

CIMMYT Genebank Review 2013

Programme: Genebanks CRP	
Genebank reviewed: CIMMYT	Site visit Dates: 19 Nov 2013 - 22 Nov 2013
	Review report Date: 10 Feb 2014
	Center and Crop Trust responses: 18 Feb 2015
Place: Mexico D.F., Mexico	
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RESEARCH
PROGRAM FOR
Managing and
Sustaining Crop
Collections



CIMMYT 2013 Genebank Review: recommendations and responses

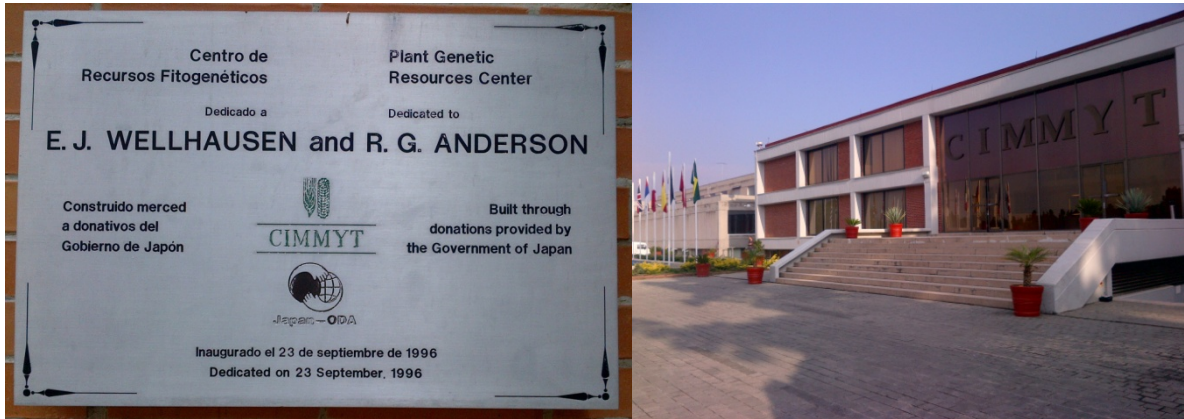
Theme	Recommendation	Responses by CIMMYT	Responses by Crop Trust
1. <i>CIMMYT & ICARDA</i>	CIMMYT and ICARDA staff should engage in discussions and actions that will result in a more rational approach to conservation of wheat and barley PGR than is presently the case. This should involve clear delineation of responsibilities for different parts of the genepool, agreement on the archiving of actively managed materials which are held in duplication and concrete mechanisms for closer communication, including data sharing resolution of taxonomic issues.	Agreed. CIMMYT and ICARDA staff will engage in discussions to rationalize their collective ex situ collection profiles An EWG Wheat Germplasm Conservation Advisory Team will provide expert guidance for the rationalization and management of such collections. Clear delineations of responsibilities will be determined, with costing options calculated, to be presented to CIMMYT and ICARDA management in 2016.	The Crop Trust supports strongly the recommendation and concrete actions proposed by CIMMYT. The reconstitution of the active collection at ICARDA beginning in 2015 is also an important opportunity to build in a rationalized approach to the conservation of barley and wheat diversity at CIMMYT and ICARDA. The Crop Trust is delighted to see the collaboration springing up also in the regeneration of CWR and ICARDA's safety duplicates. We hope that there are real benefits and efficiencies achieved in this collaboration.
2. <i>International negotiations with ITPGRFA</i>	We recommend that CIMMYT and other CGIAR Centers follow and participate in the international negotiations related to the developments of the PGRFA legal framework, and that this role be formally recognised. CIMMYT management should continue to petition the CGIAR Consortium or other relevant bodies until the effective representation of the interests of the Centers in ITPGRFA fora is assured.	Partially agreed. CIMMYT will strive to send appropriate representative(s) to international meetings when invited to do so, or will work with the Consortium Office on collective representation. However, CIMMYT's lone voice during negotiations may be insufficient to affect desired changes.	As a result of the Genebanks Options Paper, the Fund Council and Consortium Board and Office have recognised the need to ensure the representation of the Centers in the ITPGRFA and other PGR policy fora. This will ensure a much stronger CGIAR presence in these fora at least from 2017. Meanwhile CIMMYT does not have to be a lone voice while there are other active and vocal Centers also pursuing the same objectives.
3. <i>High altitude maize</i>	We recommend that CIMMYT explore the possibility of partnering with national programs and regional networks to regenerate high altitude/temperate accessions that cannot be successfully regenerated in Mexico	Agreed. CIMMYT is establishing new nurseries in Totoloapan and Toluca in Mexico, to grow high-altitude maize. Regeneration success will be measured in 2015 and 2016. If results show 50% or less success or if specific subsets of highland maize fail to regenerate in Mexico, then CIMMYT will explore options to partner with other national partners.	The Crop Trust supports the recommendation and response.
4. <i>GRIN-Global</i>	It is critically important that all information associated with the PGR collections be maintained in	Agreed. CIMMYT has committed to implementing GRIN-Global.	The Crop Trust fully supports the recommendation and the strong actions CIMMYT

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	<p>a single database that is interoperable with other information systems, and that this much of the accession information be available online. Following testing of GRIN-Global (GG), we recommend that CIMMYT concludes the piloting of different software options and implements a consolidated information management strategy within 18 months to avoid further delay of this vital effort. We encourage CIMMYT's continued leadership and participation in international community efforts to improve the functionality of GG and its utility to the genebank community</p>	<p>Implementation of GRIN-Global is supported by the Long-Term Grant and Frontrunner project. This will ensure that all PGR information is held in a single database that is interoperable with Genesys and provides information online. The implementation will be completed in 2015. Further CIMMYT is hosting the "Front Runner" position to coordinate the regional effort to adopt and improve GG.</p>	<p>is taking to address this issue.</p>
<p><i>5a. Stratified maize curatorial policy</i></p>	<p>A stratified curatorial policy should be developed for the maize collection which allows different conservation actions and storage options to be allocated to materials depending on their uniqueness and significance for long-term conservation. Included in this policy should be a realistic, costed workplan to assess and address the backlogs for regeneration. These should be developed in the next six months. Implicit also in this recommendation is the full and accurate resolution of the maize inventories. In addition, the reviewers strongly caution against using molecular information as a primary criterion to assume duplication or to discard wheat or maize accessions.</p>	<p>Partially agreed. A draft stratified curatorial policy will be drafted for Center management consultation and consideration, proposing a plan to archive accessions as viability rates decrease over time. A backlog of unprocessed seed from regenerations and from introductions has accumulated over the past decade. The main activity for both these types of materials is one of classification, collecting the background information needed to make a decision about the fate of the seed, making the decision based on the curatorial policy, and following through to either incorporate or eliminate the seed. CIMMYT will commit to considering a stratified policy only if we determine that this would be desirable and feasible.</p>	<p>The Crop Trust agrees with the spirit of the recommendation, which is to ask CIMMYT to urgently assess the status of the maize collection and inventories and determine which material is a priority for action (i.e. regeneration). Having seed remain unprocessed if it is exposed to the risk of losing viability should, of course, be avoided at all cost. We strongly urge CIMMYT to respond more concretely to this important recommendation and assemble the necessary information to make decisions without further delay.</p>
<p><i>5b. Maize drying practices</i></p>	<p>A thorough review of effective drying practices for maize to increase drying rates while maintaining optimum viability is recommended, and could help expedite processing</p>	<p>At the time of the review a new drying chamber had only recently become operational. We continue to fine-tune our technique to improve the efficiency of the</p>	<p>The Crop Trust supports the recommendation and response and looks forward to hearing the results of CIMMYT's review of best practices.</p>

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		existing system. Best practices followed by other maize collections will also be explored.	
<i>5c. Maize regeneration</i>	CIMMYT's efforts to improve maize regeneration success are commendable. In order to improve success rates, we recommend that CIMMYT explore and adopt improved agronomic practices, more flexible criteria for measuring regeneration success, and concentrate resources in the most suitable field sites. Also to be taken into account is the likelihood that much higher success rates for certain elements of the genepool may be achievable in environments not found in Mexico (ie. tropical highland races such as Cusco)	Agreed. CIMMYT will implement a workplan to investigate the effects of fungicide, insecticides and harvest times on ear rot in an experimental field in Agua Fria and implementing the treatments that have success. Equally advice from university researchers or the private sector will be sought. Alternative sites for regeneration may be considered when necessary, but the manager will also participate in discussions aimed at improving the agronomics of the CIMMYT field station.	The Crop Trust supports both the recommendation and response and will hope to see the resulting improvement in regeneration success rates.
<i>5d. Viability testing rates</i>	We recommend that seed in medium term (MT) storage conditions be tested every 5 years and seed in long term (LT) storage conditions be tested every 10 years. If MT seed viability is >85% after 5 years, it is logical to assume that the same source stored under LT conditions is also of high viability, thus it is not necessary to devote resources to testing the corresponding seed source from LT storage every 5 years unless MT seed viability drops.	Agreed. This seed testing schedule has been adopted, but will also be verified by the results of seed longevity experiment.	The Crop Trust supports the recommendation and response and recognizes the significant gains that can be made by carefully reviewing viability data.
<i>5e. Plant quarantine, seed health and germplasm distribution</i>	We recommend that the maize curatorial team thoroughly document available LT and MT maize reference samples within the next six months and confirm its procedure of maintaining reference samples of all regeneration seed lots.	Agreed. This activity is under way already. This should be completed in mid 2015. In the future, reference samples will be collected and catalogued for all the samples in the germplasm bank.	Great news! The Crop Trust is in full support.
<i>6. Stratified wheat curatorial policy</i>	A stratified curatorial policy should be developed for the wheat collection which allows different conservation actions and storage options to be allocated to materials depending on their	Agreed. A draft stratified curatorial policy will be drafted for Center management consultation and consideration proposing a plan to archive accessions as viability rates	The Crop Trust supports the recommendation and the response. This recommendation should be linked also to recommendation 1.

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	uniqueness and significance for long-term conservation. The review team recommends that clear criteria be established to deactivate or archive accessions, and other nuanced approaches be considered to facilitate the management of the wheat collection. In addition, the reviewers strongly caution against using molecular information as a primary criterion to assume duplication or to discard wheat or maize accessions.	decrease over time. We agree that the genetic definition of what constitutes a “duplicate” remains illusive and hence the use of molecular data to delve into this question needs to be used cautiously and needs to be coupled with distinctive evaluation, morphological and passport data.	
<i>7. Seed conservation science</i>	We recommend that CIMMYT make available its seed conservation data and become an active partner in seed conservation research devoted to understanding the biology of seed longevity in storage in order to advance conservation science and practice	Agreed. CIMMYT will conduct research on the effect of storage time on different types of maize seeds (flint, floury and dent). CIMMYT will be represented at the ISSS Seed Longevity Workshop in Gatersleben in July 2015. Historic viability data will be entered into GRIN-Global to obtain an overall picture of viability dynamics. This research will be conducted together with the initiative lead by GCDT and Fiona Hay.	The Crop Trust supports the recommendation and the response. Through funding from the Genebanks CRP to analyse seed longevity data across the system, we will aim to make headway in advancing conservation practice and efficiency.
<i>8. Capacity building and training</i>	We recommend that the collection managers have a voice or a listening role when research agendas are discussed, planned and implemented within CIMMYT. Transfer of information from the research programs back to the genebank managers is critical for defining the value of the collections and ultimately decision making regarding genebank management.	Agreed. Integration of the bank research agendas into the respective commodity CRP Phase 2 plans will be actively pursued. Closer integration with users of conserved germplasm will be possible through more active involvement with the Seed of Discovery project. In addition, the collections will actively pursue CRP Genebank Phase 2 development.	Work in progress. The reviewers say “transfer of information from the research programs back to the genebank managers is critical”. This is a key point, which requires sustained effort. The Crop Trust appreciates CIMMYT’s efforts to achieve better integration and sees there is an opportunity to work on this in developing the CRP Phase 2 portfolio. However, the integration is essential at a finer scientific level where scientists share data.
<i>9. Costing of genebank activities</i>	CIMMYT and the Crop Trust should continue their efforts to analyse the cost basis of the genebank activities until they have determined a fair allocation of resources for the core genebank activities of	Agreed. CIMMYT will work with colleagues at the GCDT to refine the costing basis for CIMMYT genebank activities.	The Crop Trust supports the recommendation and response. A costing exercise is under way and should be completed by November 2015.

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	different institutes in different locations.		
<i>10. Contribution of Tom Payne</i>	The review team recognizes the significant contributions of Dr Thomas Payne in providing leadership within the CGIAR system in the implementation of standards, ISO certification, GRIN-Global testing, and the establishment of the Article 15 Genebank Managers Group. We recommend that the Genebanks CRP provide a stronger mechanism for nurturing collaboration and transferring experience and training between the CGIAR genebanks	Partially agreed. The action from which this recognition derives is an essential component of CIMMYT's global mission. However, the recommendation made to the Genebanks CRP is beyond the influence of CIMMYT.	The Crop Trust supports the recommendation and response. CIMMYT's contributions to data management, quality management and other areas have been very influential. In 2015, a workshop was held at CIAT for a large number of genebank staff from CIAT, CIP and CIMMYT. They were able to discuss in-depth issues and experiences surrounding genebank operations, and come up with valuable new ideas and areas of collaboration for development. Long may this kind of collaboration last!



Review of the CIMMYT Genebank – November 19-22, 2013

Prepared by Candice Gardner, Andreas Börner, and Federico Condón

Preface: CIMMYT provides excellent physical facilities for germplasm storage, maintenance, viability and seed health testing. The long-term and medium-term storage facilities are well kept and maintained. The CIMMYT genebanks have a long history of being relatively well supported, and an outstanding record of providing germplasm and information which has supported international crop development and global food security. Disease and pest monitoring to comply with international, national, and regional phytosanitary requirements is comprehensive and very well managed. CIMMYT continues to provide outstanding leadership and training of global scientists and genebank personnel, and serve as a role model for partnerships and germplasm utilization to realize and capture the value of the collections.

Expanded Comments of Review Team

1 - Relationship of CIMMYT and ICARDA with respect to global wheat germplasm conservation

Both CIMMYT's and ICARDA's collections of wheat, barley and crop wild relatives are vital to crop improvement and world food security, and are held in trust. The review team strove to understand the security status and accessibility of both collections. We understand that safety duplicates of the collections held by ICARDA have been dispersed to Turkey, Tunisia, and other locales, as well as backed up at Svalbard. The unique accessions of ICARDA's collections are also apparently held in 'black box' at CIMMYT.

The review team believes that discussions between ICARDA and CIMMYT personnel should be conducted, aimed at immediate development and implementation of a long-term, rational approach to the conservation and utilization of the crop genetic resources held in their respective institutes. Goals should include improved understanding of the differences between the makeup and focus of their respective collections, and their existing strengths and capabilities. Understanding and constructive collaborations should strive to complement roles, avoid duplication of efforts and collections, and determine and build on existing strengths and capabilities (e.g. of CWR and barley at ICARDA). These, together with the Crop Research Programs ultimately will enhance crop improvement efforts.

Recommendation 1: CIMMYT and ICARDA staff should engage in discussions and actions that will result in a more rational approach to the conservation of wheat and barley PGR than is presently the case. This should involve the clear delineation of responsibilities for different parts of the gene pool, agreement on the archiving of actively managed materials which are held in duplication and concrete mechanisms for closer communication and collaboration, including data sharing and resolution of taxonomic issues.



2 - Impact of the international legal framework on CIMMYT activities and germplasm access

The CBD and the ITPGRFA have had impacts on germplasm exchange, germplasm movement, and access to both plant genetic resources (PGR) and regeneration environments. The continuing development and on-going negotiations of the international legal framework on the access and benefit sharing of PGRFA can affect the routine operations of distribution, introduction and

regeneration of germplasm, as well as access. The formal channels through which CIMMYT provides feedback to the decision-making bodies of the ITPGRFA are currently not working effectively. This situation should be resolved as soon as possible so that CIMMYT and other CGIAR Centers are able to have a voice in ITPGRFA fora.

Recommendation 2: We recommend that CIMMYT and other CGIAR Centres follow and participate in the international negotiations related to the developments of the PGRFA legal framework, and that this role be formally recognized. CIMMYT management should continue to petition the CGIAR Consortium or other relevant bodies until the effective representation of the interests of the Centres in ITPGRFA fora is assured.

3 - Partnership with national programs

Due to specialized and limited environmental adaptation of some accessions, especially of maize, it may be impossible to successfully regenerate all of the collection in Mexico. For these accessions, it may be necessary to partner with international or national entities with appropriate environments to successfully regenerate and maintain these accessions. Regional PGR networks can also be valuable partners to channel cooperation and prioritize actions (REGENSUR- Southern Cone PGR network; TROPIGEN- Tropical PGR network; REDARFIT- Andean PGR network; REMERFI- Mesoamerican PGR network; NORGEN- North American PGR network; CAPGERNET – Caribbean PGR network)

Recommendation 3: We recommend that CIMMYT explore the possibility of partnering with national programs and regional networks to regenerate high altitude/ temperate accessions that cannot be successfully regenerated in Mexico.

4 - Documentation of collection information and genebank information management

It is very important that CIMMYT have a comprehensive, stable strategy for documentation of all types of information associated with the accessions, much of which should be accessible through the internet, therefore increasing the accessibility and use of the PGR held in trust by CIMMYT. The real and potential value of plant genetic resources is stored in the seeds, but the realization of their value is made possible through access to the information associated with them.

Currently the information associated with the maize and wheat collections is not in a single database, nor its documentation managed in a coordinated manner, and much is not available online. This makes it necessary for germplasm users to interact personally with the curators to identify accessions that meet their objectives, a vulnerability because it poses a risk to long term commitment to PGR conservation, as a wealth of knowledge can be permanently lost due to unexpected events or the departure of key personnel. Researchers utilize Tom Payne as an essential resource to identify accessions that meet their objectives.

The curatorial staff has been working to secure vital documentation in GRIN-Global (GG) v 1.0. Completion of this very important effort is dependent on the release of the next version of GG from the USDA, which has been delayed for more than two years. The GG system cannot provide for all genebank information management needs, such as pedigree and molecular information. It is very important that CIMMYT have a comprehensive, stable strategy for documentation of all types of

information associated with the accessions, and that the GG system be fully interoperable with other sources of information, such as evaluation and characterization information from projects such as SeedS (now MasAgro), and the results of prebreeding and other research programs. Following testing of GG, decisions about IM strategy and development need to be made within 18 months to avoid further delay of this vital effort. The review team stresses the need for commitment and continuity of information management efforts, and encourages rapid transfer of data into the GG System. Stability of the information system is important and a key performance indicator.

The CIMMYT genebank staff is commended for their efforts and encouraged to continue these efforts in order to ensure all information associated with the collections is documented in a single database. These efforts are particularly noteworthy, as CIMMYT served as the very first CGIAR genebank to test and implement the GRIN-Global System, an arduous and challenging project. CIMMYT has provided analysis of their experience and feedback to the GG Development team, and to other CGIAR genebanks. They have also provided training to other CGIAR genebank staff. We encourage continued participation in international community efforts to address GG system needs and functionalities in order to improve its functionality and continued utility to the genebank community.

Recommendation 4: It is critically important that all information associated with the PGR collections be maintained in a single database that is interoperable with other information systems, and that this much of the accession information be available online. Following testing of GRIN-Global (GG), we recommend that CIMMYT concludes the piloting of different software options and implements a consolidated information management strategy within 18 months to avoid further delay of this vital effort. We encourage CIMMYT's continued leadership and participation in international community efforts to improve the functionality of GG and its utility to the genebank community.

5 - Maize collection management

5A. Status and Availability

The review team recognizes the significant efforts of the maize curation team to update inventories of the materials that a) are held in long-term or medium-term (LT or MT) storage conditions, b) are held in cold storage and are to be processed, and c) require regeneration which may or may not be possible in Mexico. The maize curator has been in her position for barely a year, understands the issues and is well prepared to address them. Further work is needed in the team to ensure that staff members are fully trained, able to do their work and cooperate fully with their colleagues. The reviewers understand that CIMMYT management provides support to encourage and build team cohesion and functionality.

It is critical that CIMMYT address the accuracy of the inventories and the status of the collection, including resolving backlogs as soon as possible, and increasing the availability of these valuable global resources. This can be accomplished through a combination of improved regeneration processes, intensive management aimed at control of ear rots and insects, and

eliminating duplicates or accessions that should be archived from the backlog. Criteria for incorporation of breeding material from researchers need to be established (non-CMLs). Development of a realistic, costed workplan to assess and address the backlogs is essential.

A clear, strong, technically based curatorial policy should be developed with rational support in place. Different policies should be created for managing accessions that are actually confirmed to be unique and of long-term importance versus pre-breeding or other materials, some of which may be of interest for a relatively short term duration. They should not be treated as a single collection of inventories. Policies and protocols that define the criteria for acquisition, classification as to collection type, purpose, and status, and their periodic review should be established. The main goal for the long-term collection held in trust should be to ensure regeneration while maintaining genetic integrity and availability, and prolonging the time between successive regenerations. Increasing availability of these valuable global resources is very important. The review team questions why CIMMYT does not include the expired Plant Variety Protected maize lines from other countries in its collection, as these are of value.

Recommendation 5a: A stratified curatorial policy should be developed for the maize collection, which allows different conservation actions and storage options to be allocated to materials depending on their uniqueness and significance for long-term conservation. Included in this policy should be a realistic, costed workplan to assess and address the backlogs for regeneration. These should be developed in the next six months. Implicit also in this recommendation is the full resolution of the maize inventories. In addition, the reviewers strongly caution against using molecular information as a primary criterion to assume duplication or to discard wheat or maize accessions

The CIMMYT Seed Bank is divided into two 400 m³ vaults, each for the conservation of seeds in the medium (active) and long (base) term. The vaults have a capacity of conserving approximately 450,000 seed samples, plus working areas and offices where samples are recorded, processed, packaged and distributed. The active vault holds seed that is extracted to meet routine seed requests, is maintained in the range of 0°C to -3°C temperature with relative humidity 25 to 30%. The base vault is kept at a temperature of -18°C, aiming to maintaining seed viability in excess of 100 years. Cytogenetic stocks are also maintained in the CIMMYT Wide Crosses Laboratory. Cold storage facilities are very good, well controlled, and generators for backup power are available.



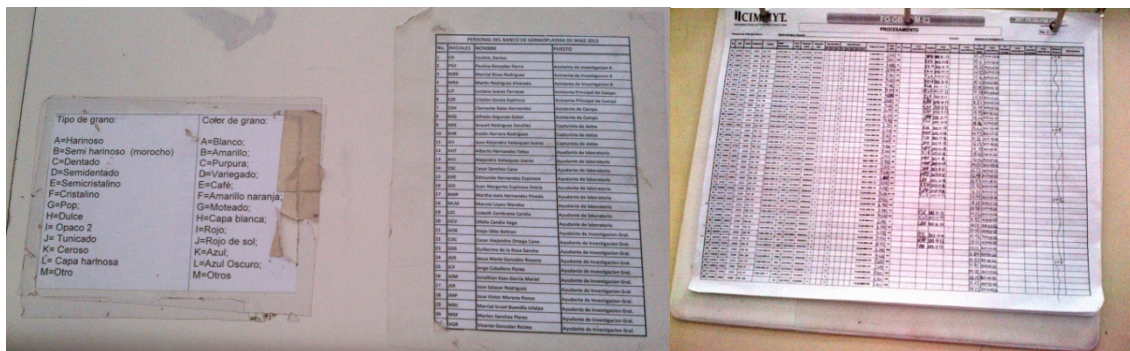


5B. Drying Protocol

Drying is accomplished over a period of multiple months at relatively low temperature. The drying chambers' capacity and drying protocols should be evaluated as they could be impeding the processing of backlogs and newly regenerated seed and impacting seed quality. It is necessary to achieve balance between drying time and temperature, as too high a temperature may result in short drying times and lower germination, while low temperature drying over an extended time risks increased proliferation of fungi that reduce seed quality and longevity and also require more energy. Maize is an allogamic crop, and due to its seed size, seed number per ear, and genetic diversity, requires large populations to maintain the genetic profile. Higher volumes and total weights potentially dictate larger drying capacity than a smaller seeded crop, like wheat, for an equal number of accessions.

Recommendation 5b: A thorough review of effective drying practices for maize to increase drying rates while maintaining optimum viability is recommended, and could help expedite processing.

Protocols for describing accessions during processing were evident and guides were posted conveniently for use by personnel. Two examples are shown below.



The review team commends the maize genebank manager for her efforts to analyze the regeneration success rates and the contributing factors to low success rates in the CIMMYT maize field sites. In order to address anthesis silking interval (ASI) delay issues associated with regeneration of some landraces, we encourage the curator to delay planting a few rows to ensure availability of pollen for late-emerging silks. The genebank staff and agronomic staff at

the regeneration locations need to improve agronomic practices, especially those practices that contribute to control of ear mold; over 50% of regeneration failures were reported due to loss of seed to ear mold. Alternative regeneration sites are being tested and evaluated, and decisions need to be made on sites to be used for the next regeneration cycle. Clear criteria are needed that define suitability of a site for regeneration (ie productivity, biotic or abiotic stress and frequency, quality of collaboration, regeneration success rate, etc). Criteria for determining regeneration success itself should be flexible; it is not reasonable to impose a fixed, 5 kg seed quantity requirement to determine success. Criteria and rationales should be documented.

Recommendation 5c: CIMMYT's efforts to improve maize regeneration success are commendable. In order to improve success rates, we recommend that CIMMYT explore and adopt improved agronomic practices, more flexible criteria for measuring regeneration success, and concentrate resources in the most suitable field sites. Also to be taken into account is the likelihood that much higher success rates for certain elements of the genepool may be achievable in environments not found in Mexico (ie tropical highland races such as Cuzco).

5D. Viability Testing of Maize

Information provided by CIMMYT personnel indicates that maize regeneration decisions are based on either the viability of seed in LT storage (sampled every 10 years), or viability of seed in MT storage (sampled every 5 years), or seed supply. If the sum of supply in both LT and MT storage is less than 500 gm, seed is regenerated. If MT seed viability is >85% after 5 years, it is logical to assume that the same sourced seed stored under LT conditions is also of high viability, thus it is not necessary to devote resources to testing the corresponding seed from LT storage every 5 years. LT seed should be tested in the case where seed in MT and LT represent different sources or when the MT seed lot's viability is <85%. Maintenance of independent LT and MT storage inventories should continue, and the use of reports to review seed supply status be continued.

Recommendation 5d: We recommend that seed in medium term (MT) storage conditions be tested every 5 years and seed in long term (LT) storage conditions be tested every 10 years. If MT seed viability is >85% after 5 years, it is logical to assume that the same source stored under LT conditions is also of high viability, thus it is not necessary to devote resources to testing the corresponding seed source from LT storage every 5 years unless MT seed viability drops.

Maintenance of reference samples of previous maize regeneration seed lots

The review team understands that a reference sample of all original seed sources has been kept, and that 100 seed reference samples of all regeneration seed lots have been kept since 2011. Older regeneration sources have been completely discarded as newer regeneration sources became available and no reference examples exist. It is important to keep at least a reference sample of all seed lots of an accession's regeneration history in the future, including original seed. The wheat collection, in contrast, has maintained at least reference size samples for all wheat seed increase lineages.



Recommendation 5e: We recommend that the maize curatorial team thoroughly document available LT and MT maize reference samples within the next six months and confirm its procedure of maintaining reference samples of all regeneration seed lots.

6 - Wheat collection management

The wheat collection contains a wealth of germplasm of various stages of development. The curator has indicated that inventory management is becoming problematic, and there is no policy regarding deactivation or archiving of accessions. There are very clear criteria to determine whether a new introduction can be accepted into the collection. The review team recommends that clear criteria be established to allow for deactivation of accessions or permanent archiving, and other nuanced approaches considered. Archived material need be stored only in LT conditions for reference purposes, and not actively maintained. Similarly, criteria for incorporation of breeding material or deactivation of materials are necessary but missing, and are likely different than criteria for germplasm to be permanently conserved. These should be developed in the next six months, and deliberations completed within a year.

Molecular characterization information, associated with the collection, produced through the SeeDs project will contribute significant value to the collections and their utilization. If the experience of other genebanks is any indicator, demand for the collections will increase as a result of publication of molecular characterization information and its analyses. Another use of this information will be to compare the diversity within and among accessions, particularly of the landraces. It is yet another source of information that can be used to understand the breadth of a collection and relationships between accessions. The reviewers strongly caution against using it as a primary criterion to assume duplication or to discard wheat or maize accessions; the nature of molecular information does not lend itself to interpretation of intrinsic phenotypic traits or their expression in different environments.



Recommendation 6: A stratified curatorial policy should be developed for the wheat collection, which allows different conservation actions and storage options to be allocated to materials depending on their uniqueness and significance for long-term conservation. The review team recommends that clear criteria be established to deactivate or archive accessions, and other nuanced approaches be considered to facilitate the management the wheat collection. In addition, the reviewers strongly caution against using molecular information as a primary criterion to assume duplication or to discard wheat or maize accessions.

7 - Conservation Research

The majority of global genebank holdings, including CIMMYT collections, are stored as seed. Therefore, seed conservation research is of exceptional importance for germplasm banks. Great differences in seed storage behavior are recognized between plant species. In addition, huge within-species variation exists. However, there is a deficit in understanding the biology behind long and short seed life. Institutions that have held large collections over a long period of time are clearly in a unique position to contribute to this much-needed research. The review panel encourages CIMMYT to make available data relevant to seed conservation research either by contributing to existing resources online, publishing data or through other means. CIMMYT should pursue opportunities to actively participate in research devoted to understanding the biology of seed longevity in storage in order to enhance conservation practices in the future.

In 2015, a seed longevity workshop organized by the International Society for Seed Science (ISSS) will be held in Gatersleben, Germany. This workshop will focus on all aspects of seed conservation. It will concentrate on molecular mechanisms, biochemistry, physiology, biophysics and genetics of seed survival. The workshop is aimed to bring together scientists involved in seed banking and seed science. Researchers from CIMMYT should active take part in this event.

Recommendation 7: We recommend that CIMMYT make available its seed conservation data and become an active partner in seed conservation research devoted to understanding the biology of seed longevity in storage in order to advance conservation science and practice.

8 - Genebank manager interactions with germplasm users

The genebank managers are in the best position to provide counsel and feedback to the researchers who utilize germplasm, whether it be SeedDs or other research endeavors. It is not clear that these managers have a voice or a listening role when research agendas are discussed, planned and implemented. Tom Payne's informal relationships with germplasm users have clearly led to a good interaction between the researchers and the genebank. This is not as evident for maize historically or at present, and is important. Transfer of information from the research programs, back to the genebank managers, is critical for defining the value of the collections, and ultimately decision making regarding genebank management.

Recommendation 8: We recommend that the collection managers have a voice or a listening role when PGR research agenda are discussed, planned and implemented at CIMMYT. Transfer of information from the research programs, back to the genebank managers, is critical for defining the value of the collections, and ultimately decision making regarding genebank management.

9 - Costing Basis

CIMMYT and the Trust need to continue their efforts to analyze genebank activities and their cost basis in order to determine a fair and comprehensive basis for the allocation of resources required to conduct core activities. Although fiscal analysis was not the purview of this genebank review team, it is evident to the team that both Trust and CIMMYT personnel are vested in developing an accurate understanding of this area, and that both parties respect and appreciate the challenges involved in such analysis. Funding support is essential for long-term collection preservation, and what is learned at each institute can be leveraged by other institutes. We applaud the partnership's success in understanding the complexity involved in genebank operations.

Recommendation 9: CIMMYT and the Crop Trust should continue their efforts to analyze the cost basis of genebank activities until they have determined a fair allocation of resources for the core genebank activities of different institutes in different locations.

10 - Leadership contributions of Tom Payne and CIMMYT to the genebanks of the CGIAR system

Last but not least, the review team recognizes the significant contributions of Dr. Thomas Payne, not only to ensuring the security and availability of the wheat germplasm collection, but to the leadership he has provided to the genebanks in the CGIAR system. Beyond this, CIMMYT has led the way in the implementation of global genebanking standards, risk assessment, ISO certification, GRIN-Global testing, and establishment of a group of genebank managers (Article 15 Genebank Managers), and should be recognized for their many contributions. The genebank CRP should provide a mechanism for nurturing collaboration and transfer of experience between the various CG centers. Exchange of procedures can be advantageous, as well as providing training opportunities for technical personnel.

Recommendation 10: The review team recognizes the significant contributions of Dr. Thomas Payne in providing leadership within the CGIAR system in the implementation of standards, ISO certification, GRIN-Global testing, and the establishment of the Article 15 Genebank Manager Group. We recommend that the Genebank CRP provide a stronger mechanism for nurturing collaboration and transferring experience and training between the CGIAR genebanks.



Left: Curator Tom Payne in Seed Storage. Right: Paulina Gonzalez and Andreas Börner



Review Participants:

Front Row (left to right): Candice Gardner, Denise Costitch, Bibiana Espinosa, Paulina Gonzalez, Amanda Dobson. Back Row (left to right): Thomas Payne, Andreas Böerner, Paula Bramel, Charlotte Lusty.

Annex: Reviewers' Biographies

Candice Gardner

Research Leader, USDA-ARS Plant Introduction Unit, North Central Regional Plant Introduction Station. Department of Agronomy – G212 Agronomy Hall. Iowa State University, Ames, IA 50011-1170

Professional Preparation (college, major, degree, year)

University of Missouri – Columbia, Corn Breeding, Ph.D., 1982

University of Missouri – Columbia, Plant Pathology, M.S., 1979

Iowa State University, Bacteriology, B.S., 1975

Appointments

1999-Present: USDA-ARS Plant Introduction Station Research Leader, and NC-7 Project Coordinator, Ames, IA

1999-Present: Collaborator faculty appointment, Department of Agronomy, Iowa State University, Ames, IA

1998-1999: Aventis USA Company, Biotechnology Development Specialist, Iowa

1982-1997: Pioneer Hi-Bred International, Inc., Corn Research Manager, Missouri

Activities

- Hosted the AGM2013 CGIAR genebank managers meeting, Iowa State University, 2013
- Member, ASA/CSSA/SSSA: Past C-8 Division Chair, 2011, Plant Genetic Resources
- AAIC (Association for the Advancement of Industrial Crops) Past-President, 2008
- GRIN-Global Project collaboration between the Global Crop Diversity Trust, Bioversity International, and USDA-ARS to develop a genebank management information system for global genebank implementation; supported in part by the Gates Foundation grant to the Trust.
- Mentored 25 Native American and other ethnically diverse interns via ISU's George Washington Carver internship program

Candice Gardner spent 17 years in private sector research following completion of graduate studies. Fifteen of these years focused on utilizing plant genetic diversity to improve maize yield, biotic and abiotic stress tolerance, and investigations to improve our understanding of genetic x environmental interactions. Two years were spent as a biotechnology trait developer working with herbicide resistance, insect resistance, and production traits and events. For the past 14 years she has been with the USDA-ARS as the Research Leader of the North Central Regional Plant Introduction Station, a genebank, at Iowa State University in Ames, IA. This provided a unique opportunity to work with six curatorial teams dedicated to conserving over 1400 crop species, entomologists, pathologists, and the GRIN-Global Development Team. She continues to dabble in plant breeding and germplasm

introgression via the GEM, or Germplasm Enhancement of Maize Project, and through the activities of graduate students.

Andreas Börner

Business address Leibniz Institute of Plant Genetics and Crop Plant Research
(IPK), Corrensstr. 3, D-06466 Gatersleben, Germany

E-mail boerner@ipk-gatersleben.de

Education

- Diploma in Plant Breeding, Martin-Luther-University, Halle-Wittenberg, 1985
- PhD in Plant Breeding and Plant Genetics, 1988
- Habilitation in Plant Breeding and Plant Genetics, 1995

Experience

- Research geneticist at IPK Gatersleben 1988-1992
- Post degree fellowship at the Cereals Department, John Innes Centre, Norwich, UK, 1990
- Leader of the Research Group Wheat Genetics at IPK Gatersleben 1992-1996
- Leader of the Research Group Resources Genetics and Reproduction at IPK Gatersleben since 1997
- Deputy Head of the Department Genebank at IPK Gatersleben since 1997
- Head Program Management and Evaluation, Genebank, IPK Gatersleben since 2005

Activities (international)

- German Country Representative of the European Association for Research on Plant Breeding (EUCARPIA)
- Chairman Cereals Section of the European Association for Research on Plant Breeding (EUCARPIA).
- Co-ordinator of the European Cereals Genetics Co-operative (EWAC).
- German Representative of Working Group Wheat of the European Cooperative Programme for Plant Genetic Resources (ECPGR).
- Member of the Seed Storage Committee of the International Seed Testing Association (ISTA)
- Member of the 'International Organising Committee' of the 19th General Congress of EUCARPIA, Budapest, Hungary, 2012.
- Member of the 'International Organising Committee' of the 3rd International Symposium on 'Genomics of Plant genetic Resources' Jeju, South Korea, 2013.
- Member of the 'International Scientific Committee' of the International Symposium on 'Genetics and Breeding of Durum Wheat' Rome, Italy, 2013.
- Chair of the 'International Organising Committee' of EUCARPIA Cereals Section-ITMI Joint Conference, Wernigerode, Germany, 2014.

Memberships of Editorial Boards

- Plant Genetic Resources – Characterization and Utilization, Cambridge, UK
- Frontiers in Crop Science and Horticulture, Switzerland
- Cereal Research Communications, Budapest, Hungary
- Hereditas, Lund, Sweden
- Field and Vegetable Crops Research, Novi Sad, Serbia
- Agriculture, Piestany, Slovak Republic

Activities (national)

- Vorsitzender der Arbeitsgemeinschaft Saatgut und Sortenwesen der Gesellschaft für Pflanzenbauwissenschaften (GPW) und der Gesellschaft für Pflanzenzüchtung (GPZ).
- Mitglied der Beratungsgruppe Entwicklungsorientierte Agrarforschung (BEAF) der Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ).

Andreas Börner received his PhD in Plant Breeding and Plant Genetics from the Martin-Luther-University, Halle-Wittenberg in 1988. Between 1990 and 1996 he was head of the research group Wheat Genetics of the Leibniz Institute of Plant Genetics and Crop Plant Research (IPK). He joined the Genebank of the IPK as the head of research group Resources Genetics and Reproduction in 1997. Since 2005 he has served as the head of program Management and Evaluation, which is responsible for the long-term maintenance of the IPK Genebank collection of cultivated plants and their wild relatives. The Genebank is a major player in the global *ex situ* plant conservation effort, housing a wide spectrum of accessions representing most of the temperate crop species. In addition to his responsibility for the optimization of the management of the collection, he runs an active research program focused on the investigation of seed longevity, the study of the genetic integrity and genetic diversity as well as a comprehensive phenotypic (phenomic) and genetic description of materials related to the major temperate cereal crops. In close co-operation with many external partners segregation and association mapping populations are exploited to detect genes (QTLs) responsible for agronomic characters of interest.

Federico Condon

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Doctor of Philosophy, University of Minnesota , Estados Unidos, Plant Breeding and Molecular Genetics: Genetic gain, diversity, and marker-trait associations in Minnesota barley germplasm

Ingeniero Agrónomo, Facultad de Agronomía - UDeLaR , Uruguay: Manejo de Rastrojo de Cebada Cervecera para la siembra de Girasol de Segunda. Tesis Ingeniero Agrónomo, Facultad de Agronomía, Universidad de la República, Uruguay. 200pp.

Mi trabajo ha tenido como contexto el estudio del efecto del mejoramiento genético vegetal en la diversidad genética de una especie cultivada, la cebada, mediante el uso de marcadores moleculares, evaluando en forma paralela la ganancia genético observada en la población bajo selección y recombinación, al igual que el desarrollo y aplicación de herramientas estadísticas para asociar marcadores moleculares y fenotipos en el contexto de una población con estructura no uniforme. En este caso se utilizo un modelo BLUP utilizando la matriz de

coancestría para modelar la estructura de covarianza entre los individuos emparentados en la población. Este tipo de modelo permite estudiar la genética de diferentes características sin generar poblaciones especialmente para dicho objetivo. Igualmente este tipo de estudios permite generar información para identificar patrones de desequilibrio por ligamiento y áreas conservadas en el genoma.