ICARDA Genebank Review 2016

Programme: Genebanks CRP	
Genebank reviewed: ICARDA	**Site visit Dates:** 30 Sept – Oct 1 (Luigi Guarino only) 16 – 22 Nov (Michael Mackay & Luigi Guarino)
	Review report Date: 22 May 2017
	Center and Crop Trust responses:
Place: Terbol, Lebanon and Rabat, Morocco	

Genebank Manager	Ahmed Amri
Review Panel	Michael Mackay
Crop Trust staff	Luigi Guarino

Recommendations	Responses by ICARDA	Responses by Crop Trust
Recommendation 1: The storage capacity constraint for ICARDA's Rabat location must be addressed as a matter of urgency, noting the Genetic Resources Section preferred option would deliver additional long term resource efficiencies. Immediate action is required.	INRA-Morocco has allocated the land for genebank expansion in October 2017 and the architect was contracted. The work of expansion will be done in 2018. the available funds in 2017 were used to acquire the compressors. Upon completion, the genebank storage capacity in Morocco will be 150,000 accessions in active collection.	Crop Trust recognises the importance of ensuring that the genebank has sufficient capacity for storing the collection and will work with ICARDA to find a solution.
Recommendation 2: The Seed Health Laboratory should be amalgamated within the GRS to provide it with greater visibility and efficiency together with providing the Biodiversity and Integrated Gene Management Program (BIGM) with a more prudent management structure.	The support provided by the Genebanks Platform to Seed Health Laboratory within the GHT module has smoothened the relationship between Genetic Resources Section and SHL at ICARDA.	Crop Trust considers that there are both advantages and disadvantages to integrating the seed health unit into the genebank. Both models exist within the CGIAR. The important point is that the GHU has well-established and audited standard operating procedures (SOPs) and is working to international standards.
Recommendation 3: The Genetic Resources Section's (GRS) pages should be updated within the ICARDA website to further elevate the visibility required for ongoing and sustainable stakeholder engagement.	The Communication Unit at ICARDA will be working closely with Genetic Resources Section to update the GRS webpage during the first quarter of 2018.	Crop Trust supports the recommendation
Recommendation 4: ICARDA should evaluate its current cost recovery and overhead policies for computing and internet access costs to ensure these are both appropriate and fair. This evaluation should include the provision of 24/7 support by appropriate internet service providers for critical system development activities.		Cost recovery for all institute services is an important topic that the Crop Trust is investigating with costing reveiws in 2018-2019.
Recommendation 5: GRS should engage with the CIMMYT genebank to develop a collaborative and rational approach to the safety	ICARDA has safeduplicated more than 44,000 accessions at CIMMYT including mainly unique accessions of Triticum and Hordeum species.	Crop Trust supports the idea of continuing to find ways of collaborating more closely between Centres and identifying ways of aligning and rationalizing activites.

Recommendations	Responses by ICARDA	Responses by Crop Trust
duplication of their wheat and barley collections.		
Recommendation 6: GRS should explore options for mechanized planting of multiplication/regeneration field plots and conduct an in-house trial to compare the effectiveness and efficiency of hand planting versus mechanical planting.	Mechanized harvesting and threshing is explored for cultivated species of various crops, but still facing problems of mixtures. However, harvesting and threshing of wild relatives and range species will remain manual.	Crop Trust supports the recommendation to find ways of improving efficiency through automation and mechanisation but recognises that the need to manage diverse collections and sustain genetic integrity will not always mean that mechanisation is appropriate.
Recommendation 7: Relevant GRS personnel and a small number of germplasm users should closely monitor the on-going development of the Genebank Documentation System to ensure it satisfies user requirements, provides quality access via workflow orientated interfaces, and will be interoperable with other relevant in-house or external systems.		Crop Trust supports this important recommendation
Recommendation 8: The GRS should negotiate an agreement with the ICARDA breeders located in Rabat to assist them to develop a cost effective elite breeding material storage facility at Marchouch.	GRS agreed to acquire around 700 new accessions (for 7 crops) annually from breeders for introduction into active collections. These accessions are considered as genetic stocks having valuable traits. For other elite germplasm, the genebank can ensure temporary conservation for 5 years.	Crop Trust agrees with the recommendation and with ICARDA's response.
Recommendation 9: ICARDA should give the highest possible priority to obtaining the necessary research and development resourcing to facilitate the customized automation of online FIGS set development by users along with the enhancement of the Documentation group's development capacity.	FIGS is used routinely to respond to requests based on sought traits. R facilitated algorithms were developed recently which will be the basis for a customized automation on on-line FIGS. Part of the funding needed is provided through the Use Module of Genebanks Platform, however, more funding will be needed starting 2018 to perform the needed	FIGS was highlighted as an important approach for the Genebank platform by the reviewers in the Independent Evaluation Arrangements review in 2016. Crop Trust's view is that for the full potential of the FIGS approach to be realised the tools and software need to be made easily accessible and applicable.

Recommendations	Responses by ICARDA	Responses by Crop Trust
	development and to maintain the FIGS development activities.	
Recommendation 10: ICARDA senior management, the BIGM Program Director and the Head of GRS should together develop a scheme to promote, support and otherwise develop and sustain new relationships between the GRS and its users. The CAIGE Project could be considered as a model for developing such relationships.	GRDC-CAIGE projects were focusing on use of FIGS approach for mining genetic resources in wheat, barley, lentil and chickpea. Most of these projects are ending in 2018. However, FIGS is routinely used to respond to most of the requests. FIGS will be promoted within the Use Module of the Genebanks Platform and in various new projects.	Integration of the genebank with users within the Centre is clearly an important and continuing goal to pursue. Facilitation from key staff and management is essential.
Recommendation 11: The GRS should seriously consider a plan and timeline to further develop its current QMS approach by collating its SOPs into a genebank operational manual that reflects its activities in logical workflow order. Such a manual could then be revisited as required to become an evolving document.	Five SOPs were developed in 2016 (distribution, regeneration/characterization, acquisition) and 4 SOPs are under development (documentation, seed health testing, conservation, collecting). Upon completion of SOPs for core genebank activities, the manual proposed will be developed.	Crop Trust supports the important recommendation to strengthen its QMS and to ensure that the SOPs remain evolving documents. An operational manual will also be a useful way of publishing parts of the SOP.
Recommendation 12: If not already in place, it is recommended that a strategy is deployed to closely monitor GRS progress under its new structural arrangements to ensure any necessity for fine-tuning is quickly identified and implemented. This should include the reconstruction workplan.	ICARDA strategy for 2017-26 included among its five strategic research priorities one dealing with preservations, protection and use of agricultural biodiversity. This will allow to increase the visibility of genetic resources conservation activities and to strengthen the continnum between conservation and utilisation.	Continued critical review and adjustment to ICARDA's decentralisation plans are important as funding and other factors affect the implementation of work and the operations in general.

REVIEW OF ICARDA GENEBANK

October/November 2016

Terbol Lebanon and Rabat Morocco

ICARDA's Terbol genebank inaugration, September 2016.
Source: ICARDA Update, October 04 2016 (www.icarda.org)

ICARDA's Rabat genebank facility November 2016. (Source: M Mackay)

1 EXECUTIVE SUMMARY

The objective of this review was to assess the operations, activities, roles, services and use of the ICARDA Genebank (Genetic Resources Section - GRS) and review its status in relation to performance targets and the feasibility of its workplans. It also pictures the status of the GRS in a context of a global system for long-term conservation and use of its specific crops/species.

The genebank houses collections of plant genetic resources (PGR) for a number of important food and feed species originating from the Fertile Crescent region, many of which were collected by ICARDA staff. They represent species of critical importance to food security, possessing novel genetic variation as demonstrated in recent years through the targeted subsets of accessions developed using the Focused Identification of Germplasm Strategy (FIGS) across a number of species.

Civil strife in Syria led to two relocations of personnel and a state of flux in delivery of routine services resulting in the two current genebanks sharing the mandate species collections between Terbol in Lebanon and Rabat in Morocco. This has necessitated the reconstruction of the collections - a daunting task in addition to delivering routine genebank services, posing challenges as well as presenting opportunities.

The challenges include increasing storage capacity at Rabat; enhancing visibility through a better web presence, gaining efficiencies through amalgamation of the Seed Health Section and negotiating fairer cost recovery and overhead conditions; closely monitoring the development and documentation of the information management system to facilitate user acceptance and successful delivery;

The potential opportunities include GRS exploring possibilities to provide IT/system development leadership under the Genebank Platform; GRS negotiating an agreement with ICARDA breeders to develop an elite breeding material storage facility at Marchouch; GRS developing new and sustainable relationships with user communities; GRS further developing QMS by collating its standard operating procedures into a genebank operational manual; ICARDA management implement a stratagem to ensure the reconstruction process is achieved within the anticipated timeframes.

Overall ICARDA's GRS is seen as a very professional team of plant genetic resources specialists, with demonstrable leadership in areas such as the identification of accessions for utilization, and is considered well able to address the challenges and take advantage of the opportunities.

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3 ACRONYMS/ABBREVIATIONS

BIGM	Biodiversity and Integrated Gene Management Program
BMS	Breeding Management System
CGIAR	Consultative Group on International Agricultural Research
Crop Trust	Global Crop Diversity Trust
FIGS	Focused Identification of Germplasm Strategy
GDS	Genebank Documentation System
GOM	Genebank Operational Manual
GRS	Genetic Resources Section
ICARDA	International Center for Agricultural Research in the Dry Areas
NENA	Near East and North Africa
ORT	Online Reporting Tool
PGR	Plant Genetic Resources
QMS	Quality Management System
SOP	Standard Operating Procedure

4 LIST OF RECOMMENDATIONS

Recommendation 1: The storage capacity constraint for ICARDA's Rabat location must be addressed as a matter of urgency, noting the Genetic Resources Section preferred option would deliver additional long term resource efficiencies. Immediate action is required.
Recommendation 2: The Seed Health Laboratory should be amalgamated within the GRS to provide it with greater visibility and efficiency together with providing the Biodiversity and Integrated Gene Management Program (BIGM) with a more prudent management structure.
Recommendation 3: The GRS pages should be updated within the ICARDA website to further elevate the visibility required for ongoing and sustainable stakeholder engagement.
Recommendation 4: ICARDA should evaluate its current cost recovery and overhead policies for computing and internet access costs to ensure these are both appropriate and fair. This evaluation should include the provision of 24/7 support by appropriate internet service providers for critical system development activities.
Recommendation 5: GRS should engage with the CIMMYT genebank to develop a collaborative and rational approach to the safety duplication of their wheat and barley collections.
Recommendation 6: GRS should explore options for mechanized planting of multiplication/regeneration field plots and conduct an in-house trial to compare the effectiveness and efficiency of hand planting versus mechanical planting.
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Recommendation 11: The GRS should seriously consider a plan and timeline to further develop its current QMS approach by collating its SOPs into a genebank operational manual that reflects its activities in logical workflow order. Such a manual could then be revisited as required to become an evolving document.
Recommendation 12: If not already in place, it is recommended that a strategy is deployed to closely monitor GRS progress under its new structural arrangements to ensure any necessity for fine-tuning is quickly identified and implemented. This should include the reconstruction workplan.

5 BACKGROUND

The ICARDA Genetic Resources Unit (GRU) was established in 1983 with the genebank becoming operational in 1985. The facilities were subsequently extended at the Tel Hadya location, just south of Aleppo, in 1989, the commissioning of which involved an international symposium on plant genetic resources.

The GRU became the Genetic Resources Section (GRS) under the Biodiversity and Integrated Gene Management Program (BIGM) established in 2006 to facilitate operational integration of conservation with utilization activities. This arrangement was still in place at the time of this review.

The CGIAR Consortium and the Global Crop Diversity Trust entered into a five-year agreement (2012-16: the 'Genebank CRP') wherein the Crop Trust was to oversee and provide sustainable support for the crop collections held at CGIAR Centers for a five year period. ICARDA's GRS was one of the 11 CGIAR genebanks under this agreement. For the period 2017-22 a new arrangement, the 'Genebank Platform', will be implemented to continue the management of the 11 CGIAR genebanks in partnership with the Crop Trust.

During this period (2012 until the present) ICARDA's GRS has been in a unique situation. The civil strife in Syria resulted in internationally recruited scientists being relocated in Tunisia for safety reasons in July 2012. This temporary arrangement was followed by the decision to develop a two nodal genebank following the establishment (in 2013) of the Rainfed Research Platform in Morocco. Consequently, as part of ICARDA's decentralization, in September 2014 most crop improvement staff were relocated to Rabat in Morocco while the remainder were relocated to Terbol in Lebanon. The GRS now operates from these two locations.

During the Genebank CRP phase the GRS has been involved largely with managing relocation activities (including obtaining infrastructure and equipment), reconstructing its base and active collections in Terbol and Rabat, and delivering services to users according to resource availability.

It is against this background that the current review of ICARDA's genebank is undertaken to assess operations, activities, roles, services, usage, status and performance against targets together with a view to identifying opportunities to enhance services, effectiveness and efficiencies into the future. The review was undertaken by Michael Mackay with assistance from Luigi Guarino as a preliminary review while ICARDA's GRS re-establishes itself.

5.1 REVIEW OBJECTIVES

The objectives of the review were to:

- Assess the operations and activities of the genebank;
- Asses the roles, services and use of the genebank, and the linkages with users and partners both within and outside the CGIAR;
- Review the status of the genebank with respect to performance targets and the feasibility of proposed workplans to reach targets;
- Consider the status of the genebank or individual collections within it, in the context of a global system for long-term conservation and use of the crop(s) in question.

In addition ICARDA GRS personnel raised the following issues for consideration:

- Visibility of genetic resources at ICARDA;
- Use of ICARDA expertise within Genebank Platform (Gap analysis, FIGS development, Crop Registries);
- Adoption of GRIN-Global;
- Conservation of *Avena* genetic resources;
- Conservation of breeding stocks and breeding germplasm.

5.2 OVERVIEW OF THE ICARDA GRS COLLECTIONS

The following information was provided by ICARDA during the review:

- Collections of faba bean, Lathyrus, forage and range species and crop wild relatives (some 45,000 accessions) are maintained and managed at Terbol, Lebanon.
- Collections of cultivated species of barley, wheat, lentil and chickpea (some 75,000 accessions) are maintained and managed at Rabat, Morocco.
- Nine contracted staff and 6 temporary staff are based in Terbol.
- Nine contracted staff are based in Rabat.

Table 1: Composition of ICARDA's collections in November 2016 (courtesy Dr Ahmed Amri).

Taxon	Accessions held in Syria	Morocco	Lebanon	Total unique accessions in 2016
Bread wheat	14,100	3487	5037	14639
Durum wheat	19,635	4312	3655	20496
Primitive wheat	912	459	124	954
Aegilops	4057	120	3953	4774
Wild *Triticum*	1584	116	2250	2079
Barley	28,465	6007	5136	29983
Wild *Hordeum*	1989	228	354	2341
Chickpea	14,214	3326	2893	15195
Wild *Cicer*	270		277	547
Lentil	10,496	4618	335	13907
Wild *Lens*	587		426	602
Faba bean	9542		3397	10034
Lathyrus	3996		1735	4281
Pisum	6106		149	6115
Medicago (annual)	8398		1321	8904
Trifolium	4536		5088	5687
Vicia	6144		637	6371
Range and pasture	5802		2130	7263
Others	219		211	229
Total	**141,052**	**22,673**	**39,108**	**154,401**

- In 2016 some 141,052 accessions were still held in Syria with 22,673 now being held in Rabat and 39,108 accessions being held in Terbol.
- The GRS held 154,400 unique accessions at the time of the review (see Table 1).
- These collections included 718 taxa of which more than 100 were perennial and more than 130 cross pollinated.
- 45% of the accessions are unique, 85% are landraces and native species, 78% are characterized, 98% are safety duplicated and 60% are stored in Svalbard.

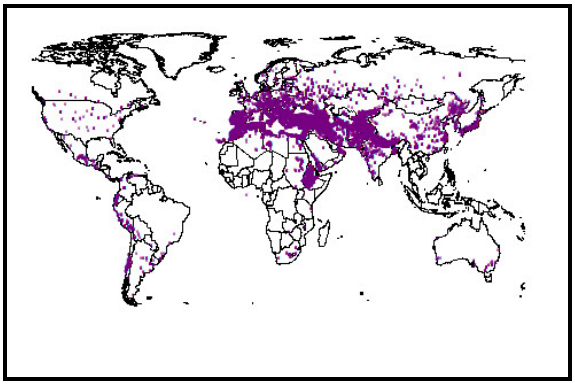

Figure 1: Origin of ICARDA GRS accessions (Courtesy Dr Ahmed Amri).

- The GRS also holds some 1,400 Rhizobium strains.
- ICARDA has conducted more than 245 collecting missions in 38 countries (around 37,000 accessions or 23.5% of the collection)

6 REVIEW OF GENEBANK

6.1 ASSESSMENT OF OPERATIONS

6.1.1 Dual Location Genebank

A decision was taken to house the new ICARDA genebank at two locations:

a) The ICARDA station at Terbol, Lebanon, managing forages, grass pea, cereal and legume wild relatives (CWR) and faba bean; and
b) The campus of the National Institute for Agricultural Research (INRA), Rabat, Morocco, managing the cereal and grain legume cultivated germplasm.

A new genebank facility was constructed at Terbol, on ICARDA's own station, where the environment was suitable for the crop wild relatives (CWR) because ICARDA mandate crop species were not considered invasive in contrast to the situation in Morocco. Additionally, the existing expertize from Aleppo was still reasonably accessible at the time of the review. Although most breeders, with the exception of faba bean, are based in Rabat they all visited regularly, and specific staff at Terbol represent all breeding programs and coordinate local activities.

Observations:

- While the bi-location of the GRS involves extra costs it also offers excellent opportunities, for example the field regeneration of invasive 'weed' species in Lebanon, so costs could largely be offset by savings in infrastructure that would be needed elsewhere. Additionally, an ICARDA presence in its mandate region can only bring positive outcomes.
- As the current arrangements within GRS are quite new it could be productive for management to monitor progress of implementation to ensure the anticipated outcomes are being achieved. Such an iterative management procedure could include genebank scope, infrastructure, staffing and equipment to facilitate fine tuning until the anticipated outcome is achieved. This notion will be further discussed in a section discussing long-term conservation and use.

6.1.2 Facilities/Infrastructure

Concern was expressed about the electricity supply at the Terbol location during Guarino's visit in early October, however this matter was reported to be resolved by mid-November.

The field facilities available to the Terbol genebank include 2.5 ha for pollination cages and five plastic houses. Importing bees from The Netherlands has recently proven difficult and local pollinators are being trialled. The nearby American University of Beirut Advancing Research and Enabling Communities (AUB AREC) facility offers 7.5 ha and access to machinery, threshing equipment and cold storage. Material that was stored at AUB was to be transferred to Terbol once the electricity supply issue was resolved. This transfer is now underway and due for completion by March 2017.

The Rabat genebank location has all the necessary laboratory services available at its INRA hosted site. These include appropriate seed handling and health facilities. Additionally it has

adequate field facilities (some 11ha) located at its Marchouch Research Station, some 68 km south of Rabat. Last year's growing season proved challenging with dry conditions however sufficient supplementary irrigation was obtained to salvage most plots and steps have been taken to ensure adequate water is available in the future. The field multiplication/regeneration activities are undertaken at this site where there are additional seed handling, packaging and temporary storage facilities, together with the required cultivation, ground preparation and husbandry equipment.

Current storage capacity at the ICARDA genebanks is detailed below and is .adequate at the moment. However the capacity in Rabat will be inadequate within two years as the collections are reconstructed.

Table 2: *Storage capacity at the two ICARDA genebank locations, November 2016.*

Location	Active Collection	Base Collection
Terbol	75,000	100,000
Rabat	45,000	50,000

Two options were discussed for developing additional storage capacity at Rabat. The preferred GRS option would be to expand the capacity at the current INRA site where there is unused land adjacent to the current ICARDA building. This has obvious advantages relating to proximity and seed handling facilities. The second option would be to locate additional capacity at INRA's El Koudia site, some 25 km south-east of Rabat. Immediate action is required to ensure sufficient capacity is available within two years.

Recommendation 1:
The storage capacity constraint for ICARDA's Rabat location must be addressed as a matter of urgency, noting the Genetic Resources Section preferred option would deliver additional long term resource efficiencies. Immediate action is required.

6.1.3 GRS within the BIGM Program

The GRS is a section within the BIGM Program. Figure 2 illustrates the components of the Program with those highlighted green being the sections.

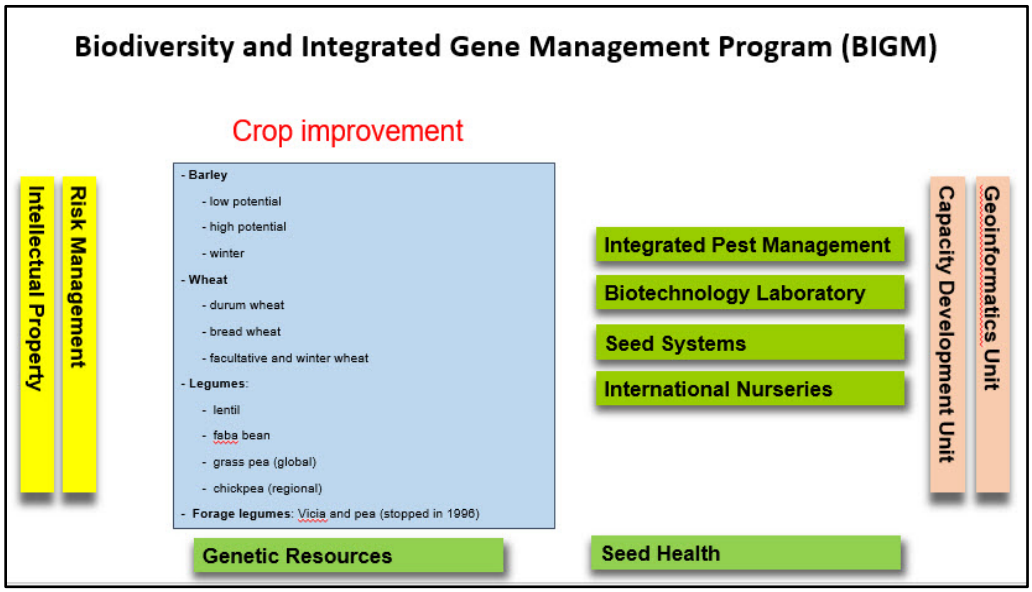

Figure 2: BIGM Program Structure (Courtesy Dr Ahmed Amri).

The users of the GRS are ultimately its closest allies and should be its greatest supporters. The integrated structure of the BIGM program provides a perfect opportunity for this relationship to be fully exploited and ICARDA is commended for its foresight in including PGR activities as an integral component of their plant improvement endeavours.

GRS raised the issue of improving the visibility of the GRS, both within and outside ICARDA. The review panel concurs with this and observes that high visibility is critical to the ability of the GRS achieving its goals; making such visibility an issue that must not be overlooked or under-estimated.

We see an opportunity to enhance the visibility of the GRS through the integration of the Seed Health Laboratory (SHL) into the GRS. A number of factors support such an amalgamation, including:

- The ratio of GRS resources devoted to service versus research is around 80:20, similar to the ratios of the SHL;
- SHL is a small section of about 6 personnel;
- Like the GRS, the SHL is located in both Terbol and Rabat;
- The global plant genetic resources mandate is inextricably linked to virtually all SHL activities relating to conservation and distribution of germplasm as well as a significant component of those related to pre-breeding.

With around 20% of SHL costs associated with GRS to be funded by the Genebank Platform (commencing 2017) when combined these factors support integration as a logical conclusion to enhance the visibility of the GRS.

Additionally, it is understood that the GRS website is dated and, while an improved design has been promised for some time, it is reported that no change has occurred. The visibility of the GRS relies to a significant extent to its exposure on the internet.

Recommendation 2:
The Seed Health Laboratory should be amalgamated within the GRS to provide it with greater visibility and efficiency together with providing the Biodiversity and Integrated Gene Management Program (BIGM) with a more prudent management structure.

Recommendation 3:
The GRS pages should be updated within the ICARDA website to further elevate the visibility required for ongoing and sustainable stakeholder engagement.

6.1.4 Institutional Arrangements

GRS staff highlighted the blanket cost recovery and overhead charges imposed by ICARDA upon services such as computer access and email. In certain circumstances a single employee requires more than a single computer to meet duty statements. As an example, the Documentation Specialist requires access to three computers to develop the Genebank Documentation System (GDS) and GRS is charged the same rate for each.

CGNET is the current service provider for ICARDA and the CGIAR centers. CGNET was reported not to provide 24/7 support for this service, unlike most other commercial internet service providers. 24/7 support is required for the uninterrupted development of web-based systems such as the GDS and Breeding Management System (BMS). These systems could be housed with other internet service providers that provide 24/7 support and more cost competitive rates.

Recommendation 4:
ICARDA should evaluate its current cost recovery and overhead policies for computing and internet access costs to ensure these are both appropriate and fair. This evaluation should include the provision of 24/7 support by appropriate internet service providers for critical system development activities.

6.2 ASSESSMENT OF ACTIVITIES

The GRS is managing common genebank activities to the standards expected of a CGIAR genebank.

6.2.1 Safety duplication

We observe that safety duplication is currently spread across many sites and locations, mainly at CGIAR genebanks (CIMMYT and ICRISAT), with a second level of safety duplication at Svalbard Global Seed Vault hosting 116,475 accessions. We were advised that 99.7% of the ICARDA active and base crop seed collections are secured outside Syria.

The review of CIMMYT's genebank in 2013 recommended, in part, that *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. While not being aware if such discussions have indeed been held, we conditionally recommend this approach be further explored by the GRS. At a minimum GRS consider developing a plan to consolidate all pre-2016 safety duplication at one location - in addition to Svalbard – with CIMMYT being a logical option because much of ICARDA's current duplication is already located there.

Recommendation 5:
GRS should engage with the CIMMYT genebank to develop a collaborative and rational approach to the safety duplication of their wheat and barley collections.

6.2.2 Viability and seed health

Backlogs of viability and seed health testing are being addressed within the work plan for reconstructing the ICARDA collections. They present a significant challenge while, at the same time, are deemed achievable with close monitoring. Having the Seed Health Section amalgamated within GRS could facilitate overcoming this backlog more effectively and efficiently.

6.2.3 Regeneration/Multiplication, Characterization and Evaluation

The Terbol genebank is located close to the AREC facility and the Lebanese Agricultural Research Institute (LARI), both of which have adequate land availability for fieldwork, and with whom there is regular contact.

The Rabat genebank has access to 11ha at ICARDA's Marchouch Research Station, 68 km south of Rabat. While last year's growing season proved challenging with dry conditions, sufficient supplementary irrigation was obtained to salvage most plots. Most field activities are undertaken at this site where there are additional seed handling, packaging and temporary storage facilities, together with the required cultivation, ground preparation and husbandry equipment.

It was further observed that the planting of multiplication and regeneration plots was undertaken by hand, requiring considerable labour input. Whilst it is appreciated that this is done to avoid planting mistakes, the GRS could investigate what forms of mechanization other collections/genebanks use to perform these field operations with the view to longer term efficiencies.

Recommendation 6:
GRS should explore options for mechanized planting of multiplication/regeneration field plots and conduct an in-house trial to compare the effectiveness and efficiency of hand planting versus mechanical planting.

6.3 ASSESSMENT OF ROLES

A number of GRS roles were discussed and observations made. The GRS appears to be performing its various roles to a high standard.

6.3.1 GRS Research Activities

Research activities currently undertaken by the GRS include:

- Genetic Diversity Analysis,
- Gap Analysis,
- FIGS Development,
- Field Guide Development,
- Herbarium Maintenance (Terbol),
- PGR Evaluation,
- Interspecific Crossing, and
- Assessment of Status and Threats to Agrobiodiversity.

The GRS has the expertise to provide leadership within the Genebank Platform for a number of these, specifically gap-analysis, FIGS development and further developing Crop Registries.

Performing these roles generally requires external funding support so enhancing the visibility of the GRS (Recommendation 2) will contribute to their sustainability.

6.3.2 Regional Leadership and Capacity Building

GRS provides leadership within the Central and West Asia and North Africa (CWANA) Region in terms of genebank outreach and capacity building. This is especially the case within the Near East and North Africa (NENA) network. While the GRS is supportive of this network, it currently cannot afford to inject funds to support it. The review deems it desirable to keep this activity alive and that GRS consider creating awareness of and test the GDS with interested NENA

genebanks with the view to providing an option to replace the previously deployed FoxPro based system.

GRS interacts with national programs, especially in the exchange and testing of germplasm and training. They have open communication channels and are aware of each other's work, particularly in Tunisia and Morocco. For other national programs within their region they usually only provide capacity building and technical backstopping.

The GRS currently conducts 1-2 regional training workshops per annum and jointly supervises around 12 PhD and two Master's degree students each year. Capacity building is also an important activity through a wheat breeding course.

6.3.3 Leadership of FIGS Development

ICARDA has led the development of the FIGS approach since obtaining a grant from the Australian Grains Research and Development Corporation (GRDC) in collaboration with the Australian Winter Cereals Collection (AWCC, now part of the Australian Grains Genebank) and the Vavilov Institute of Plant Industry in 2001.

To date there has not been sufficient resources for this work to do more than further develop useful methodologies and produce trait targeted 'FIGS Sets'. While the former is a research role, the latter is largely a personnel time-consuming pursuit that desperately needs to be automated. This is issue addressed more fully in Section 6.6.1.

6.3.4 Molecular Characterization

It was noted that ICARDA is not as active as some other centers in molecular characterization and allied activities. It was further explained that the intention was to outsource 'wet lab' activities but undertake analysis of results in-house. We suggest that ICARDA be opportunistic and, for example, collaborate with CIMMYT with wheat characterization and do the same with ICRISAT for chickpeas.

6.4 ASSESSMENT OF SERVICES

Distinct from services to users, including selection and/or dissemination of germplasm, the GRS includes a documentation unit that develops, maintains, disseminates and manages all aspects of information relating to the genebank. Additionally, the ICARDA breeders expressed the need for help to store elite breeding material and the possibilities of providing this service was discussed.

6.4.1 Information Management and Dissemination

6.4.1.1 Background

ICARDA's documentation system had been based on a multi-user, evolving FoxPro® based system for a many years. This system, while being very user friendly and effective in the past, cannot be deployed as a multi-location genebank system.

GRIN-Global was released as a scalable genebank documentation system several years ago, but has not been as widely deployed as anticipated. The primary explanation for this is that the system necessitates the need for a skilled system administrator, which many genebanks cannot afford, and that it does not emulate the workflows of many genebanks. The latter being a pre-

requisite for a successful genebank documentation system. So ICARDA's decision not to adopt GRIN-Global was taken because, unlike the FoxPro® based system, it did not sufficiently emulate the ICARDA genebank's workflows, is understandable. The beneficial features of the FoxPro® system are now being redeveloped as an online multi-user Genebank Documentation System (GDS) with the addition of further data layers (including genotypic) and functionality, including interoperability with other systems, for the exchange and sharing of information.

6.4.1.2 Genebank Documentation System (GDS)

Because it is an in-house development the GDS must be comprehensively documented to facilitate future maintenance. Succession planning for the role of developer also is a high priority.

While still under development, the ICARDA GDS is currently ticking all the correct boxes in terms of current or proposed functionality – including curatorial interface(s) and phenotypic, genetic, climatic and soil data integration plans.

The developing GDS was demonstrated for the reviewers and illustrated the following features:

- MySQL and PHP/Java based software;
- Uses globally accepted standards including GRIN-Tax, MCPD, IPGRI/Bioversity Descriptors, WIEWS Institute Codes, ISO Country Codes etc.;
- Higher level interface allows drilling to a data browser, geo maps, summaries, distribution and other activities;
- System is designed to deliver rapid access to required data using 'smart data access' methodologies – the same as used in Genesys;
- Intuitive, user friendly interface;
- Tab and click double click assisted options for drilling down to required and/or more detailed/specific data such as passport, collection site, stock/inventory, pedigree, environmental, characterization, evaluation and photographs;
- Powerful querying interface allowing any conceivable combination of available data;
- Provides reports for Crop Trust and Easy SMTA as well as updating Genesys and is planned to be interoperable with GRIN-Global for data exchange;
- The GDS plans to link phenotypic and climate data with genetic (QTL, marker etc.) data in other systems, that is provide an interoperable data exchange facility with external systems using appropriate data standards;

The GDS Curatorial Interface is being designed to emulate how curators query and request accessions with a view to integration with activity workflows and is due for delivery in March/April 2017.

Observation

- The upcoming Genebank Platform could possibly provide ICARDA with opportunities under an arrangement whereby the documentation unit considers leading/collaborating in the further enhancement/development of shared resources, including Genesys tool. For example, the GRS has the demonstrable expertise and capacity to develop genebank management tools; one of its staff performed the system analysis/design and

development of the 1st version of Genesys; and there is the obvious need for online tools to implement FIGS (or parts thereof). It is suggested that such opportunities be further explored to ascertain feasibility as well as the potential to secure resources and/or personnel to permit such endeavours.

Recommendation 7:
Relevant GRS personnel and a small number of germplasm users should closely monitor the on-going development of the Genebank Documentation System to ensure it satisfies user requirements, provides quality access via workflow orientated interfaces, and will be interoperable with other relevant in-house or external systems.

6.4.1.3 Breeding Management System (BMS)

While still largely in the planning stage, a lot of historical breeding data has been uploaded into an appropriate system similar to that used in Genesys. However, the group is currently awaiting the outcome of discussions with partners (CIMMYT and ICRISAT) to avoid duplication and ensure interoperability. It is anticipated that progress will be made in 2017.

6.4.1.4 Online Reporting Tool (ORT)

Development of automated interface between GDS and the ORT has already delivered positive feedback from the Head of the GRS because of the time saving in reporting to the Genebank CRP. ICARDA's mandate includes more species than many of the CGIAR genebanks, which makes this reporting quite a time consuming task.

It is suggested that discussions be held with the Crop Trust and other genebanks with the possible view to developing a generic automated interface with the ORT that could be used by all the genebanks operating under the Platform.

6.4.2 Storage of Breeding Material

The GRS does not see the inclusion of all elite breeding material developed by ICARDA's institutional breeders located at Rabat in its short or long term facilities as a core activity. The reviewer fully concurs with this decision having observed the repercussions of doing this at another genebank. Furthermore, the recognised demand on genebank storage space at Rabat makes this virtually impossible to consider. However it does recognise the importance breeders consider the medium to long term storage of their elite material.

Subsequent to the discussions with breeders and the GRS, and following a visit to ICARDA's Marchouch Research Station, an inexpensive solution was proposed by the reviewer and discussed at some length. This involved redeploying an unused insulated shipping container at Marchouch (pictured at right). At minimal cost to the breeders, a refrigerated, split system air conditioner could be fitted to this container would provide a constant inside temperature

suitable for the short-medium term storage of elite breeding material. The GRS indicated its willingness to support this option via their expertise and drying/seed handling facilities at Marchouch.

Recommendation 8:
GRS should negotiate an agreement with the ICARDA breeders located in Rabat to assist them to develop a cost effective elite breeding material storage facility at Marchouch. This, however, should not be done at GRS expense.

6.5 ASSESSMENT OF UTILIZATION

As mentioned elsewhere, the relationships/interactions between genebanks and their users is a key factor to the ongoing support and resourcing of genebanks. The current arrangements at ICARDA, whereby in-house users and the GRS are managed within the same program (BIGM), presents a contrast to most other institutions where decentralizing plant improvement activities seems to have become the norm. Discussions with GRS users within and outside ICARDA have indicated support for the current arrangement.

All pre-breeders and breeders consulted (both in-house and external) were supportive of the services provided by the GRS. The in-house users were particularly supportive of the development of FIGS sets of germplasm for evaluation. One consequence of this is that the GRS is planning to meet most germplasm requests with FIGS sets in the future.

External users exhibited keenness to work closely with the GRS to ensure a constant supply of novel sources of new genetic variation. One of the review team (Mackay) had many years of experience facilitating exchanges between the GRS and Australian breeders and is very aware of the respect Australian users had for ICARDA germplasm.

6.5.1 Focused Identification of Germplasm Strategy (FIGS)

It is noteworthy that the concept that developed into the FIGS approach was initially proposed at an International Symposium on the Evaluation and Utilization of Genetic Resources held at ICARDA's Tel Hadya headquarters in 1989 (Mackay, 1900). This approach has slowly developed into an innovative way to explore and exploit genetic variation in genebanks since a GRDC collaborative project (see Section 6.4.3) was initiated in the early 2000's.

While numerous FIGS sets have been developed with many exhibiting striking success, for example in the discovery of new variation at a wheat powdery mildew resistance loci (Bhullar *et al*, 2009), others have not delivered the desired alleles. However, given the limited research investment, the overall outcome has demonstrated that the approach does make the identification and deployment of novel genetic variation more effective and efficient. While a range of methodologies, from simplistic to more complex machine learning models, have been used to develop FIGS sets, further research is required into effective methods along with the development of online resources to facilitate germplasm users having the tools to develop their own FIGS sets without relying on one or two researchers to develop sets for them.

ICARDA has led the development of FIGS to date and is well positioned to continue this role if provided with the necessary resources.

Current objectives for further FIGS development include:

- Plans to define their set capacity per year – now and post development of online FIGS set development functionality.
- Plans to develop a "Lab Book" on FIGS and the filtering approach.
- Employ a consultant to program in R.
- Attract high quality PhD or Master degree students to work on development of FIGS online tools.

Opportunities noted for further development included:

- All FIGS sets developed to date should be fully documented to provide a 'library' of ways in which sets can be produced and what statistical, modelling or other tools were used, the source PGR from which the set was developed etc.
- Explore new methods of linking environmental, characterization, evaluation and genotypic data with specific traits.
- Crucial activities of FIGS to ensure its ongoing development and deployment will include capturing the metadata associated with developing each set and obtaining information collected from evaluating specific FIGS sets (after appropriate time/embargo periods to allow for publication). This would facilitate the ongoing and sustainable, heuristic development of new FIGS sets within a user community environment.

Recommendation 9:
ICARDA should give the highest possible priority to obtaining the necessary research and development resourcing to facilitate the customized automation of online FIGS set development by users along with the enhancement of the documentation group development capacity.

6.5.2 Pre-breeders/Plant Breeders

Discussions with the Integrated Pest Management (IPM) personnel within BIGM revealed tremendous support for the GRS. This is especially the case during the last 10-12 years where they have received specific trait (FIGS) sets of accessions from GRS to deliver novel genetic variation focused on the pre-breeder's requirements.

The INRA wide-cross scientist at Settat was also consulted and described the interaction with the GRS for the introgression of traits from crop wild relatives. This was noted to be a close and productive relationship.

ICARDA's BIGM breeders were likewise very supportive of the GRS and its service to them, including the value of FIGS sets to most breeding programs. Their one concern was the storage of elite breeding lines addressed earlier in Section 6.5.2.

The panel also met with Moroccan pre-breeders and breeders in Settat and Rabat. Durum and bread wheat breeders in Settat spoke positively of their interactions with GRS, as did the barley breeder based in Rabat who has used FIGS sets and has requested more.

The importance of relationships between genebanks and their user communities cannot be under estimated and is crucial to the future sustainability and effective resourcing of a genebank. Too many genebanks become ineffective without a clear mandate of providing a service to their users, who are also their clients. Most genebanks are excellent at acquiring and conserving accessions – but if their accessions are not being requested and evaluated by the plant improvement community they will always struggle for sustainable resourcing.

Recommendation 10:
ICARDA senior management, the BIGM Program Director and the Head of GRS should together develop a scheme to promote, support and otherwise develop and sustain new relationships between the GRS and its users. The CAIGE Project could be considered as a model for developing such relationships.

6.6 GENEBANK STATUS IN CONTEXT OF PERFORMANCE TARGETS AND ROLE IN A GLOBAL SYSTEM

6.6.1 Reconstruction of Collections

ICARDA is reconstructing its active and base collections in Lebanon and Morocco, together with its crop improvement activities. This was initiated in the 2016 season with the first shipment retrieved from samples conserved at the Svalbard Seed Vault. This procedure will continue for 5 to 7 years and will necessitate the expansion of the storage capacity at the Rabat location (mentioned above) as a matter of urgency.

Appendix 4 provides comprehensive details of the GRS Workplan for the reconstruction of the ICARDA collections during 2016-2023/2025/2030 (depending on species and biological status of the accessions).

This reconstruction process is further discussed in a section addressing the long-term conservation and use of the ICARDA genebank.

6.6.2 Quality Management System (QMS) and Standard Operating Procedures (SOPs)

Background

The development of quality management systems (QMS) across the 11 CGIAR genebanks was an important initiative of the Genebank CRP partnership managed by the Crop Trust. A crucial component of the QMS initiative was the development of Standard Operating Procedures (SOPs) whereby detailed documents were drawn up describing all facets of the primary functions and activities undertaken by the genebanks.

ICARDA's GRS will have completed SOPs by the end of 2016 for the following functions and activities:

- Succession planning;

- Regeneration and characterization of food legumes;
- Regeneration and characterization of cereals;
- Acquisition; and
- Distribution.

The following SOPs will be completed in 2017:

- Regeneration and characterization of forage and range species;
- Conservation;
- Documentation; and
- Seed health testing.

Further SOPs being considered for development include:

- GRS management;
- Pre-breeding; and
- Conservation and characterization of Rhizobium strains.

Some discussion was devoted to where SOPs lie within a genebank QMS. In growing this discussion it was recognized that a genebank QMS involves more than developing and fully documenting SOPs; a genebank operational manual (GOM) is an adaptable record of a genebank's mandate, mission and vision, as well as of its standard procedures, at a minimum. It should also include sections relating to personnel roles and the general activities (acquisition, conservation, distribution etc.) undertaken by the genebank. The SOPs would logically be incorporated within the description of these activities with the whole forming the GOM which facilitates the overall genebank QMS.

A well-documented genebank operational manual is a key component of a QMS. The structure of such a manual ideally follows the genebank's workflows with detailed SOPs that facilitate quality control and the orientation of new personnel in minimal time with minimal effort

Recommendation 11:
The GRS should seriously consider a plan and timeline to further develop its current QMS approach by collating its SOPs into a genebank operational manual that reflects its activities in logical workflow order.

6.6.3 Long-term Conservation and Use of Species

To recap, Terbol houses collections of faba bean, Lathyrus, forage and range species and crop wild relatives (some 45,000 accessions), while Rabat houses collections of cultivated species of barley, wheat, lentil and chickpea (some 75,000 accessions).

While the status of the two GRS genebanks appears to be very sound (in the context of a global system for long-term conservation and use of relevant mandate species) it is still early days under the two genebank location arrangement.

Some issues, to be kept in mind, were expressed by the Terbol genebank manager:

- Have permanent/long term, well trained staff at Terbol;
- See more interaction between national staff, specifically research assistants and technicians from the Terbol and Rabat genebanks that would involve workshops/training and enable these personnel to share experiences and learn from each other;
- Management to be aware that additional facilities and/or equipment might be identified for purchase as the genebank is fully commissioned;
- The reconstruction activity should not allow the need to relocate the accessions from the Tel Hadya location to be overlooked.

So, while the ICARDA GRS is delivering high quality germplasm conservation services for its mandate species, ongoing monitoring is a definite requirement to ensure both the reconstruction and the day-to-day activities are all delivered to the level expected of an international genebank.

In terms of utilization, the ICARDA GRS has an exemplary record with its role and leadership in developing and applying innovations such as the FIGS approach and being involved in exchange project (e.g. CAIGE). As mentioned elsewhere, the ongoing/sustainable resourcing for such work is a constant challenge and cannot be ignored.

A number of further matters in the current arrangements are still requiring decisive outcomes. These include the relocation and housing of the Rhizobium collection; whether or not to accept an international mandate for an *Avena* collection or cooperate with, for example, Canada in such an endeavour; determine the need, if any, for a documentation position in Terbol and a global temperate forages strategy.

The ICARDA GRS is in a unique phase of development with its two genebank location arrangements and should be expecting a number of changes to be required before its operations become more routine.

Based on comments made in this and an earlier sections (See 5 and 6.7.1), a recommendation is made below conditional upon it not already being fully addressed.

Recommendation 12:
If not already in place, it is recommended that a strategy is deployed to closely monitor GRS progress under its new structural arrangements to ensure any necessity for fine-tuning is quickly identified and implemented. This should include the reconstruction workplan.

7 APPENDICES

7.1 APPENDIX 1: REVIEW PANEL

Michael Mackay (Chair)

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Luigi Guarino (Crop Trust)

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7.2 APPENDIX 2: REVIEW AGENDA – RABAT, MOROCCO

ICARDA Genebank Review

Reviewers: Drs. Michael Mackay and Luigi Guarino

Date: 16th-23rd November 2016

Tentative agenda

16th November 2016

12:30-16:00 Arrival of Dr. Michael Mackay to Casablanca and drive to Marrakech

16:30-17:30 Meeting with ICARDA Management (DG, DDG-R, ADG-ICC and Director BIGM)

Overnight in Marrakech

17th November 2016

08:00-12:00 Drive to Rabat via INRA Research Station, Settat. Discussions with INRA PGR users.

13:00-16:30 Meeting on FIGS development

19:30 Arrival of Dr. Luigi Guarino

18th November 2016

08:30-10:30 General presentation on Genetic Resources activities at ICARDA

10:30-13:00 General discussion on core activities of ICARDA genebank

14:00-16:30 Discussion on practices and Standard Operation Procedures

16:30-15:30 Visit of Genebank facilities

19th November 2016

08:30-12:30 Visit to Marchouch experiment station

14:30-17:00 Discussion on documentation of genetic resources at ICARDA

20th November 2016

Free

21st November 2016

08:30-10:30 Meeting with ICARDA researchers and visit to different laboratories

10:30-13:00 Discussion with GR team

14:00-17:30 Discussion with GRS team

22nd November 2016

08:30-12:30 Travel to Settat to visit national genebank and discuss with INRA researchers

23rd November 2016 Return

7.3 APPENDIX 3: LIST OF PEOPLE / INSTITUTES CONSULTED

The Crop Trust member of the review panel visited the inauguration of the new Terbol genebank in late September 2016 and provided notes regarding that facility.

The panel chair met with ICARDA senior management staff in Marrakech on 16 November 2016 and visited the INRA Settat Research facility and members of ICARDA's pre-breeding team on 17 November. Both the chair and the Trust member held consultations with other ICARDA personnel, including GRS staff members, in Rabat and surrounding locations during 18-22 November.

a) **Senior Management:** Dr Aly Abousabaa, Director General; Dr Andrew Noble, Deputy Director General – Research; Dr. Mohamed El-Mourid (coordinator of North Africa Régional Program); Dr. Khalil Shideed (Assistant DG for International Cooperation and Communication); and Dr Michael Baum (Director Biodiversity and Integrated Gene Management Program)
b) **GRS Personnel Rabat:** Dr Ahmed Amri (Head); Andrea Visioni (Barley Breeding); Zakaria Kehel (FIGS Specialist); Mohamed Fawzy Nawar (Documentation Specialist); Athanasios Tsivelikas (Genebank Manager, Rabat, Morocco). **Terbol:** Mariana Yazbek (Genebank Manager, Lebanon); Ali Shehadeh (Genebank Manager, Syria); Fawzi Sueid (expertize with forage legumes and wheat, capacity development); four Research Assistants (documentation, characterization, viability testing, field operations); two Technicians (field work).
c) **ICARDA Users:** Mustapha El-Bouhssini (Entomologist); Seid-Ahmed Kemal (Pulse Pathologist); Sajid Rehman, PDF (Cereal Pathologist); Ramesh Pal Singh Verma (Barley Breeder); Andrea Visioni (Barley Breeder); Shiv Kumar Agrawal (Lentil Breeder); Miguel Sanchez Garcia (Spring Wheat Breeder); Filippo Bassi (Durum Breeder); Karthika Rajendran (Lentil Breeder); Wuletaw Tadesse Degu (Spring Bread Wheat Breeder);Safaa Kumari, Head Seed Health Laboratory (Plant Virologist)

Non-ICARDA Users: Dr J Elhaddoury (INRA Cereal Wide Cross Pre-Breeder); Dr N*sarellah* Nasserlehaq (INRA Durum Breeder); Dr Ali Amamou (INRA Bread Wheat Breeder); Dr Jilal Abderrazek (INRA Barley Breeder)

7.4 APPENDIX 4: GRS WORKPLAN FOR RECONSTRUCTING COLLECTIONS

Tables 1-5: GRS Workplan for reconstructing ICARDA's active and base collections in Lebanon and Morocco 2016-23/25/30 (numbers of accessions).

1) Self-pollinated cultivated cereals

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023
Size of collection	65,163	65,833	66,433	67,033	67,633	68,233	68,833	69,433	70,033
Acquisition	670	600	600	600	600	600	600	600	600
Samples distributed	2,203	5,000	7,000	9,000	11,000	13,000	15,000	16,000	16,000
Regeneration	0	0	600	850	1,000	1,100	1,200	1,200	1,200
Multiplication	2,625	789	3,000	3,200	3,400	3,600	3,800	4,500	4,500
Multiplication (Svalbard)	0	10,635	12,000	12,000	12,000	12,000	12,000	0	0
Characterization (descriptors)	2,625	11,424	15,600	16,050	16,400	16,700	17,000	5,700	5,700
Viability tested	1,421	800	1,600	2,400	3,200	4,000	4,800	6,000	6,000
Conserved active collection Morocco	3,414	14,419	24,348	34,648	44,948	55,248	65,548	69,433	70,033
Conserved base collection Morocco	3,556	14,748	24,851	35,325	45,799	56,273	66,747	69,433	70,033

2) Wild cereals

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023
Size of collection	2015	2016	2017	2018	2019	2020	2021	2022	2023
Acquisition	8728	10,307	10,407	10,507	10,607	10,707	10,807	10,907	11,017
Samples distributed	1579	100	100	100	100	100	100	110	110
Regeneration	84	1,075	500	500	700	700	1000	1050	1050
Multiplication	0	0	100	100	100	100	100	110	110
Multiplication (Svalbard)	558	1,161	931	500	500	500	500	540	540
Characterization (descriptors)	0	2,724	2,724	450	450	450	450	0	0
Viability tested	558	3,885	3,755	1,050	1,050	1,050	1,050	650	650
Conserved active collection Lebanon	84	200	200	200	300	400	500	640	640
Conserved base collection Lebanon	2074	5,759	8,023	8,331	8,639	8,947	9,255	10,076	11,017

3) Self-pollinated Food Legumes

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023
Size of collection	27,793	29,833	30,133	30,433	30,733	31,033	31,333	31,633	31,933
Acquisition	2,040	300	300	300	300	300	300	300	300
Samples distributed	369	600	800	1,000	1,200	1,400	1,600	2,000	2,000
Regeneration	0	0	200	200	250	250	300	300	300
Multiplication	1,054	2,885	2,000	1,800	1,600	1,500	1,500	1,500	1,500
Multiplication (Svalbard)	0	4,290	4,300	4,300	4,300	4,300	4,300	0	0
Characterization (descriptors)	1,054	7,175	6,500	6,300	6,150	6,050	6,100	1,800	1,800
Viability tested	0	600	800	1,000	1,200	1,400	1,600	1,600	1,600
Conserved active collection Morocco	1,633	7,863	11,844	15,344	18,844	22,344	25,844	31,633	31,933
Conserved base collection Morocco	1,803	8,070	12,105	15,659	19,213	22,767	26,321	31,633	31,933

4) Cross-pollinated Food Legumes

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Size of collection	14249	14342	14542	14742	14942	15142	15342	15542	15742	15942	16142
Acquisition	93	200	200	200	200	200	200	200	200	200	200
Samples distributed	0	200	200	400	600	800	900	1000	1000	1000	1000
Regeneration	0	0	0	0	0	0	0	0	0	300	300
1st cycle Multiplication (new and replenished)	1117	0	680	680	680	680	680	680	680	1380	1380
Multiplication (Svalbard)	0	2117	1000	1000	1000	1000	1000	1000	1032	0	0
2nd cycle of multiplication		0	400	400	400	400	400	400	400	400	400
Characterization (descriptors)	1117	2117	2080	2080	2080	2080	2080	2080	2112	2080	2080
Viability tested	0	200	300	400	500	600	700	800	800	800	800
Conserved in active collection in Lebanon	2000	3905	4977	6049	7121	8193	9265	10337	11438	12510	13582
Conserved in base collection in Lebanon	2460	4365	5437	6509	7581	8653	9725	10797	11898	12970	14042

5) Forage species

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Size of collection	32614	35335	35635	35935	36235	36535	36835	37135	37435	37735	38035	38335	38635	38935	39235	39535
Acquisition	2721	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
Samples distributed	0	0	100	100	100	200	200	200	300	300	300	400	400	400	500	500
Regeneration	0	0	0	50	50	100	100	150	150	200	200	250	250	300	300	300
Multiplication	533	1395	1800	300	300	300	300	300	300	300	300	300	300	300	2000	2000
Multiplication (Svalbard)	0	0	0	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	871	0	0
2nd cycle of multiplication	234	151	618	967	1127	1191	1236	1255	1282	1293	1317	1327	1351	1360	1133	1373
Characterization (descriptors)	533	1546	2418	2817	2977	3091	3136	3205	3232	3293	3317	3377	3401	2831	3433	3673
Viability tested	0	200	400	600	800	900	600	1000	1000	1000	1000	1000	1000	1000	1000	1000
Conserved in active collection in Lebanon	36	964	2415	4105	5891	7746	9627	11550	13489	15465	17455	19481	21522	23220	25280	27484
Conserved in base collection in Lebanon	270	1665	3465	5315	7165	9065	10965	12915	14865	16865	18865	20915	22965	24436	26736	29036

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