectedness between these different information sources is insufficient, leading to considerable confusion to the outside user. We request that Bioversity actively pursues better alignment and cohesion between these important resources
15	*Special germplasm risks: The RP urges ITC to focus more attention on identifying and prioritising vulnerable accessions existing within the collection or upon arrival at ITC so that they receive priority treatment and conservation management.*	Since all accessions are considered as unique and of high value they are all treated with the highest level of care. All new acquisitions, irrespective of the number of samples received, are immediately processed and monitored daily during the in vitro initiation phase. As part of the routine management of accessions, 'susceptible' or recalcitrant materials, contaminated accessions or materials which are less adapted to the storage conditions, receive alternative treatments (e.g. more frequent sub-culturing, alteration of the composition of the growth medium, transfer to samples the greenhouse as remediation treatment). In addition and as an ultimate measure of security, each accession is fully virus indexed and sanitized from virus and is processed in liquid nitrogen for safe LTS.	While appreciating the reviewers' proposal, the Crop Trust understands and supports Bioversity's response. By the nature of accession of materials into the collection, all materials should be of value and a priority for long-term conservation. Those that are of low priority should be considered for rejection. From Bioversity's response, it appears unlikely that any better care could be provided to incoming accessioned materials.

External Review of the Bioversity International Transit Centre for Banana and Plantain

E. R. Joachim Keller[1] and Gordon Prain[2]

October 14 - 17, 2013, Leuven, Belgium

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Abbreviations and Acronyms

BSV	Banana streak virus
CGIAR	Consultative Group on International Agricultural Research
CIP	International Potato Center
CRP	CGIAR Research Program
CRP-RTB	CGIAR Research Program on Roots, Tubers and Bananas
DAFF	Department of Agriculture, Fisheries and Forestry, Queensland, Australia
FAO	Food and Agriculture Organization of the United Nations
IITA	International Institute of Tropical Agriculture
IPK	Leibniz Institute of Plant Genetics and Crop Plant Research
IRD	Institut de recherche pour le développement, Montpellier, France
MGBMS	*Musa* Genebank Management System
MGIS	*Musa* Germplasm Information System
MTS	Medium term storage
NARI	National Agricultural Research Institute
RP	Review Panel (as commissioned by the Trust)
QMS	Quality management system
Trust	Global Crop Diversity Trust
UofQ	University of Queensland

Executive Summary

The International Transit Centre (ITC), based at the Catholic University of Leuven in Belgium, is an international genebank for banana and plantain under the management of Bioversity International, one of the fifteen agricultural research centers of the Consultative Group on International Agricultural Research (CGIAR).The Global Crop Diversity Trust (referred to henceforth as The Trust) is an independent international organization working to guarantee the conservation of crop diversity for food security worldwide. Through a special funding arrangement with international donors, the Trust channels financial resources and provides advice and support to the 11 international genebanks under the stewardship of the CGIAR. Since 2012 this arrangement has become organized through a CGIAR Research Program on Genebanks. The Agreement signed between The Trust and Bioversity International in 2007 requires that regular assessments of the ITC genebank operations be undertaken as a component of the funding policy of the Trust, to ensure the sustainable management of *Musa* genetic resources in the long term.

In compliance with this agreement, the Trust constituted, in August 2013, a Review Panel made up of E. R. Joachim Keller and Gordon Prain to assess the efficiency and effectiveness of the ITC genebank operation as a whole, and the status of the ITC within the context of the global system for the conservation and use of the crops in question. This covers consideration of technical, financial and general managerial aspects of the ITC.

The assessment methodology consisted of a review of documents relating to the genebank, preparation and distribution of a questionnaire to different types of genebank users, site visits, staff presentations and interviews. From October 14 to October 17 two members of the panel spent four days at ITC visiting facilities, listening to presentations from local staff and remotely from Bioversity International's offices in Montpellier and interviewing staff, partners in the University of Liege and interviewing remotely 15 users of the genebank in different parts of the world. The task of the Review Panel was supported by an expert review of the IT facilities conducted shortly before the main review. One of the members of the team that conducted the special IT review was present during the main review.

The overall finding of the Review Panel was that the ITC is a well run, effective genebank that is highly appreciated by the many different types of users of its services. The networking model through which it operates enables ITC to maintain close collaborative links with 18 field genebanks around the world and with a wide range of other organizations and this clearly contributes to its effectiveness in getting Musa germplasm used in breeding and direct adoption. Nevertheless, the RP identified opportunities for ITC to strengthen further its operations to increase efficiency, safety and uptake of its accessions. Recommendations were made relating to the **ITC genebank** itself (three actions on: infrastructure; staff and content of the *Musa* collection); **Genebank management** (six actions on: Quality Management System; medium term storage; cryopreservation; partnering in virus indexing and elimination; development of a virology strategy; and on DNA and leaf banks); **Germplasm acquisition, distribution and use** (six actions on: user analysis; partnership strategy; collaboration with other CRPs; collection missions; request to field genebanks; distributing accessions for field verification; **Documentation and information systems** (four actions on: IT procedures; characterization and evaluation information; passport data; *Musa* web resources); and **Long-term security of the collection** (two actions on: special germplasm risks; and data risks).

The Review Panel would like to acknowledge with appreciation the kindness and efficiency of local staff in organizing our stay and in providing personal and technical support, especially the presentations and visits to the facilities of ITC and a partnering laboratory at Gembloux and the successful set up of remote interviews with users across the world. Finally, the Review Panel recognizes the contribution of the Trust in carrying out and

analyzing the survey questionnaire and acknowledges excellent interaction with two members of the Trust (Paula Bramel and Charlotte Lusty), prior to the visit and on site.

E. R. Joachim Keller and Gordon Prain

1. **Introduction**

1.1. Background

The *Musa* International Transit Centre (ITC) is the world's largest in vitro collection of banana kept under the auspices of FAO. As of 2012 there were 1435 accessions of *Musa* in medium term storage (MTS), covering banana, plantain and wild species. Until now, over 90,000 samples have been supplied worldwide to 359 different locations in 103 countries. Initially, the accessions of banana and plantain were established as a *Musa* research collection within the Laboratory of Tropical Crop Improvement, Division of Plant Biotechnics of the Catholic University of Leuven. However, in recognition of the advantage of having a collection located outside the cultivation area of the crop and acknowledging the high conservation standards, the collection was identified as an international reference collection by the International Network for the Improvement of Bananas and Plantain (INIBAP) in 1985 and through an agreement with the University, named as the INIBAP Transit Center for Musa germplasm (ITC). ITC made an essential contribution to a core business of INIBAP, namely the safe exchange of *Musa* germplasm at a global level. Subsequently INIBAP became a program of the International Plant Genetic Resources Institute (IPGRI) under the auspices of the CGIAR, later renamed Bioversity. The beginning of the close association between Bioversity and the Catholic University of Leuven goes back to Professor Edmond de Langhe, an international expert on *Musa*, the founder of the Laboratory of Tropical Crop Improvement and the founding director of INIBAP. In October 2003 the International Transit Centre obtained international status through the signing of an agreement between Belgium and IPGRI, now Bioversity International.

Although the genebanks of many tropical crops are located close to their centers of diversity, the *Musa* collection is located in Belgium, where bananas are not grown. The advantage of this is mainly the phytosanitary isolation it provides from all the various diseases the genus *Musa* is facing and the absence of risk to local agriculture in receiving accessions from different parts of the world. A further advantage is certainly the absence of political instability and conflicts, which historically have threatened other germplasm collections and currently affect some countries with high *Musa* diversity. On the other hand, there are also some consequences with implications for how the *Musa* collection is managed. This mainly relates to the fact that contacts with banana growers and users of the *Musa* germplasm are geographically widely scattered. The processes of germplasm acquisition and distribution, much of the disease indexing and the exchange of information must continue as efficiently as possible despite this geographical spread.

The facilities of the ITC have continuously developed and now include in vitro storage rooms, a cryopreservation unit and access to the greenhouses of the University of Leuven. Virus pre-indexing, indexing and virus elimination are currently implemented in collaboration with a laboratory at the University of Liège (Gembloux), following the closure in 2012 of the DAFF greenhouses used by previous partners the University of Queensland, Australia.

A particular characteristic of ITC which is related partly to its location in a non-banana-growing area, but also to the networking strengths and priorities of firstly INIBAP and then Bioversity International, is its relationship with 18 field genebanks in different parts of the world. ITC is the largest collection in this genebank network and the only one operating globally and there is a crucial interdependence in terms of acquisition, virus indexing, verification of trueness-to-type and distribution for use. This intense level of networking maintained by ITC offers the chance for much greater use of genebank accessions than in genebanks which work as stand-alone entities.

In 1996 the *Musa* Germplasm Information System (MGIS) was established as an electronic database able to access information about accessions in all 18 genebanks. It contains

passport information and minimum descriptors for the accessions held in the different genebanks. End-users access MGIS to browse, search and request germplasm. In 2001 a new IT system, the *Musa* Genebank Management System (MGBMS) was introduced to ITC, to handle day-to-day data management of the ITC collection, including bar-coding using hand-held devices, data storage and retrieval, ordering, shipment tracking, support for cryo-banking etc. Currently the interface between MGIS and MGBMS is manual, requiring staff to communicate MGIS germplasm requests to the MGBMS system via email.

Another important role of ITC has been in facilitating the International *Musa* Testing Program (IMTP), to evaluate new banana varieties against reference varieties for resistance to diseases, under different conditions around the world. This has provided another information networking domain that links ITC with a global set of users.

1.2. Terms of reference of the review

This review aims to assess the efficiency and effectiveness of the genebank operation as a whole, and the status of the ITC within the context of the global system for the conservation and use of *Musa.* 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 ITC genebank
- Asses the roles, services and use of the ITC genebank, and the linkages with users and partners both within and outside the CGIAR
- Consider the status of the ITC collection and the role of the ITC in the context of a global system for long-term conservation and use of the crop 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 ITC with reference to the Costing Study estimates
- Provide actionable recommendations related to all of the above

1.3. Review methodology

A Review Panel (RP) was created consisting of two scientists with expertise in the fields of genebank management, seed storage, cryopreservation, research management, research collaboration and networking (for their backgrounds see Annex 2). With active support from the Trust and Bioversity staff, the RP were able to review a large number of documents relating to the genebank, including progress reports, earlier reviews, strategy papers and agreements (see Annex 5). The RP also elaborated a questionnaire for distribution to users of ITC on their experience and perceptions of the genebank. The distribution of the survey, reception of responses and the analysis of content were undertaken by a staff member of the Trust (Cristian Moreno, whom the RP thank for this support). A review visit with interviews was made to the ITC facilities and to the collaborating virus pre-indexing, indexing and therapy facilities at the University of Liège (Gembloux) from October 14th to 17th, 2013. During this period the local staff of ITC and staff of Bioversity based in Montpellier made live and video-linked presentations on different aspects of *Musa* conservation, acquisition and distribution and on the IT system supporting the genebank, followed by periods of question and answer. ITC staff also arranged for the RP to conduct remote interviews with a total of 15 ITC users or other kinds of stakeholders (for the program see Annex 3, and for the people contacted see Annex 4). During different parts of the review visit the panel was accompanied by one or two Trust staff members. During the entire visit Paula Bramel (Deputy Director General of the Trust) provided helpful information and advice to the RP and this support is gratefully acknowledged. Charlotte Lusty (Scientist, responsible for the Genebank CRP) who acted as main Trust contact for the RP, joined the review visit for part of the time and has been in regular contact prior to and following the review visit. We also gratefully acknowledge her support. Financial aspects of the review were independently assessed by Amanda Dobson, Finance Director of the Trust, who did not participate in the

visit. The RP reviewed presentations and results of interviews during the course of the review and on the last day provided preliminary conclusions and recommendations to representatives of Bioversity (Stephan Weise, DDG-Research and Nicolas Roux, Genetic Resources Conservation and Use Theme Leader), Paula Bramel for the Trust and ITC staff.

2. Genebank Operations

2.1. General observations

The Review Panel (RP) came to the general conclusion that the ITC is an efficient, well-managed institution operating with a high level of security and impressive level of interaction with users. The observations and recommendations which we make seek to help move the genebank to an even higher level of performance.

In our opinion the current high level of operations derives from several sources. We can cite the accumulated knowledge and experience in *Musa* botany and systematics of the Laboratory of Tropical Crop Improvement and its past and current staff and the strong historical association between *Musa* genebanks in different parts of the world and the Laboratory, which has been fully inherited by ITC. We also highlight the superior quality of the recent addition of cryopreservation for long-term storage which is internationally recognized. Another factor has been the availability of knowledge and skills for building and maintaining networks and associated information infrastructure required for this, which has been a core characteristic of INIBAP and now Bioversity International. Last but certainly not least, we recognize the strong interpersonal rapport established over more than 20 years by the Genebank Manager and the many users of the genebank accessions. This is a crucial value-added to digital information systems which we discuss further below.

Site visits enabled us to review the medium-term in vitro storage rooms, the tissue culture laboratory, the database system MGBMS, the long-term storage in cryopreservation and the leaf bank and the greenhouses. A special trip was organised to the virus pre-indexing and therapy facilities at the University of Liège at Gembloux. The various facilities were found in general to be very well maintained. Below, we comment in more detail on some aspects which we feel can introduce greater safety and/or efficiency.

2.2. Specific observations and recommendations

2.2.1. Infrastructure

Since the start of the cryopreservation activities, efficient methods to store different types of material have been developed, such as meristem explants and embryogenic masses. The cryotanks are now situated in a special room in the basement of the main building. Despite the fact that the material is well positioned, no special warning system was installed in case of hazards. The international standards require use of an oxygen-sensing system which will sound alarm when the oxygen content falls below a critical level. In some of the laboratories, this alarm is coupled with a ventilator. It is essential that the alarm is connected to a central emergency service which should act immediately in the case that a person is affected by oxygen depletion due to nitrogen outflow from a defective cryotank. In cases where the cryotanks are not yet equipped with a level-sensing safety system they also need to be connected with this central emergency service.

Recommendation 1*:* We recommend the urgent installation of an oxygen alarm system for the cryo-storage room as well as a separate nitrogen level-sensing warning system for each container connected to a central alarm system and emergency service.

2.2.2. Staff

The RP had a very positive impression about the capacities and activities of the staff of ITC. However, the Panel considers that the numbers of staff working in the genebank are not sufficient to carry out all the necessary tasks. This is especially notable in two cases.

Ines Van den houwe as Genebank Manager is intensively occupied in regular interactions with ITC users and suppliers of accessions around the world in addition to her other tasks of maintenance and documentation of MTS accessions, planning and reporting and applied research (see Annex 6). She enjoys a high level of confidence among users and as we discuss further in following sections, the RP considers this a valuable component of genebank networking and of central importance for expanding the use of genebank accessions. Furthermore, the RP makes several recommendations regarding partnerships that may expand the numbers of users and thus lead to a workload surpassing the possibilities of one skilled person. It is not realistic to try to shift the entirety of the personal interactions to others as they depend on a depth of experience and knowledge of the accessions in the genebank. At present 1.5 persons / year are envisaged for Genebank management tasks. The RP does not consider that enough for such a genebank and strongly highlights the need for another 2.5 skilled people.

The other case is cryopreservation. These activities depend on the engagement of skilled technical staff. Though the procedures are routine they are not always easy and very often rather detailed. Based on previous reports, it appears that cryopreservation activities were compromised because of shortage of technical staff. Therefore, to ensure continued growth of cryopreservation to meet the long-term safeguarding of *Musa* germplasm, at least one additional technical staff is needed to the existing one staff member.

***Recommendation 2**:* The RP identifies the need to appoint a more senior staff (above technician) as assistant to Ines Van den houwe. At the same time ITC should ensure that there are a minimum of 2 members of the technical staff dedicated to cryopreservation, meaning the addition of 1.5 staff members for this area of the genebank. We are thus suggesting the addition of 2.5 new positions to make 4 persons / year as the minimum technical staff needed to adequately manage the genebank in the long term, including cryopreservation. This level of staffing should constitute the basic requirements for routine genebank management and the necessary resources should be requested from the Trust to ensure this staffing level.

2.2.3. Content of the Musa collection

The *Musa* collection is expanding, but there is clearly a need to review the current coverage of the whole genepool of banana and plantain, given the variable accessibility to and storability of different cultivated types and wild species. Currently the collection consists of 15 groups and 40 sub-groups of cultivated forms, which occupy 76 % of the collection and 19 wild species accounting for 15 % of the collection. The remaining 9 % is accounted for by improved varieties. The review notes that there have been several calls to address gaps in the collection, which have so far met limited response, especially in the case of wild species. Latest taxonomic thinking suggests that there may be in the region of 70 wild species. In contrast to the banana types, the plantain is underrepresented. At present, a tremendous and alarming devastation of the wild banana germplasm has been noted, mainly because of the increasing deforestation in South East Asia, because most wild species grow in forest communities. Furthermore, in the present genus *Ensete*, which formerly belonged to *Musa* as well and which forms the only other genus in the botanical family Musaceae, there is also at least one species used as food and fiber in Ethiopia and elsewhere. The genepool of this genus should not be forgotten. In contrast to the cultivated banana and plantain, the wild ancestors and related *Musa* genepool as well as *Ensete* are propagated by seeds. Not enough is known about storability and germination behaviour of this germplasm. Therefore,

we support the proposal for conducting research (under CRP-RTB Theme 1, alone or jointly with ITC) into seed storage of wild accessions, including embryo excision and storage and other biotechnological methods.

Recommendation 3: The RP recommends that a clear multi-faceted strategy be developed to enable the genebank to address gaps in the collection, especially cultivated and wild types in areas under threat from climate change or deforestation, but also in underrepresented genomic groups of the cultivated banana and plantain. This might include fund-raising for and organization of collecting expeditions and new types of agreements with field genebanks.

2.2.4. IT procedures

See section 4 for an integrated review of the information and documentation procedures of the ITC genebank and of the *Musa* network more broadly.

2.2.5. Quality Management System

Today, more and more institutions, including genebanks, follow a policy of installing Quality Management Systems (QMS). This has mainly the aim to standardize procedures, make them more transparent and reproducible and, thus, to increase the trustworthiness of the institution and to facilitate technology transfer to other units working in the same area. So far no QMS has been established at ITC. The RP was informed that a special mission was expected to visit ITC in November to make recommendations for establishing such a system. We endorse the views of the team and the Trust about the need to move quickly to the implementation of a full QMS and we expect that the imminent visit of a consultancy team on QMS will accelerate this process.

2.2.6. Medium term storage

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Storage room Plantlets in MTS

Medium term storage is implemented by in vitro techniques. As of 2012 1434 accessions were stored in the culture rooms at a temperature of 16 °C at low-light conditions of permanently 25 $\mu mol \cdot m^{-2} \cdot s^{-1}$. The culture tubes are stored for 4 to 22 months (average 12 months). There is a schedule of monthly assessment of quantity and quality of the stored cultures. For initial multiplication and full re-establishment of exhausted samples, the

cultures are transferred in a cycle of four to six weeks from one subculture to the next in laminar flow boxes in an especially designated laboratory. Furthermore, susceptible material of primary explants is excised there, accompanied by various steps of bacteriological indexing.

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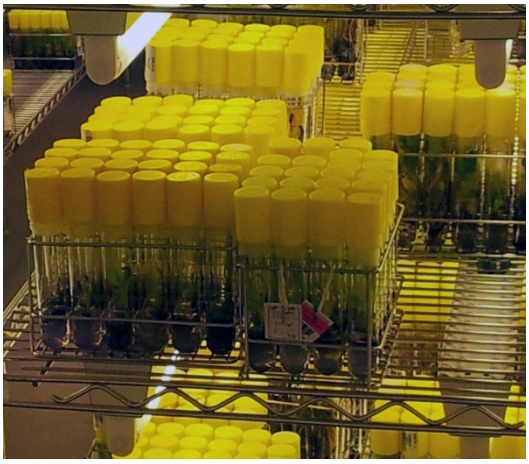
Greenhouse culture for rejuvenation / pre-indexing

©Joachim Keller, IPK

Wild banana collection

After 10 years continuous in vitro cultures, plantlets are transferred for rejuvenation into greenhouses. For virus pre-indexing and virus-therapy, the material is sent to the University of Liège in Gembloux and received back from this laboratory.



Racks containing the MTS accessions

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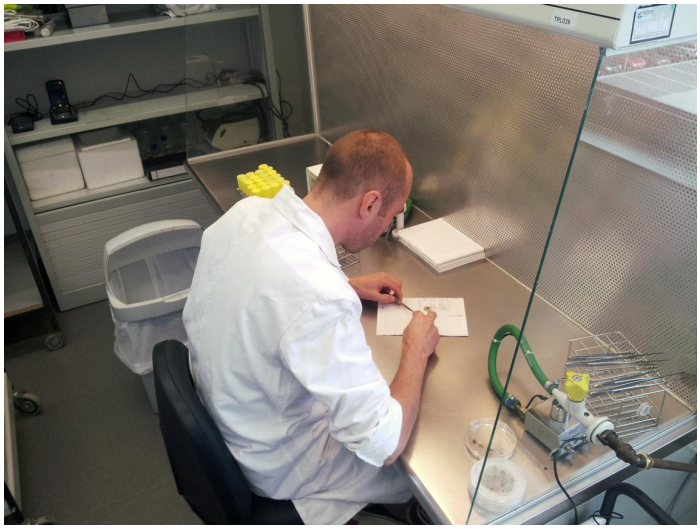
plastic bags for delivery

The MTS protocol calls for 20 replicates in vitro per accession. The vessels are treated separately and placed in special racks. Only one tube per rack is labelled with the number of the respective accession. This seems insufficient given the possibility, however remote, that racks can fall down or be knocked down by mistake or the possibility of misplacement of

tubes due to human error. The RP was informed that consistent labelling was hindered by difficult detachment of the old labels in washing procedures, thus unacceptably increasing workload.



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Transfer work in laminar flow boxes requires maximum cleanness

In vitro culture uses nutrient media which are also attractive for microorganisms which may contaminate the material. Therefore, any microbes introduced by dirty items into the laboratory and distributed there may become a real danger for the cultures. Therefore, a minimum level of cleanness should be applied to exclude for example the introduction of soil particles, in which micro-organisms are abundant.

***Recommendation 4**:* We recommend labelling all test tubes in the collection, but this should be facilitated with labels that can be more easily detached for washing than those currently used. The use of street shoes in the MTS and laboratories should be avoided.

2.2.7. Cryopreservation

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Cryotanks in the storage room

taking out of the racks is a critical procedure requiring care

Cryopreservation is the base collection of a vegetatively maintained genebank. As of 2012 it amounts to 916 accessions with a safety-backup at IRD, France. For this type of storage the cleanness of the material is an absolute requirement, including absence of virus infection. In standard procedures, virus-infected material is excluded from cryopreservation or, when cryopreserved, blocked for use and distribution. However, the RP was informed that some parts of the *Musa* germplasm is infected by viruses which are difficult to remove. Banana streak virus (BSV) partly integrates into the host genome, which enables it to surmount the virus elimination treatments in a hidden form. This is the case especially in the plantain germplasm. This is one reason for the above-mentioned underrepresentation of plantain in the collection. When we consider the intensive efforts required for virus elimination and the fundamental problems existing to attain virus-free material in some germplasm, there is an inevitable conclusion that a valuable part of the germplasm would be excluded from cryopreservation. This is not acceptable, especially considering the possibility that in the future new methods of virus cleaning may be developed. To meet the phytosanitary requirements, separation of infected and clean material should be implemented in the present management but there should not be an exclusion of the infected accessions from cryopreservation. Since the separation of virus-infected germplasm within the tanks is time-consuming a certain period for this action should be allowed.

Recommendation 5: Virus-positive material that is cryopreserved should be separated, gradually, over time, from other cryo-preserved material. In the case of very valuable material that is virus-positive, ITC should find ways to cryopreserve this material in special tanks that are separate from other materials.

2.2.8. Partnering in virus indexing and elimination

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The RP observing the bags ready for sending to partners

Virus indexing and elimination are tasks which cannot be done by the ITC staff alone, because they require a high degree of specialization both in knowledge and equipment. Up

to 2012 ITC collaborated with a team in the University of Queensland, Australia for virus indexing and elimination. In 2012 access by this university to greenhouses owned by the Department of Agriculture, Fisheries and Forestry (DAFF) was terminated and this arrangement was unable to continue. Nevertheless, the leading plant virologist at Queensland, Professor John Thomas, agreed to continue to support the ITC through advising a replacement virology group to continue the virus cleaning and indexing activities. There are also indications that the closure of the greenhouses in DAFF may be temporary for a period of two years. ITC found a good partner at the University of Liège in Gembloux. The RP was able to visit these laboratories and was introduced to the methods, facilities and responsible staff. The Gembloux team and their facilities appeared very capable of handling the additional work of indexing and elimination in addition to their original agreement with ITC to carry out pre-indexing. However, based on the experience with Queensland, ITC should not depend on only one partner for this work and are encouraged to seek additional virology laboratories as back up. In this regard, the plan of ITC to retain the contribution of John Thomas (UofQ) to continue as advisor on virus indexing, which includes to support staff at Gembloux to take on the new work is a wise move which is supported by the RP. The RP endorses also the actions of Bioversity and the Trust to involve other genebanks in virus indexing and therapy of other crops such as cassava, yam and sweet potato to increase the sustainability of the virus indexing in Gembloux.

Recommendation 6: The RP recommends that a backup option for virus indexing be identified.

2.2.9. Setup of a virology strategy

As in other areas of science plant virology methods become increasingly sophisticated and detailed. This leads to the discovery of new viruses and virus-like organisms, many of them having little or no impact on the plant. Yet existing regulations require a totally virus-free status for germplasm that is to be distributed internationally, which runs the risk of misrepresenting the role of phytosanitary policies. The final result may be senselessly counterproductive, ending up with conservation of germplasm without the possibility of its use.

Recommendation 7: The RP recommends that Bioversity/MusaNet together with ITC proactively seeks to convene a task force of virologists to clearly assess the risks and impacts of different viruses and to educate quarantine authorities and provide clear recommendations to the ITC on its management and distribution of virus infected accessions. This is currently important for BSV. Criteria need to be formulated concerning viruses of low impact with the aim at excluding them from unnecessary quarantine limitations.

2.2.10. The leaf sample collection

Freeze-drying device for leaf samples

© Max Ruas, Bioversity International

A collection of leaf samples is held to keep the DNA of the accessions in an evaluable state. The leaf bank collection was discussed and made available for inspection. The RP did not identify any special recommendations concerning the management of these banks. However, we were impressed by the significance of the collaboration with the group of Ladislav Doležel at Olomouc, Czech Republic, which is mainly engaged in molecular-genetic analyses and determinations. The input of this group led to fundamental improvement of the *Musa* germplasm characterization at ITC and forms a pillar of the *Musa* germplasm information in general. The RP encourages ITC to continue this arrangement in order to complete the leaf collection as a basis for future comparisons and true-to-type verification.

3. Germplasm acquisition, distribution and use

One of the strengths of ITC is its decentralization and interactions and interdependence with a wide range of local genebanks and other types of users, which have evolved over a long time and nurtured by the networking approach of first INIBAP and then by Bioversity and by the acquisition and distribution of materials. In a real sense ITC is not just the facilities, databases and staff housed within the Division of Plant Biotechnics of the Catholic University of Leuven, it is also the set of network linkages, the data collections in the field genebanks, the verification trials and other field testing going on all over the world, with information networked through the Montpellier-based MGIS. We believe that this key characteristic can be further strengthened to add value to services offered and to result in greater use of the accessions and greater benefits from their traits in *Musa*-growing areas of the world. This must be a principal aim of any genebank.

For this reason we support and recommend continuing the combined role of ITC as genebank for conservation as well as the facility for acquisition and distribution of germplasm. These roles are separated in other organizations, but the special situation of ITC of being a “networked genebank” means that it is advantageous to combine the roles, to enable intensive interactions with partners and other users to continue. We do not believe that the conflict of interest issue that leads some organizations to separate the functions outweigh the advantages of this intense interaction. On the contrary we discuss in following

sections the need to encourage greater proactiveness in the areas of acquisition and distribution. This will require better tools to obtain feedback from the partners about their specific demands, in order to make the work of distribution more effective.

3.1. Partnership strategy

Based on remote interviews with 15 ITC users, and the application of an on-line survey to 22 users, 13 of whom responded[1], it is clear that ITC has a very diverse set of individuals and organizations with whom it interacts and who have interests in the genebank. The survey showed that conducting experimental research was the most common reason to request material, followed by evaluations for possible introduction of material into the country. But the remote interviews with users indicated that many have multiple reasons for requesting material and also multiple interests in and contributions to ITC. For example Catur Hermanto, Head of the Indonesia Tropical Fruit Research Institute in Aripan Solok, West Sumatera, Indonesia, cites breeding as his principal reason for requesting material, but also notes that he is interested in the introduction of promising material for adoption by farmers. He is also a supplier of new accessions for the genebank, accompanied by passport information and sometimes characterization data. He also notes that some indigenous material has been lost in Indonesia, but it is still held by ITC. So he is interested in repatriation of these types. This scientist and the institute he leads, is clearly a partner of ITC, with multiple needs and interests and a great deal to contribute to the genebank.

Some users have a more specialised, but no less important relationship with ITC. For example Jaroslav Doležel, Laboratory Head and Senior Scientist in the Institute of Experimental Botany in Olomouc, Czech Republic, is a "user" in a very special sense: he is responsible for molecular characterization of new accessions which are sent to him, through the *Musa* Genotyping Center in his laboratory.

The RP examined the current typology of "users" present in reports and presentations. Currently "users" are characterized by type and geographical region. There are seven types identified, in order of importance: NARIs; Advanced Research Institutes/Universities; the CGIAR; Commercial companies; Regional organizations; Others; and unaffiliated individuals.

The RP believes that there should be greater clarity in defining the types of users involved with ITC, their characteristics, interests and contribution to the overall goals and objectives of ITC. As part of this characterization of users we suggest that a more detailed analysis be undertaken of the reasons for different users' requests, the types of germplasm requested by different users, their distribution of this material etc. to develop user profiles. We suggest that this analysis of users should lead to a reassessment of germplasm distribution strategies. For example, it may be possible to identify the potential contribution of some users as regional hubs for farmer evaluation and multiplication of promising cultivars. ITC could consider increasing the number of samples supplied to these types of users and this would be in line with proposals already being developed in CRP-RTB (Flagship BA4).

We suggest that most users of ITC germplasm are in some sense "partners", but with different degrees of formality and types of functions, but all sharing in some of the same goals in relation to the conservation and use of *Musa* germplasm as ITC. Some of these partners, such as virus indexing organizations or regional genebanks involved in verification are essential to the core functions and credibility of ITC. Within the currently revised strategy there is need for a partnership strategy as part of this process of clarifying these relationships. We believe that clarifying the types of users is an important step in improving the flow of information between ITC and its partners.

[1] Because of time constraints, only a short turn around period could be given between distribution of the survey and the cut-off point to receive answers. This was one factor in the 60 % response rate.

***Recommendation 8**:* The RP recommends that ITC develop user profiles based on a detailed analysis of the reasons for different users' requests, the types of germplasm requested, their distribution of this material etc as a means to reassess germplasm distribution. On the basis of this analysis and as part of the currently revised genebanking strategy, The RP recommends that ITC develop a partnership strategy to improve the flow of information and the establishment of closer collaborations towards promoting wider use of germplasm from the collection.

3.2. Collaboration with other CRPs

Based on reviews of the reports, presentations, discussions with staff and remote interview with Michael Abberton, Head of IITA Genetic Resources Center, it is clear that IITA has a key role in the *Musa* germplasm network, including as a user of germplasm for breeding. Yet it seems that this role could be further strengthened as could the relationship with ITC. This should be facilitated in relation to CRP-RTB by the recent appointment of Rony Swennen as IITA banana breeder. Based on the discussions we were able to have, IITA does not seem to have embraced the *Musa* "brand" (PROMUSA, MGIS) so far, for which ITC is a central element. It may be that this brand is currently very strongly associated with Bioversity, whereas it needs to become more globally owned. The relationship with IITA is very important since it also leads the Humid Tropics CRP which is identified as one of the CRPs with which ITC hopes to establish a partnership, as a supplier of *Musa* germplasm for adaptation to specific systems targeted by Humid Tropics. One mechanism that could be explored is the strengthening of the Working Group on Conservation in Musanet, in which IITA participates. This could be elevated to an "advisory group" to ITC, to link better the aspects of consdervation and use of *Musa* germplasm, which concerns both ITC and IITA (and perhaps other key players).

Recommendation 9: The RP recommends strengthening the partnership between ITC and IITA, which is a key actor in *Musa* conservation and use and the leader of the Humid Tropics CRP which is identified as one of the CRPs with which ITC hopes to engage.

3.3. Obtaining germplasm through collection missions

Responding effectively to the demands of users means maintaining as much of the *Musa* genepool as possible. In an earlier section we discussed the current status of the collection in relation to the genepool and some of the gaps in the collection. During 2012 a collecting expedition was undertaken in Indo**n**esia. Samples are currently being morphologically characterized in the field genebank before being transferred to ITC. ITC has already identified geographical locations where especially *Musa* wild species are believed to be growing. As already noted, many of these locations are forests subject to environmental damage, so there is urgency in identifying means to carry out collections.

3.4. Obtaining germplasm through requests to field genebanks

In 2012 there were only 30 accessions of mainly wild species of *Musa* donated by partners, in this case from the Philippines. Yet on the basis of remote interviews with users, it seems that a number of accessions in field collections and locally grown cultivated types are not in the ITC collection. The RP suggests that a systematic review be carried out of locally grown materials and/or field genebank materials which are not represented at ITC but which could feasibly be added and means be sought to encourage local curators to share this materials.

3.5. Distributing accessions for field verification

The field verification exercise between ITC and several field genebanks managed by NARs is strictly speaking part of genebank management. However, the RP also understood through the remote interviews that it is also a means for field genebanks to access additional material not in their collections and also to further distribute to third parties. It is not clear to

us how consistently this special form of distribution of germplasm has been undertaken in the past, whether the field genebanks involved were paid for this service, whether there were formal contracts signed, whether field verification is done in one or more sites and whether the provision of characterization data to ITC was part of the formal contract. According to the documents, 780 accessions have been field verified but only 63 accessions had characterization data on line in 2012. We have not seen any specimen LOAs or protocols for this activity. Since a large amount of field verification was done in 2004 and this is proposed to be repeated every ten years, standardization now is important.

Recommendation 10*:* The RP recommends that the process of verifying accessions for trueness-to-type is critically reviewed and that other means of authenticating accessions are considered so that a standardised method is deployed that will ensure results are available within a reasonable timeframe.

4. Documentation and information management

The RP considers that documentation and information management are both essential parts of genebank operations as well as of acquisition and distribution and require an integrated approach to ensure that all of these processes function effectively.

There are two major areas to consider: Information technology (IT), which concerns the hardware and software being deployed to manage information on accessions for genebank staff and for users; and content, the kind of information on accessions that is documented and made available to users.

4.1 IT systems

There are two IT systems used to manage information in the ITC genebank: the *Musa* Germplasm Information System (MGIS), with servers in Montpellier, holds information on germplasm in ITC as well as in 18 other *Musa* genebanks around the world. MGIS is a tool for ordering germplasm on line. The *Musa* Genebank Management System (MGBMS) supports daily operations of the ITC genebank. The current functioning of MGBMS and its interface with MGIS was reviewed by a team of IT experts and made available to the RP.

Recommendation 11: The 18 recommendations made in a special IT assessment of the genebank carried out by an expert review team should be implemented, especially the consolidation of all data in the MGBMS database, the assignment of globally unique identifiers for accessions and measures aimed at reducing risk of data loss (Annex 10).

4.2. Information content

The IT report deals to some extent with content, particularly the issue of an automatic interface between MGBMS and MGIS to share information about availability of accessions for distribution, but it is mainly concerned with the hardware and software architecture. The issue of content is particularly important for the MGIS, since that is where users get the information about germplasm that they have the option to order. We found from interviews with different kinds of users that there is a significant demand for more information about accessions. The survey indicated that 80 % of users either did not receive any characterization information or indicated that what was provided was insufficient. For evaluation information 91 % of users thought it was insufficient. Some of the users remotely interviewed reported a decline in accession information since the start of the on line system.

Though it may be common for users of genebanks to want more information than is available, what we also found was that ITC may not be fully tapping in to a willingness to provide information. Two thirds of those responding to the survey said they provided no information to ITC on accessions that they received, though it is unclear whether they were asked. There were 20 % of users who expressed a willingness to provide information.

Several users who were remotely interviewed indicated that they had data available on accessions if ITC wanted it. Perhaps more important, in relation to distribution of materials, 80 % of users indicated that they had not been asked for evaluation feedback by ITC.

From the RP's interviews with ITC staff, the issue of obtaining information about accessions is not straightforward and in some cases it may not be easy to obtain characterization or evaluation data. Nevertheless, we believe that greater efforts should be made in this regard. One possibility could be to allocate funds for joint characterization activities between ITC and regional genebanks for new accessions.

Recommendation 12: It is recommended that ITC take a more pro-active approach to obtaining characterization and evaluation data from users. Existing IT efforts to make MGIS more user-friendly should continue and intensive information campaigns be launched, both directly to field genebanks, but also through use of ProMusa on the value and importance of the data and the use of MGIS. Feedback from users indicates that lack of data can decrease potential use of accessions.

In contrast to characterization and evaluation information for accessions, 81 % of users surveyed were satisfied with the passport data. Yet passport data, which is the basic information about who collected, where, when and in some cases under what ecological circumstances, should be supplemented where possible in our opinion with "what" and "why" data – what is special about the particular land race and why it is cultivated. This refers to the large pool of indigenous characterization data, which can be added to basic passport data in situ, when collections take place. Bioversity International has an impressive reputation in the documentation and analysis of indigenous knowledge related to crop genetic diversity and we urge that this experience be harnessed to improve the quality and usefulness of passport data.

Recommendation 13: The RP recommends that ITC revise passport data structure to incorporate specific fields for indigenous knowledge and contextual ecological information (to avoid leaving this information in hard to search "comment boxes").

4.3. Personal communications and advice

Even with the on-line ordering system in place, it is clear that the advisory function of the genebank curator (Ines Van den houwe) continues to be important. We believe that "the personal touch" should not be lost as it contributes to strengthening relationships in the network. This reinforces our recommendation to increase staff support to her position.

4.4. Integration of Musa *web resources*

There are a range of very useful portals and web pages, which bring together information on bananas and plantain. These contribute to disseminating knowledge about the crops and wild relatives. The RP believes that they could contribute more strongly to linking potential users of the ITC genebank with information about accessions and the means to order them.

Recommendation 14: The RP recommends that ITC strengthens the interconnectedness of cultivar information on MGIS and in Musapedia and other information sources on PROMUSA (e.g. Musalogue) and considers providing information on main news items on the home page, with a one liner and picture and more information at the News tab.

5. Long term security of the collection

5.1. Personnel risks

We wish to underline here the issue already discussed in Section 2.2.2, that lack of sufficient qualified personnel can present a long-term threat to the integrity of the collection and reduce its contribution to long-term development goals. This issue has been dealt with in Recommendation 2.

5.2. Special germplasm risks

The current system in place in the ITC genebank requires that all accessions are treated the same. Yet it is clear that certain accessions, because of rarity or susceptibility to storage conditions or for other reasons, are at greater risk of not being easily replaced if lost. We suggest that ways be found to address more attention to these vulnerable accessions within the current system.

This has two aspects: 1) Some material is provided to ITC in the form of one or two plantlets or suckers (especially when the original material consists of few plants only), whereas other accessions are provided as abundant planting material. Donated accessions that may be easily lost should be prioritised for urgent management upon reception. 2) Susceptible material may need more or alternative treatment (additional multiplication, other methods/chemicals to eradicate pests and diseases, special culture media, other temperature regimes etc.) This may, again, create the need to postpone measures for the other materials,which have a lower risk level.
Criteria should be defined that could be used for prioritization of accessions in terms of management.

***Recommendation 15**:* The RP urges ITC to focus more attention on identifying and prioritising vulnerable accessions existing within the collection or upon arrival at ITC, so that they receive priority treatment and conservation management.

6. Concluding remarks

The RP found a very well organized institution which has grown organically over many years from the Laboratory of Tropical Crop Improvement of the Catholic University of Leuven into the widely recognized International Transit Center (ITC) of Bioversity International, one of 11 international genebanks under the stewardship of the CGIAR. With solid foundations in the scientific reputation of the university and in close association with the scientific milieu there, the ITC has maintained a high level of conservation management and research. Thanks to the fact that its target crops and crop wild relatives in the genus *Musa* grow outside Belgium, the staff of the genebank has built a highly collegiate and dynamic network of partnerships with research, conservation and crop improvement organizations throughout the tropical world. The ITC has also built a network of scientific organizations, which complement the genebank in areas of work where it lacks sufficient expertise or resources, such as genetic analysis and virology. It has also made major efforts to ensure that information technology and management have also the same high standards.

The challenge for such an organization is to ensure that it maintains its high quality and that it identifies areas where further improvements are possible. Though our overall impresson of ITC was very positive, the RP were able to identify 21 areas where recommendations for improvements could be made. Some of these recommendations involve changes in thinking, strategy or practices. Some involve increases in resources, including in personnel deployed in certain areas, especially to respond to handling increased accessions or more exacting management procedures in in vitro storage (medium term) and cryopreservation (long term). These need a solid and sufficient staffing level and we urge the donors to ensure that this is

assured. Additional staff will enable the genebank to increase the performance of the ITC in terms of conservation, information exchange and eventually the rate of use of accessions by clients. We consider it also important to continue the collaboration with the molecular-genetic laboratory at Olomouc and to intensify, diversify and secure the links with virological units to be on the phytosanitary safe side.

In conclusion we wish to state that the ITC manages a valuable germplasm collection to a high standard. It should continue its work, improving its standards in ways that we have tried to indicate and should be fully supported in this work by the Trust and by the CGIAR community.

Annexes

Annex 1: Terms of Reference to the Review Panel

Annex 2: Review Panel Members

Annex 3: Review program

Annex 4: Persons interviewed in Leuven and through remote connection

Annex 5: Documents reviewed

Annex 6: TORs of ITC staff

Annex 7: Charts on management and workflow in ITC

Annex 8: Questionnaire

Annex 9: Evaluation of the responses to the questionnaire (by Cristian Moreno, GCDT)

Annex 10: IT review (by Max Ruas, Dag Endresen, and Matija Obreza)

Annex 1: Terms of Reference to the Review Panel

1. Review aim:

- To assess the efficiency and effectiveness of the ITC genebank operation as a whole, and the status of the ITC within the context of the global system for the conservation and use of the crops in question.
- To consider technical, financial and general managerial aspects of the ITC.

2. Review objectives:

- Assess the operations and activities of the ITC genebank
- Asses the roles, services and use of the ITC genebank, and the linkages with users and partners both within and outside the CGIAR
- Consider the status of the ITC collection and the role of the ITC in the context of a global system for long-term conservation and use of the crop 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 ITC with reference to the Costing Study estimates
- Provide actionable recommendations related to all of the above
- The overall responsibility to resolve financial and budgeting issues will remain with the Trust.

3**. Review outputs**

- Report (5,000 words) with actionable recommendations clearly stated and justified.

4. ITC visit from:

- Monday 14 to Thursday 17 October 2013

5**. Summary Review Process:**

- Propose users of ITC to be consulted before review (see annex: excel sheet)
- Propose key partners to be consulted during review (see in programme below).
- A summary (1000 words) of the main areas of operation and collaboration for review or improvement should be prepared.
- Bioversity and the Panel to develop a detailed agenda of specific issues and interactions during the site visit to ITC.
- A site visit to ITC Leuven on 14-17 October 2013 is planned for interactions between the Panel and Bioversity Staff.
- Trust Finance Director (Anne Clyne) to carry out a financial audit (1-2 days, days in parallel to the ITC visit (i.e. 14-16 October). Financial staff should be informed of the process and prepared to provide details of budget allocations and financial reporting. Trust Finance Director to provide relevant financial findings to the panel.

6. Process for the Report:

- The Review Report will be developed by the Panel.
- The Report will be circulated to the Trust for initial feedback.
- Bioversity will be invited to respond to the Recommendations.
- Specific actions or workplans based on the recommendations may be requested.
- The Trust will provide its own response to the final recommendations.

- The Finalized Report will be available to all on the Trust website
- The Trust Executive Board and the CGIAR Consortium Office will review the finalized Report
- The Report will be circulated to the CGIAR genebank managers
- The Report will be presented at the Annual Genebanks Meeting

7. Review panel members:

- Joachim Keller (IPK, Head of research Group In in vitro Storage and Cryopreservation)
- Gordon Prain (CIP, Senior Scientist, Social and Health Science)
- Paula Bramel (Trust, Deputy Director General)
- Anne Clyne (Trust, Finance Director) - will not participate in Leuven but will contact Doreen Yerriah, Programme Budget Office in Montpellier by Skype

8. Proposed Detailed Agenda

- DAY 1 – Monday 14 October 2013
- DAY 2 – Tuesday 15 October 2013
- DAY 3 – Wednesday 16 October 2013
- DAY 4 – Thursday 17 October 2013 (AM)

Annex 2: Review Panel members

E. R. Joachim Keller (Panel Chairman)

Joachim has been with the Leibniz Institute of Plant Genetics and Crop Plant Research (IPK) since 1989. He got the position as a Research Group Leader when the Institute was re-organized in 1992. Since 1996, he is leading a research group of in vitro storage and cryopreservation of vegetatively propagated crop species (potato, mint and genus *Allium*). Joachim studied biology (plant physiology) at the Friedrich Schiller University Jena and got his PhD degree there in 1979, based on the physiology of plant extension growth. Until 1989 he was head of a scientific department of tissue culture in the Institute of Breeding Research in the Academy of Agricultural Sciences of the GDR, where he worked on haploid production via androgenesis and gynogenesis in cereals, *Brassica* and *Allium*. At IPK, he coordinated a European collaborative project on genetic resources management (mainly cryopreservation) of garlic and took part in several other international and national research projects. He is chairman of the *Allium* Working Group of the European Cooperative Program of Plant Genetic Resources and member of several scientific societies as well as of the Managing Board of the Association of German Cryobanks.

Gordon Prain

Gordon Prain received a Ph.D in social anthropology from the University of Cambridge, UK, based on the economics and politics of rice agriculture in South India. He was subsequently a recipient of a British Government Post-Doctoral Fellowship to work as an applied anthropologist in Latin America. As part of the Fellowship, then as a socio-economist with a Swiss-funded agricultural development project and as an anthropologist with the International Potato Center (CIP) he worked on indigenous crop production and seed systems, local conservation of crop genetic resources and food consumption issues. From 1991 to 2000 he coordinated a participatory agricultural R4D network in six countries of South-east and South Asia supported by the Dutch Government which focused on small-scale agricultural systems, crop genetic diversity conservation on farm and household nutrition issues. Returning to Latin America in 2000 he worked as global coordinator for a cross-cutting program of the CGIAR which undertook research for development on agricultural and natural resource systems in and around developing world cities. Since 2012 he has been the Global Science Leader for CIP's Research Program on Social and Health Sciences, with interests in institutional organization and partnerships, gender and the relationship between on-farm diversity and nutrition.

Annex 3: Review Program

1. Programme of the ITC visit:

Date	Proposed Topic	Interactions with the Panel in Leuven and via Video conference
DAY 1 – Monday 14 October 2013		
09:00-10:00	**Welcome and introduction to the ITC Review:** • Welcome by Bioversity International, Belgium office, to the Review Panel members – *Rony Swennen* • Welcome by the Genetic Resources Conservation and Use Theme Leader Commodities Programme of Bioversity– *Nicolas Roux* • Introduction to the review panel and to the objectives of the review - *Joachim Keller & Gordon Prain* • Discussion and clarifications on the review process and the site visit – *Chair of the review panel*	Bioversity Staff: • Rony Swennen • Nicolas Roux • Ines Van den houwe • Bart Panis • Julie Sardos • Max Ruas
10:00-10:30	***Coffee/tea break***	
10:30-12:00	**Presentation on the ITC genebank facilities and activities (operations and main activities of the past 5 years)** • Presentation 1: Introduction to ITC genebank operations - *Nicolas Roux – 10 minutes* • *Presentation 2:* Medium term storage- *Ines Van den houwe – 15 minutes* • *Presentation 3:* Long term storage - *Bart Panis– 15 minutes* • *Presentation 4:* Musa Genebank Management System (MGBMS) - *Max Ruas– 10 minutes* • *Discussion – 40 minutes*	Bioversity Staff: • Nicolas Roux • Ines Van den houwe • Bart Panis • Max Ruas
12.00-13-00	Reviewers' interactions with ITC users via conference calls • User 1: Giovanni Forgione, Phytolab (commercial TC lab), Burundi – 3*0 minutes* • *User 2:* Babita Dussoruth, Areucrop (National programme on conservation and use), Mauritius– *30 minutes*	To be contacted by video conference**: Check availability in advance** • Giovanni Forgione (Phytolab, Burundi) • Matthew Turner, Nishikata Botanical garden, Japan) • Babita Dussoruth, Areucrop, Mauritius
13:00-14:00	***Lunch***	
14:00-15:30	**Visit of the ITC genebank facilities, its operations and the staff:** • Medium term storage facilities • Demo of the database system MGBMS • Tissue culture facilities • Long term storage facilities/ leaf bank • Green houses	Bioversity Staff: • Nicolas Roux • Ines Van den houwe • Bart Panis • Els Kempenaers • ITC additional staff *Contact person: Ines Van den Houwe*
15:30-16:00	***Coffee/tea break***	

16:00-17:00	**Presentation on Characterization** – *Julie Sardos - 15 minutes* • Morphological characterization and field verification • Molecular characterization **Presentation on the *Musa* Germplasm Information System (MGIS)** – *Max Ruas – 15 minutes* **General discussion** – 30 minutes	Bioversity Staff: • Ines Van den houwe • Julie Sardos • Max Ruas • Nicolas Roux
17:00-18:00	***General discussion on genebank operations and facilities***	Bioversity Staff: • Rony Swennen • Nicolas Roux • Ines Van den Houwe • Bart Panis • Julie Sardos • Max Ruas
DAY 2 – Tuesday 15 October 2013		
	Interviews with partners	To be contacted by video conference**: Check availability in advance** *Contact person: Marleen Stockmans*
08:30-09:00	Collecting and gap filling	• Catur Hermanto (ITFRI-Indonesia) (*A contact was made with ITFRI for recent collecting missions in Indonesia*)
09-00-09.30	*Musa* genotyping Centre	• Jaroslav Dolezel (IEB-Czech Republic)
09.30-10.00	Virus indexing centre	• John Thomas (DAFF-Australia)
10:00-10:30	***Coffee/tea break***	
10.30-11.30	Field verification sites • Lorna Herradura (BPI-The Philippines), • Emmanuel Fondi (CARBAP-Cameroon) • Deborah Karamura (Bioversity/NARO-Uganda)	• Lorna Herradura (BPI-The Philippines), • Emmanuel Fondi (CARBAP-Cameroon) • Deborah Karamura (Bioversity/NARO-Uganda)
11.30-11.45	Cryobanking	• Anuradha Agrawal (NBPGR-India)
11.45-12:00	Safety back up	• Stéphane Dussert (IRD-France)
12:00-12:45	***Lunch***	
12:45-13:45	**Reviewers' interactions with ITC users via conference calls** • *User 3:* Dina Gallick, Eden Project, UK – *30 minutes* • User 4: Gino Aguirre Villarroel, fitogenetica, Bolivia - *30 minutes*	• Gino Aguirre Villarroel, (fitogenetica, Bolivia) • Dina Gallick, Eden (Project, UK)
13:45-14:30	Transport from Leuven to Gembloux	
14:30-17:30	**Visit to the virus pre-indexing and therapy**	Panel Members and Charlotte

	facilities at the University of Liege (Gembloux) • Musa Viruses Pre-indexing • Musa Virus therapy • Research on BBrMV therapy • Future Virus Indexing Centre	Lusty (Scientist,Trust) Bioversity Staff: • Nicolas Roux • Ines Van den houwe • Bart Panis • Julie Sardos • Max Ruas University staff • Hassam Jijakli • Sébastien Massart • Caroline Declerck • Angelo Locicero *Contact person: Nicolas Roux*
17:30-18:15	Transport back to Leuven	
18:15 - 19:00	**Germplasm partnership (cont.)** • Field verification sites • Kodjo Tomekpe (CIRAD-Guadeloupe) • Brian Irish (USDA- Puerto Rico)	To be contacted by video conference**: Check availability in advance** Kodjo Tomekpe (CIRAD-Guadeloupe) Brian Irish (USDA- Puerto Rico) *Contact person : Bart Panis*
DAY 3 – Wednesday 16 October 2013		
09:00-9:30	**Linkages with other CRPs: (**Roots Tubers and Bananas (RTB); Humid Tropics; Nutrition; Climate Change…) o Successes o Constraints • Presentation- *Nicolas Roux – 15 minutes* • Q&A: 15 minutes	Bioversity Staff: • Nicolas Roux • Bart Panis • Ines Van den houwe • Julie Sardos KU Leuven: • Sebastien Carpentier IITA: • Rony Swennen
9:30-10:30	**Interviews on linkages with other CRPs** • Dietmar Stoian (Bioversity) – 30 minutes • Michael Abberton (IITA) – 30 minutes	To be contacted by video conference: **Check availability in advance** • Dietmar Stoian (Bioversity) • Michael Abberton (IITA)
10.30-11.00	***Reviewers contact users*** • *User 5:* Matthew Turner, Nishikata Botanical garden, Japan– 3*0 minutes*	To be contacted by video conference: **Check availability in advance** • Matthew Turner, Nishikata Botanical garden, Japan
11:00-11:20	***Coffee/tea break***	
11:20-12:00	• Presentation on the Global Strategy for the Conservation and Use of *Musa* Genetic Resources and its implementation through MusaNet (Global *Musa* Genetic Resources Network) – *Nicolas Roux – 10 minutes* • Discussion – *30 minutes*	Bioversity Staff: • Nicolas Roux To be contacted by video conference: • Brigitte Laliberté
12.00-12.30	***ITC linkages with PROMUSA***	Bioversity Staff To be contacted by video

		conference: **Check availability in advance** • Inge van den Berg
12.30-13.00	***ITC linkages with partners in the regeneration project***	Bioversity Staff To be contacted by video conference: **Check availability in advance** • Anne Vezina
13:00-14:00	***Lunch***	
14:00-15:30	• Review of any outstanding issues with Bioversity staff (eg. health testing, cryobanking, collecting missions, seed conservation,...) • Discussion on points of clarification from the Panel	Bioversity Staff: • Rony Swennen • Nicolas Roux • Ines Van den houwe • Bart Panis • Julie Sardos • Max Ruas
15:30-16:00	***Coffee/tea break***	
16:00-16:30	• Graham Thiele (RTB) – 30 minutes	To be contacted by video conference: **Check availability in advance** • Graham Thiele (RTB)
16:30-18:00	**Time out** • Next steps of the Review and plans for additional interactions and information resources to consult	
DAY 4 – Thursday 17 October 2013		
09:00-10:30	• Presentation by the Review Panel of the preliminary recommendations • Initial feedback from Bioversity Staff	Bioversity Staff: • Stephan Weise • Rony Swennen • Nicolas Roux • Ines Van den houwe • Bart Panis • Julie Sardos • Max Ruas Bioversity senior Management to be contacted by video conference: **Check availability in advance** • Ann Tutwiler • Dietmar Stoian
10:30-11:00	***Coffee/tea break***	
11:00-12:30	Discussion on further issues	
12:30-14:00	***Lunch***	
14:00-16:00	Drafting review report	

Annex 4: Persons Interviewed in Leuven, Gembloux and Remotely

1. Leuven and Gembloux

	Name	**Title and Responsibilities at Bioversity vis a vis *Musa* genetic resources**
1.	Stephan Weise	Deputy Director of Research
2.	Nicolas Roux	Senior Scientist, Genetic Resources Conservation and Use Theme Leader, MusaNet Coordinator, GMGC Coordinator, Genebanks-CRP focal point for Bioversity International, CRP-RTB Theme 1 (Genetic resources) Theme Leader.
3.	Rony Swennen	Director, Bioversity-Leuven office /IITA banana breeder/ KUL professor
4.	Bart Panis	Senior Scientist, cryobanking and plant physiology
5.	Ines Van den Houwe	Scientist, ITC Genebank Manager
6.	Max Ruas	Programme specialist, Information System Analyst (Commodity Programme), MGIS database manager
7.	Julie Sardos	Associate Scientist, Genetic Resources Characterization
8.	Brigitte Laliberté	Scientist, Genetic Resources Conservation and Use Strategies
9.	Inge van den Berg	Scientist, Genetic Resources Evaluation (IMTP), ProMusa coordinator
10.	Anne Vezina	Programme Specialist, Science communication
11.	Sébastien Massart	Laboratoire de Phytopathologie, Gembloux Agro Bio Tech, Univ. Liège
12.	Caroline De Clerck	Laboratoire de Phytopathologie, Gembloux Agro Bio Tech, Univ. Liège

2. Partners and External Germplasm Users Consulted

	Name	Title, Institution and Responsibilities
1.	Catur Hermanto	Head, Indonesia Tropical Fruit Research Institute (ITFRI) Jl. Raya Solok - Aripan Km. 8 Solok, West Sumatera , Indonesia
2.	Anuradha Agrawal	Senior Scientist, National Bureau of Plant Genetic Resources (NBPGR); Pusa Campus - New Delhi 110 012 – India
3.	John Thomas	Dr John E Thomas, Principal Research Fellow, The University of Queensland; Queensland Alliance for Agriculture and Food Innovation; Ecosciences Precinct, Level 2C west, GPO Box 267 – Brisbane - Queensland 4001, Australia
4.	Lorna Herradura	Center Chief, Bureau of Plant Industries (BPI) Philippines Davao National Crops Research & Development Center, Bago Oshiro, Davao, Philippines
5.	Emmanuel Fondi	*Musa* diversity Scientist and gene bank curator, CARBAP BP 832 Douala, Cameroun
6.	Jaroslav Doležel	Head of the laboratory; Senior scientist Institute of Experimental Botany; Šlechtitelů 31 CZ-783 71 Olomouc-Holice; Czech Republic
7.	Brian Irish	Horticulturist/Curator, Tropical Agriculture Research Station 2200 Pedro Albizu Campos Ave, Suite 201, USDA-ARS TARS Mayaguez, PR 00680; Puerto Rico
8.	Graham Thiele	Director, CGIAR Research Program on Roots, Tubers and Bananas CIP – Apartado 1558, Lima 12, Perú
9.	Michael Abberton	Head, Genetic Resources Center; International Institute of Tropical Agriculture (IITA), PMB 5320, Oyo Road, Ibadan, Nigeria
10.	Giovanni Forgione	Phytolab, Burundi
11.	Deborah Karamura	Scientist, On farm conservation and supporting the NARO collection in NARO-Mbarara, Uganda
12.	Babita Dussoruth	Areucrop, 'AREU Agricultural Research Extension Unit, Mauritius
13.	Dina Gallick	Eden Project, UK

Annex 5: List of documents provided to the Review Panel

1. Center Genebank Review – Guidelines and Terms of Reference, provided by the Trust, June 13, 2013
2. Summary of the Trust Commissioned Review of the ITC Collection Managed by Bioversity International, Draft date 2 October 2013
3. Long-term conservation strategy for Banana
4. Global Conservation Strategy for *Musa (*Banana and Plantain). A consultative document prepared by INIBAP with the collaboration of numerous partners in the *Musa* research-and-development community (coordinator Anne Vézina). IPGRI March 2006
5. Agreement between the Global Crop Diversity Trust and Bioversity International providing for the long-term funding of *ex situ* collections of germplasm held by Bioversity, signed by Prof. Cary Fowler and Dr. Emile Frison on 12. and 13. 12. 2007
6. CRP-RTB 3.4: Roots, tubers, and bananas for food security and income. Revised Proposal by CIP, Bioversity International, CIAT, and IITA, 8 April 2011
7. "In Trust for the International Community". Plan and Partnership for Managing and Sustaining CGIAR-held Collections. CRP Research Support
8. CRP for Managing and Sustaining Crop Collections. The genebanks CRP. Concept note for discussion with donors and partners, June 2013 (Discussion document).
9. Benson, Erica E., Keith Harding, Daniel Debouck, Dominique Dumet, Roosevelt Escobar, Graciela Mafla, Bart Panis, Ana Panta, David Tay, Ines Van den houwe and Nicolas Roux. 2011. Refinement and standardization of storage procedures for clonal crops - Global Public Goods Phase 2: Part II. Status of in vitro conservation technologies for: Andean root and tuber crops, cassava, *Musa*, potato, sweetpotato and yam. System-wide Genetic Resources Programme, Rome, Italy
10. 2007 to 2011 AR Indicators (Excel file)
11. Providing for the Long-term funding of ex situ collections of germplasm held by Bioversity. Long-term Trust grant for Musa. Grant no. LTG07004. 2007 Annual Report compiled by Nicolas Roux.
12. Long Term funding for ex-situ conservation. 2008 Annual Technical Report
13. Long Term funding for ex-situ conservation. 2009 Annual Technical Report
14. Long Term funding for ex-situ conservation to Bioversity International. 2010 Annual Technical Report
15. Long Term funding for ex-situ conservation to Bioversity International. 2011 Annual Technical Report
16. Bioversity Performance indicators 2011 Baselines Banana and Institute
17. Bioversity Performance indicators 2012 Annual report Banana
18. ITC Operations, Collaborations and Future Improvement
19. BA4 Flagship: Increased understanding of and access to *Musa* diversity to improve smallholder banana farm and food systems
20. Christelová, Pavla, Miroslav Valárik, Eva Hřibová, Ines Van den houwe, Stéphanie Channelière, Nicolas Roux and Jaroslav Doležel. 2011. A platform for efficient genotyping in *Musa* using microsatellite markers. AoB PLANTS plr024 doi: 10.1093/aobpla/plr024
21. Garming, H., Roux, N. and Van den houwe, I. 2010. The impact of the *Musa* International Transit Centre - Review of its services and cost-effectiveness and recommendations for rationalization of its operations. Bioversity International, Montpellier, France. 2010
22. Panis, B. and N.T. Thinh. 2001. Cryopreservation of *Musa* germplasm. INIBAP Technical Guideline 5 (J.V. Escalant and S. Sharrock, eds). International Network for the Improvement of Banana and Plantain, Montpellier, France. International Plant Genetic Resources Institute, 2001.

23. Accelerating the phytosanitary process in sweetpotato, potato, cassava, yam and banana; Project draft

Annex 6: Terms of Reference of the ITC Staff

Bart Panis

1/ Supervise ITC cryopreservation activities (CRP- Genebank – 10%)

- Oversee that 25 to 30 accessions are being cryopreserved every year.
- To develop ISO norms for the ITC operations (develop standard operating procedures)
- To serve as Genebank Manager in charge in case the Genebank Manager during long abscence

2/ Research on banana conservation methodologies (CRP-RTB – 50%)

- To improve methods for banana botanical seed conservation (P 1.2.1.2)
  - Obtain seeds of wild species from partners mainly from South East Asia but not exclusively
  - Study seed anatomy
  - Develop in vitro germination techniques.
  - To develop protocols for seed cryopreservation
  - To develop protocols for Musa seed storage under non-cryopreserved condition (low moisture/low temperature)
  - To conduct physiology studies on seeds
- To improve methods for Musa Medium-term storage (in vitro)(P 1.2.1.3)
  - To analyse the in vitro storage potential of most genotypes at ITC (compile existing results and prepare article with the Genebank manager)
  - To study the potential of storing more accessions for more than 1 year at ITC
- To improve methods for safety back-up of Musa conservation (P 1.2.1.4)
  - To standardize methods for safety back-up of the ITC Global Musa collection (develop standard operating procedures)
  - To test the back box material (deposited at IRD) for its post-thaw regeneration ability
  - To field verify a subset of accessions maintained under cryopreservation conditions with key partners already involved in In vitro field verification work
  - Determine the maximal number of subcultures under medium term storage conditions, based on the results obtained in field verification (rejuvenation).
  - Make an inventory about types of somaclonal variants in Musa and evaluate ITC data about frequency of occurrence
- To contribute to the development of an early screening method (in vitro/autotrophic system/greenhouse) for drought (P 1.2.3)
- To investigate the possibility to develop eradication methods using Cryotherapy and chemotherapy (test compounds against BSV also used against HIV) in collaboration with the University of Liège (Gembloux) (P 1.2.5)

3/ Research on cross cutting activities (CRP-RTB – 40 %)

- To optimise ex-situ and in-situ conservation methodologies (P 1.1.1.1)
  - To improve and validate medium term storage (slow-growth in vitro protocols) procedures across crops.
  - Develop a training manual on cassava, banana, plantain, potato, sweetpotato and yam in vitro conservation methodologies.
  - To investigate the feasibility to develop a central cryobank for cassava, banana, plantain, potato, sweetpotato and yam.
- To assess the integrity of germplasm during cryopreservation (P 1.1.1.2)

    - Plants derived from cryopreservation assessed for their trueness to type.
- To improve and validate long term storage procedures (Cryopreservation) (P 1.1.1.3)
    - To validate the exercice that was initiated in previous projects (GPG2 and GCDT projects)
    - To use the model of the Bioversity Black Box concept and apply it to other CRP- RTB centres
    - To develop or optimize medium- and long- term storage techniques for other RT (e.g. edible aroids) via the droplet vitrification protocol

4/ To attract students, scientific collaborators and funding for the listed research items in consultation with Bioversity staff

Max Ruas

Information system analyst (Commodity crops)

Under the supervision of the Project Coordinator F04 and the Programme Director, Commodities for Livelihoods, and in consultation with other members of the Programme staff, especially the Genetic Resources Information Specialist:
Complete the upgrade and maintenance of the *Musa* Germplasm Information System (MGIS) including:

- Coordination of all necessary tasks to ensure that the upgraded MGIS is available on line
- Gathering feedback and incorporating lessons learnt into the upgrade in agreement with the Documentation Advisory Group of MusaNet.
- Definition of the work-flow and supervision of the work of the externally contracted programmer developing the web interface for MGIS.
- Coordination of the upgrade of the Musa Genebank Management System (MGBMS) with the upgrade of MGIS and especially to assure the automatic feed of data (shipments, virus indexing, passport data etc) between the two, including provision of technical support and advice to the MGBMS developer(s).
- Assuring an effective feed of data from MGBMS and MGIS to the System-wide Accession-Level Information System (GENESYS) and 'one-stop-shop' germplasm availability and ordering system
- Negotiating and liaising with other holders of Musa genetic resources information to assure a coordinated data feed, via MGIS to GENESYS.

Liaise with Rome-based informatics staff and collaborate, when required, in the development of GENESYS and GRIN-Global.
Liaise with informatics and crop specialists at CIRAD, University of Reading, USDA and other partner institutions to explore possible synergies between genetic resources information systems for banana, coconut and cacao and assist in upgrading information systems for coconut and cacao.

Nicolas Roux

Senior Scientist

Objective 1: To assure the effective conservation and exchange of Musa genetic resources (20%)

1. Development and coordination of MusaNet
2. Oversee the conservation of global Musa germplasm resources (MTS and LTS)
3. Improvement of the safe movement of germplasm process
4. Improvement of the Musa characterization process (morphological and molecular)

5. Oversee the support to National Musa collections
6. Standardization of storage procedures for clonal crops
7. To represent Bioversity and ITC in the Intercenter Working Group for Annual Genebanks Meetings (AGM)

Objective 2: To enhance the understanding of Musa genetic resources in support to breeders (10%)

8. Coordinate the Global Musa Genomics Consortium (GMGC)
9. Facilitate the development of genome resources
10. Advise partners on collaborative biotech projects implementation
11. Oversee the evaluation of Musa genetic resources

Objective 3: To enhance lesson learned experiences sharing across commodities (Musa, Coconut and Cacao) (10%)

12. Oversee the enhancement of the Musa Germplasm Information System (MGIS)
13. Oversee the enhancement of the Coconut Genetic Resources database and the International Cocoa Germplasm Database

Objective 4: To coordinate the genetic resources conservation and use theme of Bioversity and staff management (50%)

14. Monitor technical and financial reporting and LOAs of grants in GR Theme
15. Manage the following grants directly: Trust Long term, DGDC (ITC) and part of DGDC-CIALCA (ITC part), USAID-LF, ITC adding Value, CRP-RTB complementary project: NGS; Breeding program
16. Prepare project proposals in collaboration with project coordinators, regional coordinators and grant managers
17. Develop (in consultation with Programme leader) staffing plan in relevant subject area and implement through Performance Agreements, capacity building etc.
18. Assuring coordination with other Bioversity programmes and people
19. Providing inputs to other Bioversity activities and projects as required
20. Publish as first author and/or Co-author on review articles and focused research article

Objective 5: Theme 1 (Genetic Resources Conservation and accessibility) within CRP-RTB (10%) (see attached specific TOR for Research Theme leaders of RTB).

Julie Sardos

Under the supervision of the Project Coordinator for "Conserving and promoting the use of genetic resources of commodity crops", within the "Commodities for Livelihoods" programme, in consultation with other members of the Bioversity's genetic resources team and in close collaboration with the MGIS database developer, the Genetic Resources Associate Scientist will:

- Conduct research on the morphological and molecular characterization of genetic resources and study the complementarities between in situ and ex situ conservation in a vegetatively propagated crop such as Musa.
- Work with partners understanding of the Musa genetic diversity and answering research questions about evolution of the species.
- Develop a system to measure and monitor the loss of genetic integrity of conserved germplasm and in particular the behaviour of Musa accessions maintained in vitro at Bioversity's International Transit Centre (ITC) representing the Global Musa Collection.
- In close consultation with experts in Musa taxonomy, improve the data input and validation process to ensure data quality, and work closely with Musa collection curators worldwide to help them gather, enter and regularly update their data in MGIS in an accurate manner.

- Work with partners to enhance the value of MGIS to users through the incorporation of standardized characterization and evaluation data.
- Contribute to the production of various publications (in print and on-line) related to genetic resources characterization, information and documentation.
- Within the framework of MusaNet, a recently established genetic resources network for the implementation of the Global Musa Conservation and Use Strategy, assist the MusaNet coordinator in promoting material and information exchange to assure effective links and collaboration between ITC, Musa ex situ collections and Musa scientists.
- Manage grants that are related to genetic resources conservation, characterization and use.
- Contribute in other ways to the genetic resources research activities of Bioversity as may be agreed in consultation with the Project Coordinator for "Conserving and promoting the use of genetic resources of commodity crops", within the "Commodities for Livelihoods" programme.

Rony Swennen

For Bioversity related work, you will report to the Deputy Director General, Research and will:

- Be the representative of Bioversity in Belgium
- Provide administrative oversight to Bioversity staff based in Belgium
- Represent Bioversity at international meetings and on visits to partner organisations
- Contribute to the Conservation and Availability Programme in the area of germplasm conservation, and to the Commodities Programme for *Musa* conservation and genetic improvement
- Contribute to writing strategy papers, technical publications and various scientific papers on issues relating to genetic resources conservation and use
- Review and evaluate project proposals and scientific papers developed by or submitted to, Bioversity

Assist in developing Bioversity's research and development agenda by participating in programme planning meetings and other discussions.

Ines Van den houwe
Function: ITC Genebank Curator

Responsibilites and tasks:

Manage the acquisition and secure maintenance of Musa diversity in the genebank

- Liaise with donors of germplasm and organize the acquisition and introduction of new diversity into the collection in harmony with legal arrangements and compliance with phytosanitary requirements
- Plan and coordinate the conservation activities (MTS, LTS, leaf tissue collection) according to quality standards ensuring effectiveness and cost-efficiency

Manage the distribution Musa germplasm to users

- Handling of all requests for germplasm
- Coordinate the supply of germplasm to users ensuring compliance with treaties, MTA's, national and international guidelines, phytosanitary agreements and requirements
- Obtain services from governmental /scientific agencies to ensure plant health

- Provide information to researchers to facilitate the use of the collection

Documenting the genebank accessions and operation

- Work closely with the database manager to develop and upgrade the genebank management system, including linkages with MGIS
- Ensure that appropriate information is maintained in the genebank database
- Documenting of all genebank processes and procedures

Applied research

- Develop and conduct applied research activities to enhance the sustainability and efficiency of the conservation and utilization functions of the genebank
- Capacity building: supervision of trainees and student projects

General

- Develop and update processes and procedures to improve the efficiency of operations; oversee the implementation of best practices
- Technical follow-up and reporting of projects related to the genebank operations
- Financial planning related to the genebank
- Providing input for the development of project proposals and strategic documents for the genebank
- Participate/ Represent the ITC in thematic meetings and workshops
- Play an active role in the MusaNet Conservation Thematic Group
- Work closely with the Commodity program staff involved in collecting, characterizing, evaluating and documenting Musa GR
- Advise visitors to the gene bank

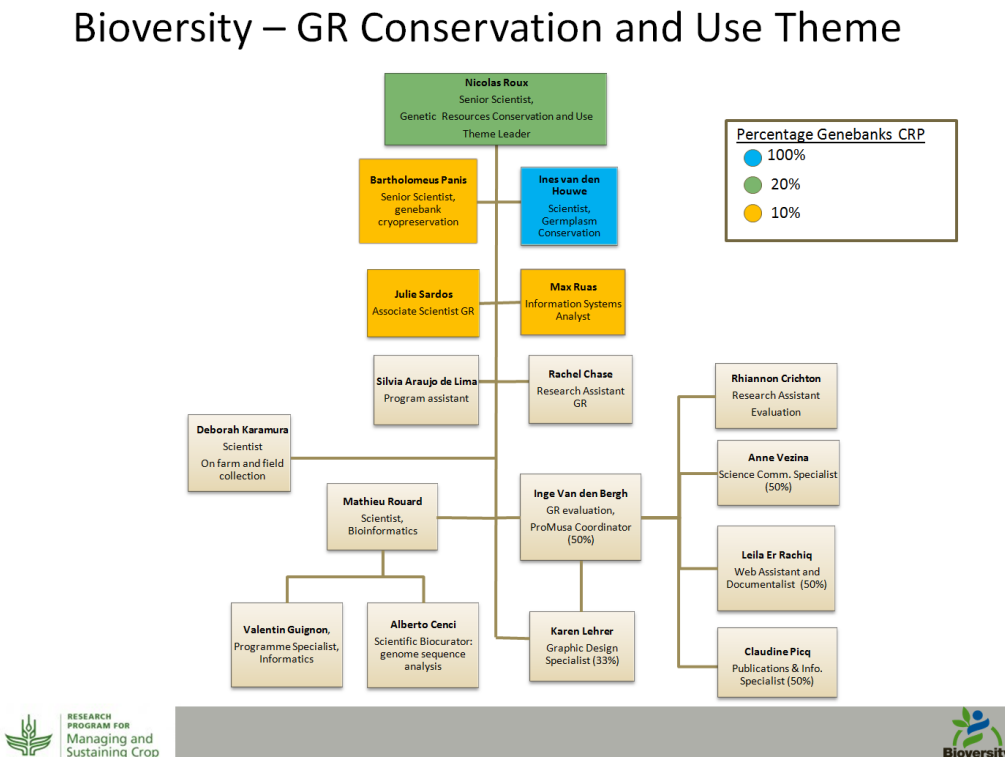
People management

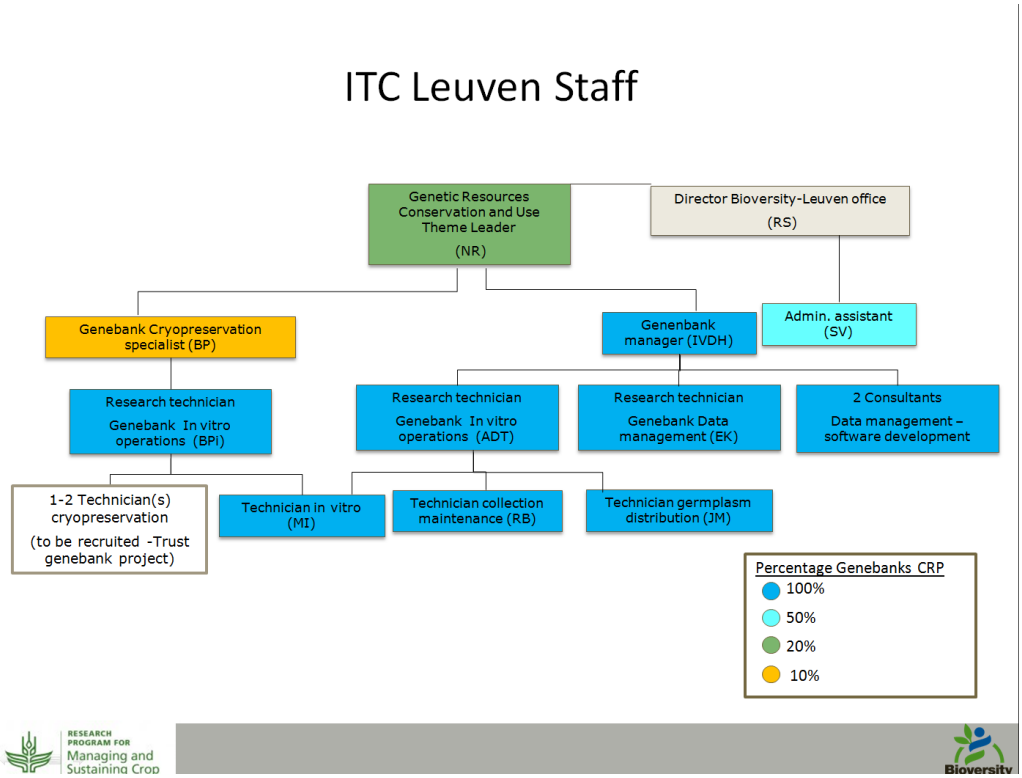
- Supervise a team of 5 professional genebank staff members, and *ad hoc* consultants

Publications

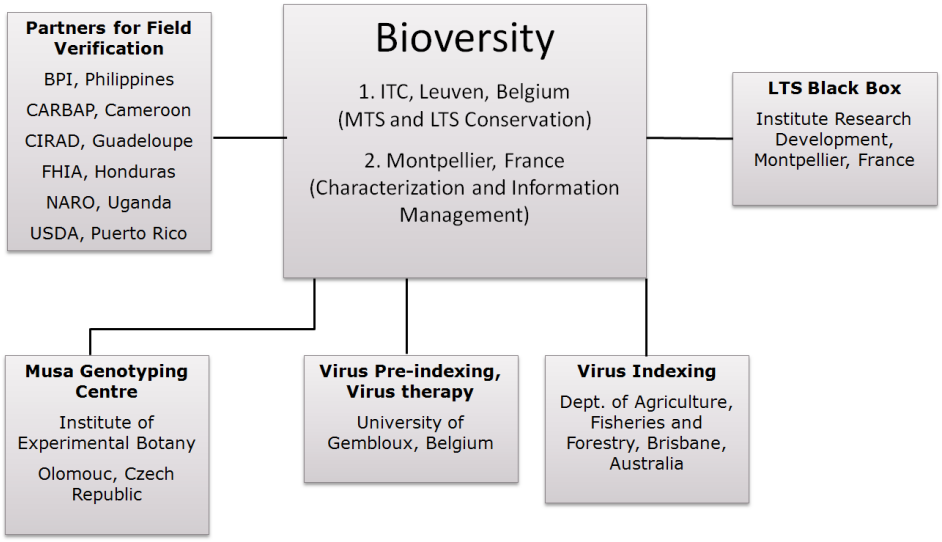
- Co-author publications, proceedings and technical guidelines and impact studies
- Other expected ouputs will be defined when establishing the performance appraisal

Annex 7: Selected charts on management and workflow in ITC, (by Nicolas Roux, Ines Van den houwe and Bart Panis)

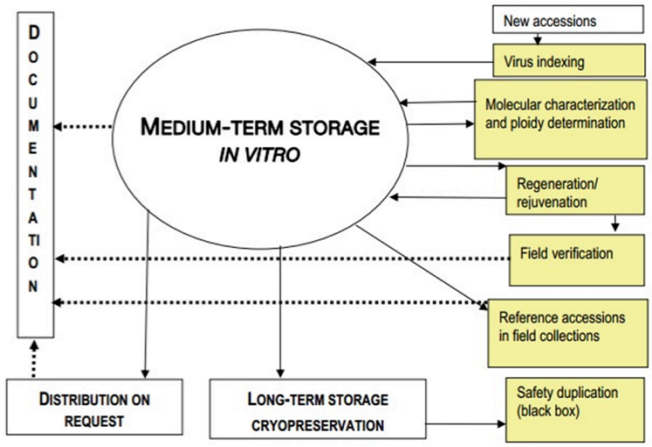




ITC Operational Chart

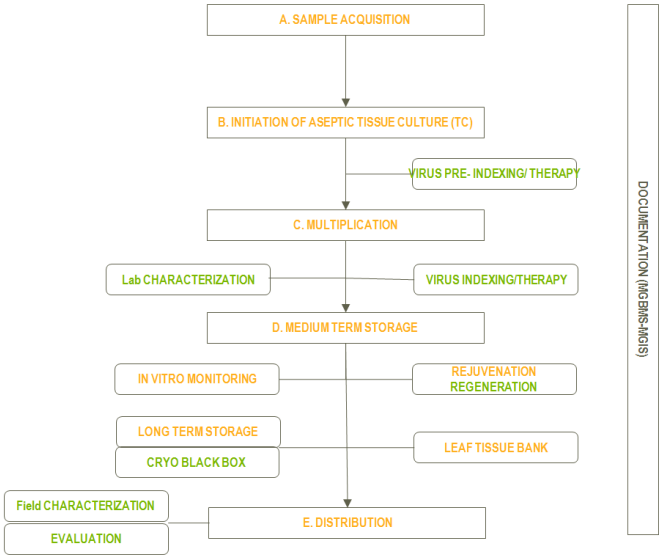


Flow of Operations



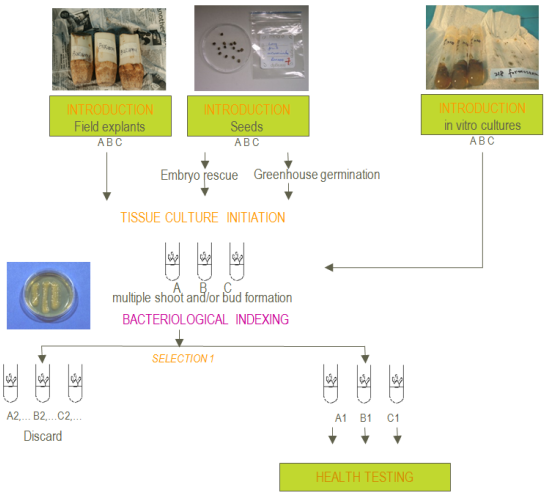
Germplasm activities

Major steps in establishing and managing the in vitro collection



Outsourced/in partnership

Acquisition-Introduction



Germplasm health testing

→FAO International Guidelines for the safe movement of *Musa* germplasm – 1989/1996

Methodologies

1/ Pre-indexing

Testing of accession lines grown in screenhouse at 3 months

Specific tests :

PCR for BBTV/CMV/BBrMV/BSVs/BanMMV

2/ Virus therapy

	CMV	BBTV	BSV	BanMMV
Meristem culture	-	+++	++	
Thermotherapy	+++			+++
Chemotherapy	+		+++	+
Electrotherapy	-		+++	
Cryotherapy	+		+++	

3/ VIC indexing

Testing of accession subset of TC plantlets grown in screenhouse at 3 and 6 months

Specific tests (knowns) :

Multiplex PCR for BBTV/CMV/BBrMV/BSVs

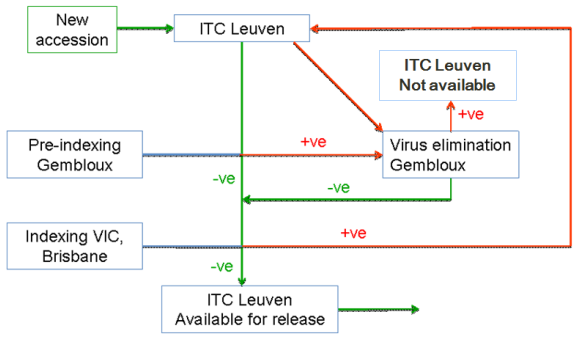
PCR for BanMMV

ISEM

Non-specific tests (unknowns) :

Visual inspection for symptoms

Minipreps/EM



Université de Liège

The University Of Queensland AUSTRALIA

Bioversity International

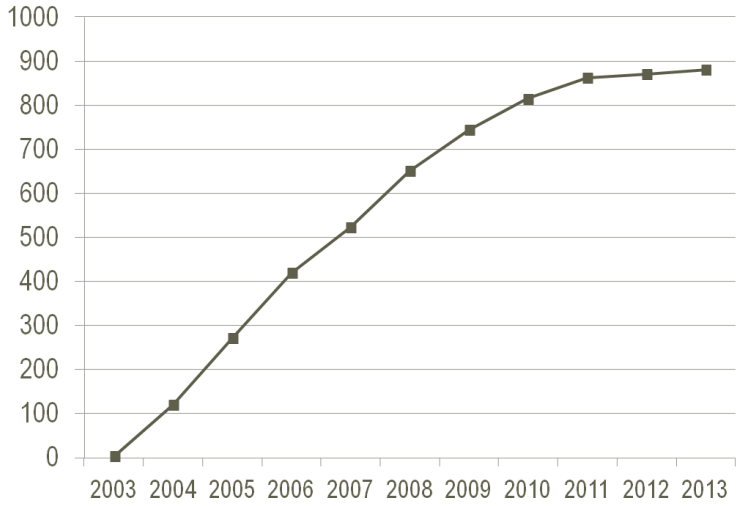
Comparison of the 3 cryopreservation protocols

	Simple freezing	Vitrification of proliferating cultures	Vitrification of apical meristems[a]
Time needed before cryopreservation can take place[b]	5-16 months	5-16 months	5-7 months
Preparation of starting material	difficult	difficult	easy
Preparation of meristem for freezing	easy	easy	very difficult
N° of explants which can be cryopreserved per person per day	600	400	60
User friendliness of protocol	+++	++	+

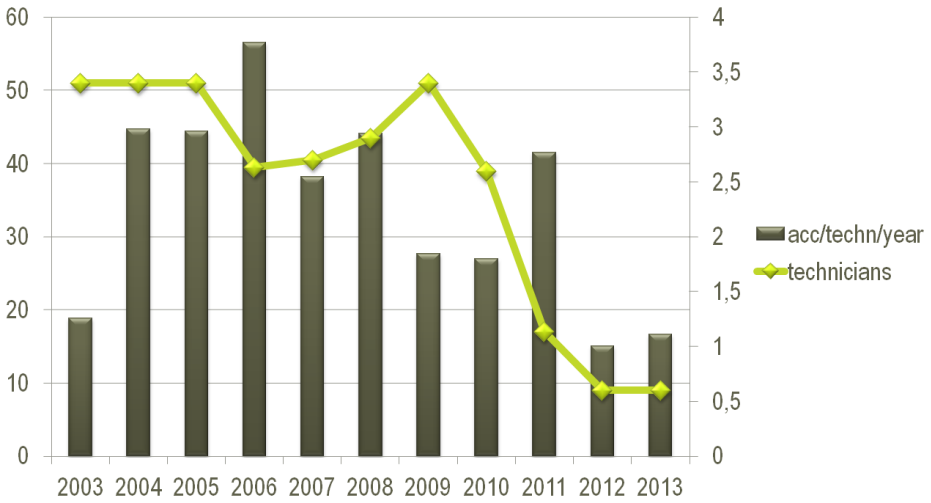
[a] Results obtained at K.U.leuven

[b] Time between an accession is received from the ITC and it can be used for cryopreservation

Number of accessions cryopreserved



How many accessions can one technician cryopreserve per year



Annex 8: Brief Questionnaire to users of ITC genebank services

Dear ITC Musa genebank user,
Your name was provided to us by Bioversity as a user of the ITC Musa Genebank which is managed by Bioversity. We are conducting a Global Crop Diversity Trust commissioned review of the genebank and we are keen to hear directly from users of the genebank about their experiences. Because of time constraints, we will be interacting directly through video conferencing with only a small number of users during the course of the review. To expand the amount of feedback we would like to invite a larger number of users to respond to a short questionnaire. We are interested to learn about your perception of the services of the ITC genebank, what works well, what information is available and what could be improved. We would be very appreciative if you could complete the questionnaire below by 17 October. This will be a major contribution to improving the services of the genebank in the future.
Many thanks

Joachim Keller and Gordon Prain
Bioversity Genebank Panel

Some questions on use of ITC genebank services

1. How many times have you requested material from the ITC genebank?
……
2. What were the reasons for requesting material? Please indicate number of times for each reason.

Breeding	……
Evaluation for possible introduction as cultivar	……..
Experimental research on performance of material	……..
Basic research	……...
Other	……...

3. What kind of material most commonly did you request?
c In vitro cultures
c Leaf sample DNA
Other (please specify)
……..

4. What quantity of material did you receive? Was it enough for your necessities?
……

5. How was the quality of the material received?

	Excellent	Sufficient	Poor
Vigour	c	c	c
Cleanness (diseases free)	c	c	c
Other (please specify)			

……

Some questions on information about accessions you requested

6. In your opinion, was sufficient the information on:

	Yes	No	Not provided
Passport	c	c	c
Characterization	c	c	c

Evaluation c c c
Comments
……

7. In your opinion, how was the quality of the information? Was it sufficiently detailed? Did it meet your needs?
……

8. Did you seek additional information from the genebank about particular accessions? Please comment if adequate information was readily available.

c Yes
c No
Comment
…….

Some questions on the procedure to request material

9. Did you always receive the material you requested?

c Yes
c No

10. How did you find the process for requesting material?

c Simple and efficient
c Reasonable
c Complicated and time consuming
c Frustrating
Please, justify your choice
…….

11. What has been the average time between requesting and receiving materials? Please provide an estimated time.
……..

12. Were any of the materials that you requested not received? Comment on whether you received explanations for lack of supply and how often this situation occurred to you.

c No, I always received the material I have requested
c Yes
Comment
…….

Some questions on feedback to ITC

13. In case of experimental research carried out with material received from ITC, what kind of information did you supply to the ITC afterwards?

c Evaluation data
c Research results
c Published paper
c I did not supplied any information
Additional comments

……

14. Did ITC request you to feedback on the results obtained? Please provide additional comments.

c Yes
c No
c Not applicable
Provide additional comments
……..……

15. Did you ever send information of results which was actually not requested by ITC?
If yes, comment if you have received feedback from ITC.

c Yes
c No
Comment
……

Final observations

16. Concerning the service you have received from ITC, what general comments (positive or critical) do you have?
……..

17. What can you suggest in order to improve the service offered by ITC?
……

18. In the future, how do you plan to interact with ITC?

c Requesting new material
c Requesting again received material
c Requesting additional information of received material
c Providing results or feedback of experimental research
c No future interaction is planned
Other (please specify)
……..……

19. If you have requested/received material from other(s) Musa genebanks, how would you assess the service provided by ITC in comparison to other(s) genebanks? Provide specific reasons.

c ITC service was better
c ITC service was comparable/similar
c ITC service was worse
Please, provide at least three reasons and comment
……..……

Annex 9: Evaluation of the responses to the questionnaire (by Cristian Moreno, GCDT)

The survey was conducted from 9th of October to 5th of November (2013). A questionnaire was submitted to 22 selected users through the Surveymonkey platform. All 19 questions had a field for open comments and no question was compulsory (see Appendix 1). In addition to the Email invitation for answering the survey, users were reminded twice before the survey was closed. The results (Appendix 2) are presented below and correspond to answers and comments of the 13 responses that were received (although only 12 completed the questionnaire entirely).

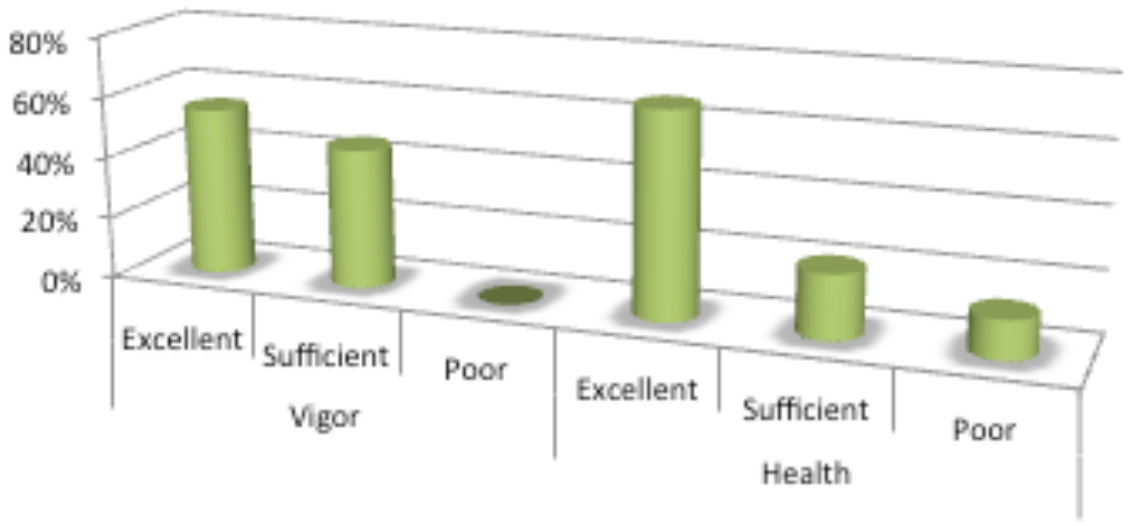
Use purpose

On average, users have requested material from the Bioversity genebank 4.83 times in total. 5 of the 13 users reported that the material was used for conducting experimental research on performance (38 %) and the next most frequent request was for evaluation for possible introduction into their countries (31 %). However, recipients used the material for multiple purposes: most popularly received material was used for experimental research on performance in 29 % of cases, then 22 % for evaluation for possible introduction as cultivars, basic research was conducted with 17 % of material and 10 % was included in breeding experiments. In addition, other uses reported were multiplication (10 %) and evaluation of disease resistance (2 %).

Quality of material received

The material received by users was in vitro cultures (92 %) and rooted plants (8 %). Additionally to the in vitro cultures, one user received also leaf samples (for DNA) and rooted plants. Concerning the quality of the material received, users were satisfied about vigor and health (disease-free) (Fig. 1).

Fig. 1. Vigor and health of material distributed by Bioversity ITC Genebank – users' perception.



It was mentioned that it would be desirable to receive a higher number of plants and/or specific indications for the treatment of those less vigorous accessions (e.g. recalcitrant accessions, small plantlets) in order to achieve a full successful growth (survival). Bacterial problems were also mentioned by 16 % of users.

Information

Information on passport data was sufficient for 80 % of users. However, most users said the information provided on characterization was either insufficient (30 %) or not provided at all (50 %). A similar situation was reported concerning evaluation information, 91 % of users reported that data were insufficient or not provided. In general, the quality of the information provided was not sufficiently detailed and more information is needed (33 % of respondents). Thus, 42 % of respondents reported they have sought additional information on the requested accessions.

Distribution

On average, the material was received 3.85 months (115 days) after requested (from 2 weeks to 9 months). 58 % of users reported that they have received all material requested. A reasonable explanation was given (e.g. health status) for those material not distributed[2]. Users were satisfied with the ordering procedure and found it to be simple and efficient (42 %) or reasonable (58 %).

Users' feedback

66 % of users said that they did not supply any information at all to the Bioversity genebank, while 20 % of users provided information of published papers. Interestingly, 20 % of users expressed their explicit willingness to provide information on their results. No feedback had been requested from Bioversity according to 80 % of users. Only 20 % declared they have received a request from Bioversity for feedback.

Users' opinion on the services provided by the Bioversity Genebank

All users have a good opinion of the service received with 50 % of users describing the services as very positive using adjectives such as "fantastic", "excellent", "great job", "very impressive", "very grateful for all effort". Although most users did not request material from any other genebank (66 %), two out of four users, who had experiences with other genebanks, said that Bioversity's services are better while the other two describe services as comparable.

When users were asked to suggest improvements to the services of the Bioversity genebank, 46 % did not provide any suggestions (some have only recently interacted with Bioversity, so have "no suggestions yet") and 15 % were satisfied with services received and do not suggest any specific improvement. Then, suggestions were made for: (i) updating the information of available accessions, (ii) correcting and updating information provided on the Musa Germplasm Information System (MGIS), (iii) providing more detailed information in

[2] Users suggested the need for having updated information on accessions availability (see suggestions on Users' opinion).

reference material (e.g. Musalogue) and online sources (MGIS) and, (iv) increasing the number of proliferating shoots per distributed accession[3].

Future interactions

All users said that they will keep interacting with Bioversity in the future. The purposes of future interactions are presented in Figure 2.

Fig. 2. Future interactions of users with Bioversity Genebank.

[3] This could be particularly considered for recalcitrant accessions and when the plantlets distributed are too small (low survival expected) as mentioned on Quality of material received.

Annex 10: IT assessment of Bioversity International Musa Genebank at KU Leuven

- **Max Ruas**, Bioversity International
- **Dag Endresen**, GBIF-Norway, Natural History Museum of the University in Oslo
- **Matija Obreza**, Global Crop Diversity Trust

Recommendations

1. We recommend ensuring reduced SQL permissions granted to users so that tables cannot (accidentally) be deleted using DROP TABLE.
2. We recommend transferring all remaining data to the new MGBMS database as soon as possible.
3. We provide a strong recommendation that the ITC accession numbers are complemented with persistent identifiers (PID)/Globally Unique Identifiers (GUID) to ensure a globally unique identification. Consider assigning a PID/GUID to all accessions in MGBMS and MGIS. Note that the same accession should get the same PID/GUID alphanumeric number in both MGBMS and MGIS.
4. Bioversity International should ensure that the program source code of all components of MGBMS is kept in a source code repository and that all changes to the program source code are always accessible in that repository.
5. Technical documentation, user guides and program executables should be organized and kept in a central location (for example, a Bioversity Wiki space).
6. Consider using the existing Bioversity's Issue Tracker (at http://dev.agrobiodiversity.org/jira/) to manage MGBMS software improvement and bug fix requests.
7. Consider switching from the expensive handheld computers to cheaper mobile platforms which should be easier to replace in case of hardware failure or incompatibility due to changes in IT infrastructure.
8. Consider tracking the actual current quantity for each lot in MGBMS. This would allow for simpler generation of management reports and alerts.
9. Developers should consider introducing a middle-tier that abstracts the database access from the handheld devices and Personal Computers.
10. When planning investments in new and future software developments, consider replacing current barcodes with QR codes. QR codes can encode more content (such as resolvable HTTP UUID identifiers, PIDs). QR codes also provide fast machine readability with error correction, which is useful if parts of the label get damaged.
11. Consider running the Print Service as part of a (middle-tier) web service or website.
12. Consider improving user experience by using AWT layout managers (BorderLayout, …), use of toolbars and menu bars for quick access to commonly accessed functions, or potentially implement user interface with SWT.
13. Consider implementing the standard reports required for reporting to the Secretary of the ITPGRFA and other reports that drive the priorities for germplasm regeneration in the MGBMS PC application.
14. Consider implementing "Alerts" where the curator and genebank staff are informed by theMGBMS that a particular accession needs regeneration due to low stock.
15. We recommend that the data synchronization between MGBMS and MGIS be automated. This could be done by adding a button or a scheduled job or executed on MGBMS startup to push availability data to MGIS directly.
16. Instead of forwarding material request information from MGIS by email, MGBMS should fetch this data from MGIS by a scheduled job or on MGBMS program start or by a "Fetch requests from MGIS" button in MGBMS. Such solution would remove

dependency on email (messages may end up in the Spam folder, or not delivered for various reasons) and also remove the need to implement email attachments in MGIS and CSV parsers in MGBMS. However, a simple and brief email alert might perhaps be useful to keep just to alert the staff that there is a new seed request pending.

17. Consider capturing requests for material currently not available in MGBMS, and follow up onthese requests later when material becomes available. This would also allow to see trends in incoming requests and allow for better planning of regeneration.
18. Consider to plan for a future migration of the MGBMS system to a web-system. Such a migration would allow for easier maintenance of the front-end for both hand-held devices and the desktop application in one code base. The current information system is a dual solution implemented using Java for desktop and .NET for handhelds.

Assessment of IT support to genebank operations

We visited Bioversity Musa Germplasm Transit Centre to assess the IT systems and applications in view of managing the Banana collection. In this document, we refer to this genebank as “Musa genebank”, “Bioversity Musa genebank”, or ITC.

Introduction

The two components of the IT system at Bioversity Musa genebank are:

- MGBMS, the Musa Genebank Management System
- MGIS, the Musa Germplasm Information System at http://www.crop-diversity.org/banana/

MGBMS supports daily operations of the genebank. In this document we focus on the MGBMS, but provide some comments regarding MGIS and the interaction between the two systems. Musa passport and characterization data is managed in MGIS, a publicly accessible web application. MGIS handles requests for Musa germplasm.

Musa genebank

Germplasm backups: Black box backup at IRD, cryo backup.

Operations: Distribution (up to 3 months to clone), Monitoring, Acquisition, Virus Indexing (outsourced), Cryo

Extra operation: Screening for bacteria (the smelly box). In the process of establishing the Musa leaf bank.

Staff Structure

- Manager, Ines
  - Data/Documentation, Els
  - T/C Lab Manager, Annick
    - 3 Technicians (Ronald, Jeroen, ?dy)
  - Cryobanking, Bart
    - Bar
      t

Description of IT components of MGBMS

Development of the first version of MGBMS started in 2001, followed by a later redesign. MGBMS is currently being updated to add features.

Components:

- MS SQL Database, hosted, operated and maintained by KU Leuven IT department
- Print Server, an application that centrally manages barcode printing
- Native application on handhelds, a .Net Compact Framework C# application
- PurgeDB, a C# standalone application used to browse, query and directly manage data in the MS SQL database
- MGBMS, a Java standalone application complementing the handhelds application

Individual applications connect and directly interact with the MS SQL Database. Barcode printing is handled through a “Print Server” service, running on the Windows server, which relays print jobs to the Zebra barcode printers.

Software components of the IT system are developed and supported by two consultants: one working with .Net framework and the other with Java. Their responsibilities separate based on the programming language used in implementation of a particular software IT component.

Hardware:

Windows Server 2003 R2 SP2: 1

Microsoft SQL Server 2005: 1

Client (PC) computers

Handheld computer, Motorola (MC 50 (x2) and MC 65(x2)): 4

Zebra barcode printer (Gk420): 4

Network infrastructure: operated by KU Leuven. Security restrictions and network segmentation follows KU Leuven IT policies.

Data safety and security

IT department of KU Leuven is ensuring regular backups of the Windows Server which is hosting the MS SQL database. This is a good arrangement for the Musa genebank as they do not have to deal with backups and disaster recovery of the entire Server.

Additionally, database backups can be created on demand using the PurgeDB tool (“Backup database on connect”). The function allows creation of a database backup outside the schedule. It gives staff peace of mind when curating larger datasets.

User authentication and authorization are managed by MS SQL Server. This allows the administrator to configure access permissions for individual users. Depending on permissions of the user of PurgeDB tool, they could potentially modify or delete any record in the database.

Software on Handheld computers

The software for handheld Windows Mobile computers is designed from the start (by Els)

to support the genebank operations. Because the system is tailor made, it fully matches their requirements, including the terminology.

The application covers for practically all of the Musa genebank operations. The software on handhelds could not better match the needs of the Musa genebank. A few additional features are being developed.

The software on handheld computers connects to the MS SQL database directly. This very tight integration of the handheld application to the database backend will prevent easy replacement of the database backend or an easy replacement of the handheld devices (currently Windows Mobile).

Recommendation: Developers should consider introducing a middle-tier that abstracts the database access from the handhelds, and allows for an implementation of MGBMS Mobile on other mobile devices (for example Android or iOS platform).

Current quantity of material is not automatically tracked by the system. Quantity is updated during “Monitoring”. When low quantity is observed by the staff, they tick a “TCR needed” checkbox.

Recommendation: Consider tracking the actual current quantity for each lot. This would allow for simpler generation of management reports and alerts.

Handhelds currently used in ITC are Motorola MC 50 (x2) and MC 65(x2). These mobile computers are expensive (in the range of USD 1,500.00 per device) compared to currently available mobile devices (e.g. Android tablets).

Recommendation: Consider switching from the expensive handheld computers to cheaper mobile platforms which should be easier to replace in case of hardware failure or incompatibility due to changes in IT infrastructure (e.g. WLAN changes).

Barcoding

All inventory items (lots) are individually barcoded until they reach “Long Term Storage” phase. At that stage, only the box with tubes and one tube are barcoded.

The barcoded content is an alphanumeric string that uniquely identifies the lot. 1-D barcode format is used. Reading the 1-D format is supported by all barcode readers and it requires very little processing.

Recommendation: ITC could consider replacing current barcodes with QR codes. QR codes can encode more content (such as a HTTP URI UUID, PID) and provide fast machine readability including error correction if parts of the label are damaged.

The “Print Service” running on the Windows Server currently handles all requests for barcode printing (from MGBMS or from handheld computers). Network segmentation at KU Leuven may not allow this service to be seen from other network segments (e.g. the green-house).

Recommendation: Consider running the Print Service as part of a (middle-tier) web service or website.

MGBMS

New features are being developed: ordering, shipment tracking, support for cryo-banking, field verification, extra queries, availability of material for distribution (based

on various parameters), user manual.

Some data are still being transferred from the old database to the new MGBMS database.

Recommendation: We recommend transferring all remaining data to the new MGBMS database as soon as possible.

The accessions held in the MGBMS are identified by their catalog number. The Musa accessions are already today published and shared into other global germplasm catalogs. See as example the Musa accession ITC1021 published two times to the GBIF data portal: http://www.gbif.org/occurrence/165318026 and http://www.gbif.org/occurrence/208277059.

Using PIDs will ensure that the identity of accessions will be maintained and understood across different information systems and data portals. PIDs will enable integration of information about the same accession maintained by different information systems (either locally or worldwide). The catalog numbers should be maintained, but used as human readable accession names and not as the machine-readable accession identifier.

Recommendation: Complement ITC accession numbers with persistent identifiers (PID)/Globally Unique Identifiers (GUID) to ensure a globally unique identification. Consider assigning a PID/GUID to all accessions in MGBMS and MGIS. Note that the same accession should get the same PID/GUID alphanumeric number in both MGBMS and MGIS.

MGIS

The MGIS service is hosted in Montpellier offices. Implemented in Java with Spring MVC and running in Tomcat servlet container. Uses MySQL database. Source code is maintained in Bioversity's private Subversion repository.

In this assessment we only focus on the integration between MGBMS and MGIS systems.

MGBMS and MGIS integration

End-users interact with MGIS to browse, search and request germplasm. Germplasm availability information from MGBMS is manually uploaded to Microsoft Azure cloud service. MGIS uses this cloud database to check availability before allowing users to request for material.

Manual synchronization of MGBMS data to MGIS is done by connecting through a VPN to the MS SQL Server at KU Leuven and then uploading the data to Azure cloud.

Requests for germplasm are sent from MGIS to ITC staff (and the requestor) by email. The request email contains a CSV attachment with information on requested germplasm names and types (leaf sample, …).

MGIS does not allow to request for material that is currently not available. Consider capturing requests for material currently not available in MGBMS, and follow up on these requests later when material becomes available. This would also allow to see trends in incoming requests and allow for better planning of regeneration.

Recommendation: We recommend that the data synchronization between MGBMS and MGIS be automated. This could be done by adding a button or a scheduled job or executed on MGBMS startup to push availability data to MGIS directly.

Recommendation: Instead of forwarding material request information from MGIS by email, MGBMS should fetch this data from MGIS by a scheduled job or on MGBMS program start or by a “Fetch requests from MGIS” button in MGBMS. Such solution would remove dependency on email (messages may end up in the Spam folder, or not delivered for various reasons) and also remove the need to implement email attachments in MGIS and CSV parsers in MGBMS. However, a simple and brief email alert might perhaps be useful to keep just to alert the staff that there is a new seed request pending.

Recommendation: Consider capturing requests for material currently not available in MGBMS, and follow up on these requests later when material becomes available. This would also allow to see trends in incoming requests and allow for better planning of regeneration.

Software development process

MGBMS is developed and supported by two consultants. The developers maintain archives of the program source code. ITC or Bioversity does not keep a repository of the program source code.

Recommendation: Bioversity International should ensure that the program source code of all components of MGBMS is kept in a source code repository and that all changes to the program source code are always accessible in that repository. This will allow for transparency in implementation efforts and also allow for a safe backup of the program source code.

Recommendation: Technical documentation, user guides and program executables should be organized and kept in a central location (for example, a Bioversity Wiki space).

Requests for improvement and bug fixes are now managed in an Excel file or through emails.

Recommendation: Consider using the existing Bioversity’s Issue Tracker (at http://dev.agrobiodiversity.org/jira/) to manage software improvement and bug fix requests also for MGBMS.

Recommendation: Consider to plan for a future migration of the MGBMS system to a web- system. Such a migration would allow for easier maintenance of the front-end for both hand- held devices and the desktop application in one code base. The current information system is a dual solution implemented using Java for desktop and .NET for handhelds.

- Such approach addresses the following issues: it becomes the “middle-tier”, serving both desktop and mobile clients.
- The database backend does not need to be exposed and the KU Leuven IT department will likely be more open to make the web site available outside the assigned network segment.