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COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

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FACILITATING THE IMPLEMENTATION AND MONITORING OF THE GENEBANK STANDARDS

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CGRFA 17

I. INTRODUCTION

1. The *Genebank Standards for Plant Genetic Resources for Food and Agriculture*¹ (Genebank Standards), endorsed by FAO's Commission on Genetic Resources for Food and Agriculture (the Commission), provide international standards for the *ex situ* conservation of plant genetic resources for food and agriculture (PGRFA) in seed banks, field genebanks, *in vitro* culture and under cryopreservation. They therefore constitute an important tool for implementing both the *International Treaty on Plant Genetic Resources for Food and Agriculture* (the Treaty) and the *Second Global Plan of Action for Plant Genetic Resources for Food and Agriculture* (Second GPA), which is a supporting component of the Treaty².
2. The Commission, at its Fifteenth Regular Session, requested FAO to propose a mechanism for monitoring the application of the Genebank Standards³. As step towards responding to this request and in a bid to receive feedback on the utility of the Genebank Standards from a wide stakeholder base, FAO undertook a global survey that targeted the relevant practitioners in national, regional and international genebanks.
3. Parallel to this, FAO received feedback from the Global Crop Diversity Trust (Crop Trust) on its experiences in working with international genebanks to implement the Genebank Standards through their respective Quality Management Systems (QMS). In general the Genebank Standards were considered a very useful and relevant tool to establish standards for genebank operations. However, it was indicated that the step-wise activities (action steps) for the workflows of routine genebank operations were not easily evident in the Genebank Standards. FAO therefore prepared action steps that could guide, in a sequential manner, technical support staff of genebanks in their work. Based on the actions steps, practical guides could be developed as companion material to the Genebank Standards.
4. Subsequently, FAO, in collaboration with the Crop Trust, organized an expert consultation to deliberate on the findings of the survey and to review the draft actions steps for the practical guides. This document presents the results of the survey and the outcomes of the consultation.

II. GLOBAL SURVEY ON MONITORING THE APPLICATION OF THE GENE BANK STANDARDS FOR PLANT GENETIC RESOURCES

5. FAO invited the staff of national, regional and international genebanks to participate in an online survey between August and December 2017 to monitor both the extent of their use of, and the level of satisfaction with, the Genebank Standards.
6. Respondents were requested to indicate how 'useful' the Genebank Standards were for the workflows for the conservation of orthodox seeds; field genebanks; and *in vitro* and cryopreservation, respectively. They were also requested to rate how 'useful' they found the supporting elements of the Genebank Standards, i.e. the sections on context; technical Aspects; and contingencies, respectively. The options were: 'extremely useful', 'very useful', 'useful', 'slightly useful', 'not useful', 'not applicable to our work', and 'never consulted'. Respondents were then asked to indicate if the Genebank Standards had served as a template for the development of standard operating procedures for their genebanks and whether their genebank procedures were aligned to the Genebank Standards. Additionally, respondents were asked to provide open-ended comments to all the sections of the survey, including a final one on specific suggestions for improving the Genebank Standards.
7. A total of 104 respondents from 56 countries, representing all FAO regions and five international organizations, participated in the survey. Of these, 44 were genebank managers, 31 curators of collections, 9 documentation officers, 4 technical officers and 16 categorized as 'others'.
8. The majority of the respondents (86.3 percent) considered the Genebank Standards for all three conservation types (orthodox seeds, field genebanks and *in vitro* and cryopreservation) as either

¹ FAO. 2014. *Genebank Standards for Plant Genetic Resources for Food and Agriculture*. Rev. ed. Rome. <http://www.fao.org/agriculture/crops/thematic-sitemap/theme/seeds-pgr/gbs/en/>

² Treaty, Article 14.

³ CGRFA-15/15/Report, paragraph 51.

‘useful’ or ‘very useful’, while eight percent found them ‘slightly useful’ or ‘not useful’ and 5.7 percent reported that they had never consulted the Genebank Standards (Table 1).

9. Similarly, 90.8 percent of the respondents rated the supporting sections as ‘useful’ or ‘very useful’, 8.5 percent as ‘slightly useful’ or ‘not useful’, and 0.7 reported that they had never consulted these sections (Table 2). Interestingly, 66.3 percent reported that they had used the Genebank Standards to develop standard operating procedures for their genebank operations (Figure 1), yet 82 percent responded that their genebank procedures were not fully aligned with the Genebank Standards (Figure 2).

10. In conclusion, the Genebank Standards were generally considered valuable. However, more specific technical and operational guidance was considered necessary in order to apply them effectively. It was also indicated that some areas of the Genebank Standards required updating in order to reflect the advances in the relevant scientific and technological disciplines (e.g. molecular genetics), while other areas required expansion (e.g., more specific guidance on workflow activities and more guidance for crop wild relatives). Respondents also identified poor staffing and inadequate budget and infrastructure as constraints to genebank operations.

III. EXPERT CONSULTATION TO FACILITATE THE IMPLEMENTATION OF THE GENE BANK STANDARDS

11. In April 2018, FAO and the Crop Trust convened a global expert consultation in Bonn, Germany to seek advice as to how (i) to enhance the utility and user-friendliness of the Genebank Standards and (ii) to monitor the implementation of the Genebank Standards.

12. The experts reviewed draft actions steps for the conservation of orthodox seeds, conservation in field genebanks, and *in vitro* conservation, respectively. Mirroring the outcomes of the survey and the experiences of the Crop Trust with the development of QMS for the international genebanks, the experts concluded that presenting the information contained in the Genebank Standards in a more user-friendly format detailing the different action steps of the genebank workflow in a sequential manner could help practitioners and facilitate more widespread adoption of the Genebank Standards.

13. Experts also expressed a strong preference for presenting the action steps in three practical stand-alone guides, corresponding to the three conservation types (i.e. orthodox seeds, field genebanks and *in vitro* culture). The reasoning was that, being less bulky, this would enable users to focus only on the practical guide of interest.

14. The expert consultation underscored the need to develop similar practical guides for the conservation of recalcitrant seeds in seed genebanks, cryopreservation, and DNA samples, respectively, especially as these become more mainstream, the underpinning technologies mature and widely applicable protocols become available.

15. The experts also deliberated on a workable mechanism for monitoring the implementation of the Genebank Standards.

IV. VOLUNTARY PRACTICAL GUIDES TO THE USE OF THE GENE BANK STANDARDS

16. The action steps of the workflows for routine genebank operations for the conservation of orthodox seeds, conservation in field genebanks, and *in vitro* conservation are contained in a sequential manner in Annexes 1, 2 and 3 to this document. These steps are adapted from the Genebank Standards and have been updated reflecting the current status of knowledge.

17. It is suggested that three standalone voluntary practical guides be further developed based on the action steps. Each voluntary practical guide would include an introduction outlining the underlying principles for each conservation process; the action steps presented sequentially with supporting tools such as flow charts, tables, diagrams, photos, technical guidance, and links to the Genebank Standards and other technical references; and the required staffing profiles and infrastructure.

18. Similarly, as the technologies mature and validated protocols become available, FAO would develop additional standalone booklets, especially for the conservation of recalcitrant seeds in seed genebanks, cryopreservation, and DNA samples, respectively.

V. STRATEGY FOR MONITORING THE IMPLEMENTATION OF THE GENE BANK STANDARDS

19. It is envisioned that the practical guides will also facilitate the monitoring of the implementation of the Genebank Standards. Checklists or clauses based on the action steps for each conservation approach, as presented in the voluntary practical guides, could be developed to assist genebanks in their internal monitoring. These in turn could be the tool for monitoring genebank operations based on the Genebank Standards.

20. An approach may entail surveys on qualitative assessments, based on self-evaluations by competent authorities, of key processes (e.g. acquisition, distribution, documentation), carried out periodically based on the decision of the Commission.

VI. CONCLUSION

21. Draft voluntary practical guides, as well as a proposal for monitoring the implementation of the Genebank Standards, could be prepared for consideration by the Working Group and the Commission at their next sessions.

TABLES AND FIGURES

Table 1. Weighted averages of responses to the Global Survey on Monitoring the Application of the Genebank Standards for Plant Genetic Resources on the usefulness of the Genebank Standards for orthodox seeds, field genebanks and *in vitro* culture and cryopreservation

	Extremely useful	Very useful	Useful	Slightly useful	Not useful	Never consulted
Orthodox seed	24.4	37.2	27.9	7.4	0.6	2.5
Field genebank	23.6	35	28.2	6.7	0.3	6.2
<i>In vitro</i> culture/ cryopreservation	23	32.5	24.5	9	0.5	10.5
Overall average	23.8	35.3	27.2	7.5	0.5	5.7

Table 2. Weighted averages of responses to the Global Survey on Monitoring the Application of the Genebank Standards for Plant Genetic Resources on the usefulness of the supporting sections of the Genebank Standards

	Extremely useful	Very useful	Useful	Slightly useful	Not useful	Never consulted
Context	22.4	38.8	36.7	2.0	0.0	0.0
Technical Aspects	27.0	40.0	27.0	5.0	1.0	0.0
Contingencies	22.4	26.5	31.6	16.3	1.0	2.0
Overall average	24.0	35.1	31.7	7.8	0.7	0.7

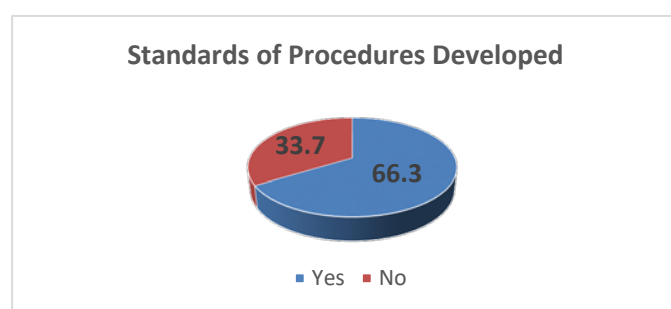


Figure 1. Percentage of respondents of the Global Survey on Monitoring the Application of the Genebank Standards for Plant Genetic Resources that reported that they have used the Genebank Standards to develop Standards of Procedures (blue) and those that reported that they have not (orange)

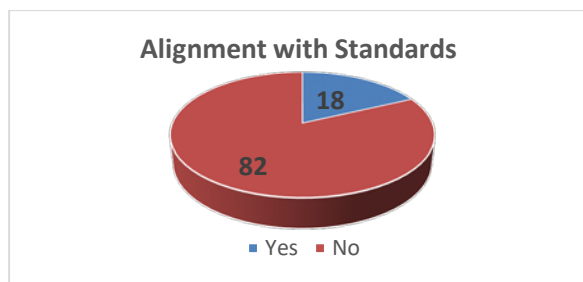


Figure 2. Percentage of respondents of the Global Survey on Monitoring the Application of the Genebank Standards for Plant Genetic Resources who reported that their genebank procedures were (blue) and were not (orange) aligned with the standards set out in the Genebank Standards

Annex 1. Draft Action Steps for the Conservation of Orthodox Seeds

Below are the normative and operational actions required for safeguarding orthodox seeds under medium- and long-term storage conditions in seed genebanks.

1.1 Acquisition of Germplasm

The genebank should have documented policies and/or procedures as applicable for acquiring germplasm in accordance with legal, phytosanitary and other regulations and requirements.

- ✓ Develop a clear strategy for germplasm acquisition according to your institute's mandate.
- ✓ Ensure that germplasm added to the collection is legally acquired, and accompanied by all relevant documentation.
- ✓ Ensure that your genebank abides by national, regional and international phytosanitary and any other import regulations and requirements from the relevant authorities in your country.
- ✓ Conduct seed collection missions as close as possible to the time of maturation and prior to natural seed dispersal, avoiding potential genetic contamination, to ensure maximum seed quality.
- ✓ Collect only seeds from visibly healthy plants, devoid of disease and insect pest infestations or other damage.
- ✓ If possible, collect from an appropriate number of individual plants such that the germplasm is genetically representative of the population, depending on the breeding system of the target species, while avoiding the depletion the natural population targeted for collecting.
- ✓ Ensure that the period between collecting, shipping and processing and then transferring to the field genebank is as short as possible to prevent loss and deterioration of the material.
- ✓ Ensure that choice of packaging and transport allows for safe and timely delivery.
- ✓ Germplasm added to the genebank collection should be accompanied by associated data outlined in the FAO/Bioversity Multi-Crop Passport Descriptors.
- ✓ Ensure that all samples are correctly labelled with the unique identification number.

1.2 Drying and Storage

The genebank should have documented policies and/or procedures as applicable for introducing acquired germplasm into long-term and medium-term storage.

- ✓ Clean all seed samples to remove empty or damaged seed and unwanted residue.
- ✓ Dry all seed samples to equilibrium in a controlled environment of 5–20°C and 10–25 percent of relative humidity.
- ✓ After drying, package samples meant for long-term storage in clearly labelled airtight containers.
- ✓ Store long-term base collections at a temperature of $-18\pm 3^{\circ}\text{C}$.
- ✓ After drying, package samples that will be accessed often (and are likely to be depleted before viability falls to the regeneration level) in clearly labelled easily-opened containers
- ✓ Store medium-term active collections at 5–10°C.
- ✓ Take and keep a small reference sample of seeds.
- ✓ Record, validate and upload to the genebank information management system all cleaning, drying and storage data, including associated metadata.

1.3 Seed Viability Monitoring

The genebank should have a documented policy and/or procedure as applicable describing the viability monitoring system used to detect falls in viability. Viability is usually assessed by testing germinability, taking into account dormant seeds that are viable but do not germinate.

- ✓ Conduct seed germinability testing following optimized and well-documented procedures.
- ✓ Conduct the initial seed germinability test after cleaning and drying the sample or at the latest within 12 months after receipt of the sample at the genebank.
- ✓ The minimum initial viability for most species should be 85 percent unless documented scientific evidence supports accepting a lower percentage for certain species.
- ✓ Ensure that a monitoring system is in place to test the viability status of samples at regular intervals during storage.
- ✓ Strive to ensure that the genebank information management system includes tools to report when the next viability monitoring test is due.
- ✓ Record, validate and upload to the genebank information management system all viability monitoring data, including associated metadata.

1.4 Regeneration

The genebank should have a documented policy and/or procedure as applicable for regeneration⁴ of germplasm, including step-by-step instructions to monitor seed inventory and seed viability, field preparation, selection of accessions, sample size, sowing, crop management, pollination control, identity verification, harvest and post-harvest management and documentation.

- ✓ Ensure that the genebank information management system includes tools to continuously check seed inventory and seed viability and report when regeneration is required.
- ✓ Regenerate accessions when seed viability or seed quantity fall below the respective regeneration thresholds.
- ✓ Ensure that species-specific regeneration procedures minimize risk to the genetic integrity of the accession.
- ✓ Record, validate and upload to the genebank information management system all regeneration data, including associated metadata.

1.5 Characterization

The genebank should have a documented policy and/or procedure as applicable for characterization of germplasm, including step-by-step instructions describing field designs, growth cycle stages during which characterization data is obtained, descriptors used, and the manner in which the data is collected and validated.

- ✓ Characterize as many accessions as possible, and within five to seven years of acquisition, if possible.
- ✓ Characterize germplasm for a set of highly heritable morphological traits to describe the phenotype of plants, ensuring that species-specific characterization procedures are based upon standardized and calibrated measuring formats and categories, following internationally agreed descriptor lists as far as possible.
- ✓ If resources are available, utilize molecular marker technologies and genomic tools for characterization, complementing phenotypic characterization.
- ✓ Record, validate and upload to the genebank information management system all characterization data, including associated metadata.
- ✓ Make relevant characterization data publicly available.

1.6 Evaluation

The genebank should have documented policies and/or procedures for the evaluation of germplasm, including step-by-step instructions describing seed sampling techniques, replicated multi-location, multi-year designs, growth cycle stages during which evaluation data is obtained, data collected (agronomic performance, biotic resistance, abiotic tolerance and nutritional), and the manner in which the data is analysed and validated. The methods/protocols, formats and measurements for evaluation should be properly documented with citations.

⁴ Note that we are using the term regeneration to depict both regeneration and multiplication.

- ✓ Obtain evaluation data for as many accessions as practically possible, through laboratory, greenhouse and/or field analysis as may be applicable.
- ✓ Whenever possible, collaborate with national or international research organisations, with field stations in different agro-ecological environments, or with members of national or regional genetic resources networks.
- ✓ Carry out germplasm evaluation in collaboration with plant breeders and other specialists (virologists, entomologists, mycologists, plant pathologists, chemists, molecular biologists, statisticians).
- ✓ Use an experimental design with replicates and conduct the evaluations in different environments and/or over multiple years.
- ✓ If desired, work with molecular breeders to identify appropriate trait-associated markers to streamline evaluation efforts.
- ✓ Use newly developed screening protocols to make sure that internationally validated protocols are respected.
- ✓ Present evaluation data either as discrete values (e.g. scores for severity of disease symptoms or symptoms of abiotic stresses) or as continuous values based on measuring.
- ✓ Record, validate and upload to the genebank information management system all evaluation data, including associated metadata.
- ✓ Strive to make relevant evaluation data publicly available.

1.7 Documentation

The genebank should have a documented policy and/or procedure as applicable for managing genebank data and information, including data sharing guidelines.

- ✓ Ensure that your genebank adopts international data standards to provide consistency in data shared among different information systems and programs.
- ✓ Establish a genebank information management system specifically for your genebank or use/adapt one of the several models available.
- ✓ Data should be publically available in a search-query database.
- ✓ Document passport data of accessions using FAO/Bioversity Multi-Crop Passport Descriptors.
- ✓ Validate and upload all data and information generated relating to all aspects of conservation and use of germplasm, including metadata.
- ✓ Strive to process the digitizing of paper data and ensure quality information management by having measures to detect manual, hand written and electronic data entries for transcription errors.
- ✓ If possible, have staff members with specific responsibility for managing the genebank information management system, including keeping data up-to-date at all times.
- ✓ Duplicate data at regular intervals and store them at a remote site to guard against loss from fire, computer failure, data breach, etc.

1.8 Distribution and Exchange

The genebank should have a documented policy and/or procedure as applicable for the distribution of germplasm, including the review process to check for fulfilment of legal, phytosanitary and other regulations and requirements, and step-by step-instructions of consignment preparation, post-consignment follow-up and reporting to the Secretariat of the ITPGRFA or to any other National Focal Point, as appropriate/when necessary.

- ✓ Ensure that your genebank complies with national, regional and international regulations and agreements.
- ✓ Ensure that users requesting material provide full details about the documentation they require in order for you to successfully provide them with the materials.
- ✓ Arrange with competent authorities or agents (i.e. National Plant Protection Organization) to inspect or test the material in order to ensure compliance with regulations of the importing country and to issue the relevant phytosanitary certificate.

- ✓ Have a policy and or/procedure in place for the number of seeds to distribute for any given species.
- ✓ Ensure that the time span between receipt of a request for seeds and the dispatch of the seeds are kept to a minimum.
- ✓ Ensure that the samples are correctly labelled, preferably with computer-produced labels to reduce transcription errors in names and numbers.
- ✓ Include all required documentation inside the shipment (for the recipient) and attached to the outside of the container for the Customs officials to guarantee smooth processing during transit and at the border of the destination country.
- ✓ Ensure that choice of packaging and transport allows for safe and timely delivery.
- ✓ Once the shipment has been successfully dispatched, document the information in the genebank information management system.
- ✓ The supplying genebank should monitor the delivery and condition of the germplasm on arrival at its destination to ensure that high quality germplasm reaches the recipient in a minimum time.

1.9 Safety Duplication

The genebank should have a documented policy and/or procedure as applicable for the safety duplication of germplasm, including the review process to check for fulfilment of legal, phytosanitary and other regulations and requirements and step-by-step instructions of consignment preparation, post-consignment follow-up, shipment schedules and monitoring of the viability of safety duplicated material.

- ✓ Store a safety duplicate sample for every original accession in a geographically distant area, under the same or better conditions than those in the original genebank.
- ✓ Draw up a legal agreement setting out the responsibilities of the depositing and the recipient genebank, and the terms and conditions under which material is maintained and managed.
- ✓ Ensure compliance with legal, phytosanitary and other regulations and requirements and that each safety duplicate sample is accompanied by relevant associated information.
- ✓ Ensure that the safety duplicate is of high quality and of sufficient quantity.
- ✓ Ensure that choice of packaging and transport allows for safe and timely delivery.
- ✓ Include minimum information along with the shipment, including an itemized list with accession identification, key passport data, total amount of seeds (by weight or number), type of container, etc.
- ✓ Record, validate and upload to the genebank information management system all safety duplication data, including associated metadata.
- ✓ Regularly check/compare the genebank information management system to ensure that any new material not duplicated in the recipient genebank is identified and prepared for safety duplication, as appropriate.

1.10 Security and Personnel

A genebank should have a documented risk management strategy in place that includes *inter alia* measures against power cut, fire, flooding and earthquakes.

- ✓ Develop a risk management strategy.
- ✓ Appoint a staff member with responsibility for Occupational Safety and Health (OSH) in your genebank and arrange for that person to go for training in OSH.
- ✓ Ensure that all staff are aware of OSH requirements and are kept up-to-date regarding any changes.
- ✓ Ensure that the genebank has a critical human resource plan with appropriate annual budget allocation (core and project funds) and that staff have the critical skills, experience and qualifications required to implement all genebank tasks effectively and efficiently.
- ✓ Include risks associated with staffing in the risk identification, analysis and management.

Annex 2. Draft Action Steps for Conservation in Field Genebanks

Below are the normative and operational actions required for safeguarding germplasm under medium- and long-term storage conditions in field genebanks.

1.1 Choice of Location of the Field Genebank

The genebank should have a documented policy and/or procedure as applicable in place for selecting and acquiring land for the field genebank, including a checklist of requirements and regulations.

- ✓ Select a site in which the agro-ecological conditions of the field genebank is as similar as possible to the environment where the collected plant materials originated.
- ✓ Select a site location that minimizes risks from natural and manmade disasters.
- ✓ Choose a site that is secure over the long-term (minimum of 50 years) based on written, guaranteed or gazetted land tenure.
- ✓ If possible, select a site that provides sufficient space for future expansion as new accessions might need to be added after a couple of years of establishment of the field genebank.
- ✓ Select a site within easy reach for curatorial staff and field labourers through transport.
- ✓ Select land area for the field genebank that is suitable for using machinery for mulching, fertilizer and pesticide applications.
- ✓ Select a site with easy access to a water source for pesticide applications and supplemental irrigation as required.
- ✓ Select a site with access to facilities for propagation and raising plants in nurseries.
- ✓ For those species used to produce seeds for distribution, choose the site in order to minimize risks of gene flow and contamination from crops, wild populations of the same species or related species with which it can cross-pollinate, to maintain genetic integrity.

1.2 Acquisition of Germplasm

The genebank should have documented policies and/or procedures as applicable for acquiring germplasm in accordance with legal and phytosanitary requirements.

- ✓ Develop a clear strategy for germplasm acquisition according to your institute's mandate:
- ✓ Ensure that germplasm added to the collection is legally acquired, and accompanied by all relevant documentation.
- ✓ Ensure that your genebank abides by national, regional and international phytosanitary and any other import regulations and requirements from the relevant authorities in your country.
- ✓ Determine type of propagating material to collect (recalcitrant seeds or vegetative materials).
- ✓ If collecting recalcitrant seeds, conduct seed collection missions as close as possible to the time of maturation and prior to natural seed dispersal, avoiding potential genetic contamination, to ensure maximum seed quality
- ✓ Collect only plant propagules from visibly healthy plants, devoid of disease and insect pest infestations or other damage.
- ✓ If possible, collect from an appropriate number of individual plants such that the germplasm is genetically representative of the population, depending on the breeding system of the target species, while avoiding the depletion the natural population targeted for collecting.
- ✓ Ensure that the period between collecting, shipping and processing and then transferring to the field genebank is as short as possible to prevent loss and deterioration of the material.
- ✓ Ensure that choice of packaging and transport allows for safe and timely delivery.
- ✓ Germplasm added to the field genebank collection should be accompanied by associated data outlined in the FAO/Bioversity Multi-Crop Passport Descriptors.
- ✓ Ensure that all samples are correctly labelled with the unique identification number.

1.3 Establishment of Field Collections

The genebank should have documented policies and/or procedures as applicable regarding germplasm in its collections including field preparation, introduction into field and live plant collections, inventory and field maps.

- ✓ Incorporate field and plot design, individual plot layout, electronic and print maps, as well as barcodes and field labels during the establishment phase of the field genebank.
- ✓ Maintain a sufficient number of plants in order to capture genetic diversity and ensure safety of accessions.
- ✓ Choose the optimum location of individual accessions for effective management of the field collection and ease of monitoring, characterization and evaluation purposes.
- ✓ Utilize appropriate spacing of plants at the plot design phase to allow for proper growth of individual plants.
- ✓ Plant reference accessions in the same field to facilitate identification, etc.
- ✓ For crop wild relatives that originated in natural forests, provide a higher shade intensity and good drainage at the field genebank site to simulate natural growing conditions.
- ✓ Practice weed control for rapid and vigorous plant growth.
- ✓ Establish and follow recommended isolation distances, use isolation cages or pollination control measures for propagation purposes.
- ✓ Insert hedgerows at the outside of field plots to help prevent pesticide drift and provide security to the accessions from invading animals or unauthorized persons.
- ✓ If possible install an irrigation system to water the plants in the case of drought or when there is high demand (e.g., establishment, fruit-setting period)
- ✓ Install clearly written labels with two water resistant indelible tags.
- ✓ Prepare a field map that shows the exact location of each accession in the plot, in both hard and electronic copies (if possible), and update regularly.

1.4 Field Management

The field genebank should have a documented policy and/or procedure as applicable for conservation of field and live plant collections, including step-by-step instructions for the cleaning, field management processes, cultural practices, identity verification and monitoring of germplasm in the collections.

- ✓ Keep in mind that maintenance practices of field collections are crop-specific and may vary according to the intended use of the collection (conservation, evaluation, distribution).
- ✓ Have a system in place for the correct identification of all associated pests and diseases for the range of crops that are included in the collection.
- ✓ After establishing the collection, be proactive and aid optimum plant growth by supplying favourable conditions, paying particular attention to the needs of crop wild relatives, if applicable.
- ✓ Maintain the genetic integrity of the collection.
- ✓ Monitor all accessions regularly to determine if there are any new animal, insect or disease pests and for any possible vandalism.

1.5 Regeneration and Propagation

The genebank should have a documented policy and/or procedure as applicable for regeneration and propagation of germplasm, including step-by-step instructions for the review process, field preparation, selection of accessions, sample size, sowing, crop management, pollination control, identity verification, propagation methodologies and documentation.

- ✓ Regularly monitor the field collection to capture any dying or dead plants within an accession.
- ✓ The timing of regeneration/rejuvenation should be planned in such a way that it coincides with the normal planting season of the crop. It will be species- and possibly site-specific.
- ✓ Whenever possible, propagate plants vegetatively so that each offspring is an exact replica of the parent plant.

- ✓ In the case of annual crops, make storage facilities available and easily accessible for vegetative propagules that are harvested annually and kept in storage until the next planting season.
- ✓ Register field management information in your database.

1.6 Characterization

The genebank should have a documented policy and/or procedure as applicable for characterization of germplasm, including step-by-step instructions describing sampling techniques, growth cycle stages during which characterization data is obtained, descriptors used (taxonomic, morphological, phenotypic, biochemical, nutritional, physiological and molecular), and the manner in which the data is collected and validated.

- ✓ Characterize all accessions at maturity.
- ✓ Characterize germplasm for a set of highly heritable morphological traits to describe the phenotype of plants, ensuring that species-specific characterization procedures are based upon standardized and calibrated measuring formats and categories, following internationally agreed descriptor lists as far as possible.
- ✓ If resources are available, utilize molecular marker technologies and genomic tools for characterization, complementing phenotypic characterization.
- ✓ Record, validate and upload to the genebank information management system all characterization data, including associated metadata.
- ✓ Make relevant characterization data publicly available.

1.7 Evaluation

The genebank should have documented policies and/or procedures as applicable for the evaluation of germplasm, including step-by-step instructions describing sampling techniques, replicated multi-location, multi-year designs, growth cycle stages during which evaluation data is obtained, descriptors used (agronomic performance, biotic resistance, abiotic tolerance and nutritional traits), and the manner in which the data is analysed and validated. The methods/protocols, formats and measurements for evaluation should be properly documented with citations.

- ✓ Obtain evaluation data for as many accessions as practically possible, through laboratory, greenhouse and/or field analysis as may be applicable.
- ✓ Whenever possible, collaborate with national or international research organisations, with field stations in different agro-ecological environments, or with members of national or regional genetic resources networks.
- ✓ Carry out germplasm evaluation in collaboration with plant breeders and other specialists (virologists, entomologists, mycologists, plant pathologists, chemists, molecular biologists, statisticians).
- ✓ Use an experimental design with replicates and conduct the evaluations in different environments and/or over multiple years.
- ✓ If desired, work with molecular breeders to identify appropriate trait-associated markers to streamline evaluation efforts.
- ✓ Use newly developed screening protocols to make sure that internationally validated protocols are respected.
- ✓ Present evaluation data either as discrete values (e.g. scores for severity of disease symptoms or symptoms of abiotic stresses) or as continuous values based on measuring.
- ✓ Record, validate and upload to the genebank information management system all evaluation data, including associated metadata.
- ✓ Strive to make relevant evaluation data publicly available.

1.8 Documentation

The genebank should have a documented policy and/or procedure as applicable managing genebank data and information, including data sharing guidelines.

- ✓ Ensure that your genebank adopts international data standards to provide consistency in data shared among different information systems and programs.
- ✓ Establish a genebank information management system specifically for your genebank or use/adapt one of the several models available.
- ✓ Data should be publically available in a search-query database, if possible.
- ✓ Document passport data of accessions using FAO/Bioversity Multi-Crop Passport Descriptors
- ✓ Validate and upload all data and information generated relating to all aspects of conservation and use of germplasm, including metadata.
- ✓ Strive to process the digitizing of paper data and ensure quality information management by having measures to detect manual, hand written and electronic data entries for transcription errors.
- ✓ If possible, have staff members with specific responsibility for managing the genebank documentation system, including keeping data up-to-date at all times.
- ✓ Duplicate data at regular intervals and store them at a remote site to guard against loss from fire, computer failure, data breach, etc.

1.9 Distribution

The genebank should have a documented policy and/or procedure as applicable for the distribution of germplasm, including the review process to check for fulfilment of legal, phytosanitary and other regulations and requirements, and step-by-step instructions of consignment preparation, post-consignment follow-up and reporting to the Secretariat of the ITPGRFA or to any other National Focal Point, as appropriate/when necessary.

- ✓ Ensure that your genebank complies with national, regional and international regulations and agreements.
- ✓ Ensure that users requesting material provide full details about the documentation they require in order for you to successfully provide them with the materials.
- ✓ Subject vegetative material from field genebanks to therapy and indexing procedures before distributing it to germplasm users. Indexing for difficult to detect pathogens such as viruses is important to reduce the risk of their spread.
- ✓ Arrange with competent authorities or agents (i.e. National Plant Protection Organization) to inspect or test the material in order to ensure compliance with regulations of the importing country and to issue the relevant phytosanitary certificate.
- ✓ Have a policy and/or procedure in place for the number of samples to distribute for any given species.
- ✓ Ensure that the time span between receipt of a request for germplasm and its dispatch are kept to a minimum.
- ✓ Ensure that the samples are correctly labelled, preferably with computer-produced labels to reduce transcription errors in names and numbers.
- ✓ Include all required documentation inside the shipment (for the recipient) and attached to the outside of the container for the Customs officials to guarantee smooth processing during transit and at the border of the destination country.
- ✓ Ensure that choice of packaging and transport allows for safe and timely delivery.
- ✓ Once the shipment has been successfully dispatched, document the information in the genebank documentation system.
- ✓ The supplying genebank should monitor the delivery and condition of the germplasm on arrival at its destination to ensure that high quality germplasm reaches the recipient in a minimum time:

1.10 Security and Safety Duplication

A genebank should have a documented risk management strategy in place that includes inter alia measures against power cut, fire, flooding and earthquakes. The genebank should also have a policy and/or procedure as applicable for the safety duplication of germplasm, including the review process to check for fulfilment of legal, phytosanitary and other regulations and requirements and step-by step-instructions of consignment preparation, post-consignment follow-up, shipment schedules and monitoring of the viability of safety duplicated material.

A. Security/Personnel

- ✓ Develop a risk management strategy.
- ✓ Appoint a staff member with responsibility for Occupational Safety and Health (OSH) in your genebank and arrange for that person to go for training in OSH.
- ✓ Ensure that all staff are aware of OSH requirements and are kept up-to-date regarding any changes.
- ✓ Ensure that the genebank has a critical human resource plan with appropriate annual budget allocation (core and project funds) and that staff have the critical skills, experience and qualifications required to implement all genebank tasks effectively and efficiently.
- ✓ Include risks associated with staffing in the risk identification, analysis and management.

B. Safety Duplication

- ✓ Store a safety duplicate sample for every original accession in a geographically distant area, under the same or better conditions than those in the original genebank.
- ✓ Discuss with the host genebank early in the planning process what documentation (genebank and host country) is required, including an assessment of the customs and quarantine procedures.
- ✓ Draw up a legal agreement setting out the responsibilities of the depositing and the recipient genebank, and the terms and conditions under which material is maintained and managed.
- ✓ Ensure compliance with legal, phytosanitary and other regulations and requirements and that each safety duplicate sample is accompanied by relevant associated information.
- ✓ Ensure that the safety duplicate is of high quality and of sufficient quantity.
- ✓ Ensure that choice of packaging and transport allows for safe and timely delivery.
- ✓ Include minimum information along with the shipment, including an itemized list with accession identification, key passport data, total amount of propagules (by weight or number), type of container, etc.
- ✓ Record, validate and upload to the genebank information management system all safety duplication data, including associated metadata.
- ✓ Regularly check/compare the genebank information management system to ensure that any new material not duplicated in the recipient genebank is identified and prepared for safety duplication, as appropriate.

Annex 3. Draft Action Steps for Conservation *In vitro*

Below are the normative and operational actions required for safeguarding germplasm under medium- and long-term storage conditions via *in vitro* culture.

1.1 Acquisition of Germplasm

The genebank should have documented policies and/or procedures as applicable for acquiring germplasm in accordance with legal and phytosanitary requirements.

- ✓ Develop a clear strategy for germplasm acquisition according to your institute's mandate.
- ✓ Ensure that germplasm added to the collection is legally acquired, and accompanied by all relevant documentation.
- ✓ Ensure that your genebank abides by national, regional and international phytosanitary and any other import regulations and requirements from the relevant authorities in your country.
- ✓ Determine type of propagating material to collect (recalcitrant seeds or vegetative materials).
- ✓ If collecting recalcitrant seeds, conduct seed collection missions as close as possible to the time of maturation and prior to natural seed dispersal, avoiding potential genetic contamination, to ensure maximum seed quality
- ✓ Collect only plant propagules from visibly healthy plants, devoid of disease and insect pest infestations or other damage.
- ✓ If possible, collect from an appropriate number of individual plants such that the sample is genetically representative of the population, depending on the breeding system of the target species, while avoiding the depletion the natural population targeted for collecting.
- ✓ Ensure that the period between collecting, shipping and processing and then transferring to the field genebank is as short as possible to prevent loss and deterioration of the material.
- ✓ Ensure that choice of packaging and transport allows for safe and timely delivery.
- ✓ Germplasm added to the genebank collection should be accompanied by associated data outlined in the FAO/Bioversity Multi-Crop Passport Descriptors.
- ✓ Carry out all checking and decontamination activities in an area physically separated from laboratory and storage facilities.
- ✓ Ensure that all samples are correctly labelled with the unique identification number.

1.2 *In vitro* Culture and Slow-growth Storage

The genebank should have a documented policy and/or procedure as applicable for *in vitro* culture and slow-growth storage including guidelines and methodologies for explant identification, initiation into *in vitro* and propagation/multiplication, medium composition, light and temperature regimes, regeneration, rejuvenation, characterization and evaluation.

A. *In vitro* culture

- ✓ Determine the culture media composition for initiating the explant *in vitro* and for multiplication.
- ✓ Determine the appropriate explant and the optimum time (growth stage and physiological age of parent plant) for initiation into culture for a particular genus from the literature or by experiment.
- ✓ Ensure that explants are free from known diseases and microbial contaminants.
- ✓ Once successfully initiated into culture, multiply the accession either for normal growth (active growing conditions) or slow growth storage.
- ✓ Clearly label culture containers following genebank practice.
- ✓ Select germplasm for storage from young cultures that have not been subject to too many subcultures in order to minimize the chance of selecting a variant plant.

B. Slow-growth Storage

- ✓ Decide the type of slow growth storage required.

- ✓ Select the optimum storage conditions by visually assessing the general performance of each culture using the following criteria, vigour, fungal and bacterial contamination, chlorosis, blackening, tissue necrosis, hyperhydration and etiolation.
- ✓ Determine the number of replicates to put into storage.
- ✓ Clearly label culture containers following genebank practice.

A. Regeneration

- ✓ At the end of a storage period cultures can be placed in optimal conditions to encourage regrowth before the start of the next storage cycle.
- ✓ Carry out regular screening to remove *in vitro* cultures that show any variation from whole plantlets or shoots etc.
- ✓ Periodically assess genetic stability via visual assessment, regeneration and transfer to the field for morphological observations, cytological techniques, or using molecular techniques.
- ✓ Carry out characterization and evaluation when accessions are taken out of *in vitro* conditions.
- ✓ In the case of contamination of all replicates, material should be transferred to the greenhouse, if plantlets are available, or subjected to regeneration and/or a decontamination treatment.

1.3 Documentation

The genebank should have a documented policy managing genebank data and information, including data sharing guidelines.

- ✓ Ensure that your genebank adopts international data standards to provide consistency in data shared among different information systems and programs.
- ✓ Establish a genebank information management system specifically for your genebank or use/adapt one of the several models available.
- ✓ Data should be publically available in a search-query database.
- ✓ Document passport data of accessions using FAO/Bioversity Multi-Crop Passport Descriptors.
- ✓ Validate and upload all data and information generated relating to all aspects of conservation and use of germplasm, including metadata.
- ✓ Strive to process the digitizing of paper data and ensure quality information management by having measures to detect manual, hand written and electronic data entries for transcription errors.
- ✓ If possible, have staff members with specific responsibility for managing the genebank information management system, including keeping data up-to-date at all times.
- ✓ Duplicate data at regular intervals and stored at a remote site to guard against loss from fire, computer failure, data breach, etc.

1.4 Distribution and Exchange

The genebank should have a documented policy and/or procedure as applicable for the distribution of germplasm, including the review process to check for fulfilment of legal, phytosanitary and other regulations and requirements, and step-by step-instructions of consignment preparation, post-consignment follow-up and reporting to the Secretariat of the ITPGRFA or to any other National Focal Point, as appropriate/when necessary.

- ✓ Ensure that your genebank complies with national, regional and international regulations and agreements.
- ✓ Ensure that users requesting material provide full details about the documentation they require in order for you to successfully provide them with the materials.
- ✓ Arrange with competent authorities or agents (i.e. National Plant Protection Organization) to inspect or test the material in order to ensure that it meets the import requirements to assure compliance with regulations of the importing country and to issue the relevant phytosanitary certificate or other necessary documents.
- ✓ Have a policy in place for the number of samples to distribute for any given species.
- ✓ Endeavour to assess the capacity of the recipient in adequately managing *in vitro* material

- ✓ Ensure that germplasm for distribution is in good condition when it leaves the genebank. Ensure that the samples are correctly labelled.
- ✓ Ensure that the time span between receipt of a request for germplasm and its dispatch are kept to a minimum.
- ✓ Include all required documentation inside the shipment (for the recipient) and attached to the outside of the container for the Customs officials to guarantee smooth processing during transit and at the border of the destination country.
- ✓ Ensure that choice of packaging and transport allows for safe and timely delivery.
- ✓ Once the shipment has been successfully dispatched, document the information in the genebank documentation system.
- ✓ Follow up with the recipient as to assess the recipient's capacity in handling germplasm and status and performance of the distributed germplasm by requesting feedback.

1.5 Security and Safety duplication

A genebank should have a documented risk management strategy in place that includes inter alia measures against power cut, fire, flooding and earthquakes. The genebank should also have a policy and/or procedure as applicable for the safety duplication of germplasm, including the review process to check for fulfilment of legal, phytosanitary and other regulations and requirements and step-by step-instructions of consignment preparation, post-consignment follow-up, shipment schedules and monitoring of the viability of safety duplicated material.

A. Security/Personnel

- ✓ Develop a risk management strategy.
- ✓ Appoint a staff member with responsibility for Occupational Safety and Health (OSH) in your genebank and arrange for that person to go for training in OSH.
- ✓ Ensure that all staff are aware of OSH requirements and are kept up-to-date regarding any changes.
- ✓ Ensure that the genebank has a critical human resource plan with appropriate annual budget allocation (core and project funds) and that staff have the critical skills, experience and qualifications required to implement all genebank tasks effectively and efficiently.
- ✓ Include risks associated with staffing in the risk identification, analysis and management.

B. Safety duplication

- ✓ Store a safety duplicate sample for every original accession in a geographically distant area, under the same or better conditions than those in the original genebank.
- ✓ If your genebank does not already have an agreement with another genebank to duplicate your original accessions, consider where best you might do so, which will depend on your chosen method of safety duplication.
- ✓ Discuss with the host genebank early in the planning process what documentation (genebank and host country) is required, including an assessment of the customs and quarantine procedures.
- ✓ Draw up a legal agreement setting out the responsibilities of the depositing and the recipient genebank, and the terms and conditions under which material is maintained and managed.
- ✓ Ensure compliance with legal, phytosanitary and other regulations and requirements and that each safety duplicate sample is accompanied by relevant associated information.
- ✓ Ensure that the safety duplicate is of high quality and of sufficient quantity.
- ✓ Ensure that choice of packaging and transport allows for safe and timely delivery.
- ✓ Include minimum information along with the shipment, including an itemized list with accession identification, key passport data, total amount of propagules (by weight or number), type of container, etc.
- ✓ Record, validate and upload to the genebank information management system all safety duplication data, including associated metadata.

- ✓ Regularly check/compare the genebank management system to ensure that any new material not duplicated in the recipient genebank is identified and prepared for safety duplication, as appropriate.