



Genebank Peer Reviews: A powerful tool to improve genebank quality and promote collaboration

Theo van Hintum^a, Sharon Balding^b, Gergana Desheva^c, John Dickie^b, María José Díez^d, Luis Guasch^e, Pavol Hauptvogel^f, Vojtěch Holubec^g, Dagmar Janovská^g, Ulrike Lohwasser^h, Isaura Martín^e, Ludmila Papoušková^g, Beate Schierscher-Viretⁱ, Lise Lykke Steffensen^j, Katya Uzundzhalieva^c, Patrizia Vaccino^k and José Vicente Valcárcel^d

^a Centre for Genetic Resources, The Netherlands (CGN), Wageningen University and Research (WUR), Wageningen, The Netherlands

^b Millennium Seed Bank (MSB), Royal Botanic Gardens Kew, Wakehurst Place, Ardingly, UK

^c Agricultural Academy, Institute of Plant Genetic Resources "Konstantin Malkov" (IPGR), Sadovo, Bulgaria

^d Institute for the Conservation and Improvement of the Valentian Agrodiversity (COMAV), Polytechnic University of Valencia, Spain

^e National Institute for Agricultural and Food Research and Technology (INIA-CSIC), Spanish Plant Genetic Resources Centre (CRF), Alcalá de Henares, Madrid, Spain

^f Research Institute of Plant Production (RIPP), National Agricultural and Food Centre (NPPC), Piešťany, Slovakia

^g Czech AgriFood Research Center (CARC), Ruzyně, Prague, Czech Republic

^h Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Gatersleben, Germany

ⁱ AGROSCOPE, Changins, Nyon, Switzerland

^j Nordic Genetic Resource Center (NordGen), Alnarp, Sweden

^k Research Center for Cereal and Industrial Crops (CREA-CI), Council for Agricultural Research and Economics (CREA), Vercelli, Italy

Abstract: The conservation of plant genetic resources (PGR) is critical to ensuring global food security and agricultural sustainability. Genebanks play a vital role in *ex situ* conservation, complementing *in situ* strategies by preserving crop diversity (incl. their wild relatives) and providing access to biological materials for research, breeding and farming. However, maintaining high conservation standards and ensuring accessibility remains a global challenge. To address this, the 'Genebank Peer Review' system was developed as a collaborative quality assessment and improvement mechanism. This system facilitates reciprocal evaluations among genebanks, promoting transparency, capacity building and continuous improvement in conservation practices. Implemented in Europe since 2019, the peer review process involves structured self-assessments, site visits and expert evaluations, culminating in publicly available reports that guide genebanks in enhancing their operations. Feedback from participating institutions highlights the system's effectiveness in fostering knowledge exchange, strengthening professional networks and improving genebank management practices. Despite its success, challenges remain, particularly regarding expert availability and resource constraints. Future efforts should focus on institutionalizing mentorship programmes to sustain and expand the impact of Genebank Peer Reviews and monitor improvements.

Keywords: crop diversity, *ex situ* conservation, plant genetic resources, peer review, quality improvement

Citation: van Hintum, T., Balding, S., Desheva, G., Dickie, J., Díez, M. J., Guasch, L., Hauptvogel, P., Holubec, V., Janovská, D., Lohwasser, U., Martín, I., Papoušková, L., Schierscher-Viret, B., Steffensen, L. L., Uzundzhalieva, K., Vaccino, P., Valcárcel, J. V. (2025). Genebank Peer Reviews: A powerful tool to improve genebank quality and promote collaboration. *Genetic Resources* 6 (11), 115–121. doi: [10.46265/genresj.OADZ7911](https://doi.org/10.46265/genresj.OADZ7911).

© Copyright 2025 the Authors.

This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Introduction

To ensure a sufficient food supply for the growing global population, it is crucial to conserve plant genetic resources (PGR) and make them accessible for crop research, plant breeding and cultivation, both now and in the future. Since the 1960s, genebanks have been established to complement traditional *in situ* conservation methods (Engels and Ebert, 2021). This shift from *in situ* to *ex situ* was necessary due to changes in agriculture, land use, and environmental conditions that threatened to erode the *in situ* biodiversity.

Genebanks offer several advantages over *in situ* conservation, including improved access to both information and biological material. However, the task of conserving PGR is huge, and no single genebank or country can manage it alone. It requires a global effort with contributions from various actors. Many research institutions involved in plant breeding have established genebanks, and most countries maintain a national genebank or a network of genebanks, often linked to national breeding programmes. According to the Food and Agriculture Organization (FAO, 2025), in 2022 the global genebank network conserved approximately 5.9 million accessions across 871 genebanks composed of 13 international genebanks (such as those managed by CGIAR), 6 regional and the remaining 852 national genebanks – more than half of them in Europe.

The global effort to conserve PGR is supported by international treaties and collaborations, such as the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA, (FAO, 2009)), which aims to ensure the conservation and sustainable use of PGR and the fair sharing of benefits arising from their use. This collaborative approach is essential for maintaining the genetic diversity needed to adapt to future agricultural challenges and ensure food security.

Obviously, not every genebank intends to contribute to the ‘global effort’. Included in the 871 genebanks are many local – what could be called ‘working collections’, not meeting any standards (FAO, 2014) in terms of conservation practice or access. For example, only 123 out of the 852 genebank deposited seeds at the Svalbard Global Seed Vault (<https://www.seedvault.no/>). This could be due to well-considered decisions, but in most cases, it may be a lack of awareness, with resulting shortcomings in procedures.

To be considered part of the ‘global effort’ a genebank should have adopted two principles: (1) the material should be properly conserved and (2) the material should be accessible for use.

The first principle, proper conservation, is a technical issue. Obviously one can disagree about the technical details, such as the frequency of germination tests, the population size of regenerations, and the need to triplicate at the Svalbard Global Seed Vault, but the objective is clear. Technical disputes are about the balance between security (genetic integrity and seed quality) and costs: the higher the security, the higher the

costs per unit and as a result the lower the number of units that can be conserved.

The second principle, access, is not only technical, but also has a political dimension. On the technical side, one could ask what information should be provided about the material, what percentage of the material conserved should be readily available for distribution, or what a genebank should be willing to do, to get the material to the requestor (in terms of plant passports, import permits, non-GMO statements, etc.). On the political side, it can be more complex. Considerations will have to take account of access and benefit-sharing policies: who is allowed to receive material and under what conditions?

Fortunately, there is a broad base of experience to draw on. Regarding the conservation issues, there are the FAO Genebank Standards (FAO, 2014) and extensive experience from genebanks. Regarding the access issues, there are the ITPGRFA, the EU regulation on the Nagoya Protocol (EU, 2014) and organizations such as the European Cooperative Programme for Plant Genetic Resources (ECPGR) setting standards or proposing best practices (<https://www.ecpgr.org/>).

In the domain of genebank performance monitoring, a certain level of experience has been accumulated within the community. A number of genebanks have adopted the ISO 9001 standard for quality management, thereby ensuring adherence to established protocols, effective risk management, and the implementation of continuous quality improvement mechanisms, including procedures for addressing user feedback and complaints. Additionally, the Global Crop Diversity Trust has developed the Genebank Quality Management System (GQMS) and has provided support for its implementation across CGIAR genebanks (Lusty et al, 2021). Nevertheless, the establishment and maintenance of such systems entail substantial investments, both from the genebanks themselves and from the entities responsible for review and auditing (see also van Hintum and Wijnker (2024)). In a situation where the genebank community has community standards, the challenge is to ensure that the members of this community meet those standards, especially where funds are scarce. Some genebanks will already meet the standards to a certain extent, while others will need changes in protocols or even additional equipment or staff. In the attempt to improve the quality of operations in the community, the obvious first step is to determine the status quo. The members of the community, the genebanks, need to determine how they are doing, and identify where improvements can or should be made. For this reason, the ‘Genebank Peer Review’ system was designed to create clarity and transparency about the status of genebanks and to build capacity to improve collections’ status where needed and possible. Initially, this peer-review system is aimed at the European national genebanks wanting to be part of the global effort to conserve PGR for future generations and make it available to the current.

History of the Genebank Peer Review system

The PGR community in Europe is very heterogeneous, consisting of hundreds of genebanks (FAO, 2025), with a huge range of objectives, sizes and methodologies. Ideally, Europe could set up a system similar to the USDA National Plant Germplasm System (<https://www.ars-grin.gov/npgs/>), i.e. including some central and some sub-regionally specialized facilities, with proper coordination, quality management and a clear policy regarding access. ECPGR, as the collaborative umbrella organization for European countries, has made efforts to address the heterogeneous and fragmented landscape but has yet to achieve significant improvements in coordination. Initiatives such as AEGIS (www.ecpgr.org/aegis), a catalogue of PGR managed according to standards in various participating European genebanks, were promising but still need major steps forward to become effective (van Hintum *et al*, 2021).

During an ECPGR meeting about 'Assessing current practices and procedures to strengthen AEGIS' held in Madrid in December 2018, a plan was presented to improve transparency and build capacity in the European genebank community based on mutual visits of genebank staff members (Engels *et al*, 2019). This plan – called 'Improving PGR Conservation and Access in Europe; a plan to create a voluntary genebank's peer review system' – was prepared and presented by the Centre for Genetic Resources, The Netherlands (CGN), based on its involvement in the reviewing process organized by the Global Crop Diversity Trust coordinating and supporting the operations of the CGIAR genebanks (Lusty *et al*, 2021). The plan was received positively and it was decided that: "Peer review proof of concept will be tested (colleague experts visiting, discussing and learning from each other – not an auditing or policing exercise)" and that "Under the coordination of CGN, first peer-review cycle will be completed in early 2019".

In the first months of 2019, CGN formulated protocols for peer reviews, including elements of AQUAS, the quality management system of AEGIS (ECPGR, 2025a). In the period from February to April 2019, a pilot cycle of peer reviews was organized, partly in the framework of the EU project GenRes Bridge (<https://www.genresbridge.eu/>). This project aimed "to strengthen conservation and sustainable use of genetic resources by accelerating collaborative efforts and widening capacities in plant, forest and animal domains". The pilot cycle involved the IHAR-BIP genebank in Radzików, Poland, the COMAV genebank in Valencia, Spain and CGN in Wageningen, The Netherlands. After each visit a short report was written with observations and recommendations, and after the complete cycle, a summary of experiences and conclusions was written and made public on the ECPGR website (van Hintum *et al*, 2019).

Based on this pilot cycle of reviews, the protocols for the peer reviews were further improved and the concept was used in another EU-funded project, AGENT

(Activated Genebank Network, <https://agent-project.eu/>). This project aimed "to unlock the full potential of biological material stored in gene banks worldwide by utilizing FAIR international data standards and an open digital infrastructure for managing plant genetic resources". In this context another four cycles of reviews were organized in the period 2022–2024, with 12 reviews involving eleven genebanks; CGN was involved in two cycles.

The concept of Genebank Peer Reviews

The fundamental principle of Genebank Peer Reviews is straightforward: within a cycle of three reciprocal visits, experienced staff members from two genebanks evaluate the facilities and operations of a third institution. These visits are preceded by a self-assessment conducted by the host genebank, the results of which are made available to the reviewers. During the review process, the visiting experts are granted full access to relevant information. Following the evaluation, the reviewers compile a report, which is subsequently published online, contingent upon the consent of the reviewed genebank. Further details, primarily based on the GenRes Bridge report on this activity (GenRes Bridge, 2021), are provided below.

Objectives

The primary objective of the peer review process is to provide a comprehensive description of the management, facilities and procedures of a genebank and evaluate them. This serves two key purposes: (1) enabling expert colleagues to offer technical feedback on these aspects, and, when necessary, (2) facilitating the development of an expert-driven improvement plan. Such an improvement plan, informed by the review report, may be utilized in fundraising efforts. The transparency fostered by these peer reviews is expected to benefit the PGR community by identifying both strengths and weaknesses within the PGR management infrastructure. This, in turn, will allow for the optimization of strong points and the implementation of targeted measures to address areas requiring improvement.

The peer-review process aims to assess all pertinent aspects of the genebank under evaluation, including management, facilities and procedures, within a 2-to-3-day visit.

Preparation

The initial phase of the process entails identifying appropriate partners and systematically planning the reviews, as detailed below:

- Three participating genebanks are selected. This selection is based on the context of the reviews, i.e. the genebanks participating in the project that organizes the peer reviews, and obviously the enthusiasm of the genebanks to be included.
- Each genebank designates a qualified representative who will actively participate in all three

reviews. This individual should possess extensive knowledge of their respective genebank and expertise in PGR management. The representative will serve as the primary contact throughout the review process. In exceptional cases, a genebank may appoint two representatives if warranted.

- Tentative dates for the three reviews are determined, with each review expected to last between two and three days, depending on the complexity of the operations.

For each review:

- The reviewed genebank provides, when available, technical information relevant to its operations, including management structures, facilities and procedures. This is achieved through the completion of the Operational Genebank Manual, which should be compiled using the template provided by ECPGR (2010), or a version slightly expanded version for the peer reviews (see [Supplemental Material 1](#)).
- Reviewers may request specific data to facilitate their preparatory work.
- The reviewed genebank prepares a draft agenda, allowing reviewers to provide feedback and propose amendments beforehand.
- The reviewed genebank arranges accommodation for the reviewers and covers the associated costs.
- Reviewers organize and finance their own travel to the genebank's country.

Review process

- The reviewed genebank assumes responsibility for organizing local transportation during the review and covering related expenses.
- The reviewers are granted full access to the genebanks records, staff and facilities upon request. Should any restrictions apply, these must be formally documented along with a rationale.
- Throughout the visit, the reviewers engage in comprehensive discussions and visits encompassing all relevant aspects of the genebank's operations, including those outlined in the Operational Genebank Manual. Additionally, broader issues such as funding stability, management structures and organizational effectiveness are examined. A checklist of key discussion points is available (see [Supplemental Material 2](#)).
- The review concludes with a final session dedicated to discussing the observations made by the review team.

Post-review process

- The reviewers prepare a preliminary report summarizing their findings, structured according to the checklist of discussion points.
- The reviewed genebank is given an opportunity to verify the factual accuracy of the report and propose necessary corrections.

- The reviewers finalize the report and provide it to the reviewed genebank for internal use in improvement planning and fundraising efforts.
- The reviewed genebank determines which sections of the report should remain confidential. The public version of the report will reference restricted sections, allowing interested parties to request additional information bilaterally.
- The public report is made available to relevant stakeholders including colleague genebanks and funding agencies (ECPGR, 2025b).

Additional considerations

The review process is designed to be collaborative and founded on mutual trust. The purpose of the review is not to critique individuals but rather to enhance the efficiency and management of the reviewed genebank and exchange knowledge. Consequently, review teams should be kept small, and all activities beyond the core review tasks should be conducted collectively. Furthermore, the proposed cost-sharing arrangement – whereby the host institution covers all local expenses while visiting team members are responsible only for their travel costs to the host country – aims to alleviate financial burdens, particularly for genebanks located in regions with lower cost levels.

Experiences and lessons learned

The concept of Genebank Peer Reviews was formulated in 2019, and since then five cycles of three visits each have been organized in Europe in the frame of Genres Bridge and AGENT projects, involving 12 genebanks (CGN was involved in three cycles, IHAR in two). An overview of the reviews is given in [Table 1](#).

When asked to evaluate their experiences with the Genebank Peer Review, the feedback from the genebanks involved was predominantly positive. The quotes in this paragraph are from this feedback and the evaluation of the first pilot cycle of reviews (van Hintum et al, 2019).

Many participants initially needed to familiarize themselves with the concept of Genebank Peer Reviews. As one participating genebank noted, “Although the initial impression was merely that of undergoing an evaluation process to assess the work carried out at the bank, once the process began, the perception shifted to viewing it as an opportunity to receive guidance from personnel with extensive experience in managing germplasm collections.”

The process of developing the Operational Genebank Manual was widely regarded as a constructive exercise, offering new insights into the genebank's operations – insights that some genebank managers had not previously considered. However, for genebanks that already had established quality management systems (van Hintum and Wijnker, 2024), the exercise was sometimes perceived as redundant, as it primarily involved restructuring existing quality manuals to fit the Operational Genebank Manual format.

Table 1. The Genebank Peer Reviews performed in the period 2019–2024. For the reports and additional information see <https://www.ecpgr.org/aegis/aquas/peer-visits>.

Insitute of reviewed genebank	Location visited	Date review visit	Reviewers
Centro de Conservación y Mejora de la Agrodiversidad Valenciana (COMAV)	Valencia, Spain	7-8 February 2019	Theo van Hintum (CGN), Wieslaw Podyma (IHAR-PIB)
Centre for Genetic Resources, the Netherlands (CGN)	Wageningen, The Netherlands	6-8 March 2019	Wieslaw Podyma (IHAR-PIB), María José Díez & José Vicente Valcárcel (COMAV)
National Center for Plant Genetic Resources (IHAR-PIB)	Radzików, Poland	16-17 April 2019	María José Díez & José Vicente Valcárcel (COMAV), Theo van Hintum (CGN)
Crop Research Institute (CRI)	Prague, Czech Republic	12-13 May 2022	Pavol Hauptvogel (RIPP), Ulrike Lohwasser (IPK), Theo van Hintum (CGN)
Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)	Gatersleben, Germany	19-20 July 2022	Dagmar Janovská & Ludmila Papoušková (CRI), Pavol Hauptvogel & Iveta Čičová (RIPP)
Research Institute of Plant Production (RIPP)	Piešťany, Slovakia	23-24 August 2022	Dagmar Janovská & Ludmila Papoušková & Vojtěch Holubec (CRI), Ulrike Lohwasser (IPK)
Centro Nacional de Recursos Fitogenéticos (CRF)	Madrid, Spain	7-8 July 2022	Katya Uzundzhaliyeva & Gergana Desheva (IPGR), Theo van Hintum (CGN)
Centre for Genetic Resources, the Netherlands (CGN)	Wageningen, The Netherlands	19-20 July 2022	Isaura Martin & Luis Guasch (CRF), Katya Uzundzhaliyeva & Gergana Desheva (IPGR, Bulgaria)
Institute of Plant Genetic Resources 'Konstantin Malkov' IPGR)	Sadovo, Bulgaria	6-7 October 2022	Luis Guasch & Isaura Martín (CRF), Theo van Hintum (CGN)
Nordic Genetic Resource Center (NordGen)	Alnarp, Sweden	29-30 June 2023	John Dickie (MSB), Theo van Hintum (CGN)
Millennium Seed Bank (MSB)	Ardingly, UK	6-7 July 2023	Theo van Hintum (CGN), Lise Lykke Steffensen (NordGen)
Centre for Genetic Resources, the Netherlands (CGN)	Wageningen, The Netherlands	21-22 September 2023	Lise Lykke Steffensen (NordGen), John Dickie & Sharon Balding (MSB)
National Center for Plant Genetic Resources (IHAR-PIB)	Radzików, Poland	21-23 October 2024	Beate Schierscher-Viret (AGROSCOPE), Patrizia Vaccino (CREA-CI)
Research Center for Cereal and Industrial Crops (CREA-CI)	Vercelli, Italy	23-24 September 2024	Maja Boczkowska (IHAR), Beate Schierscher-Viret (AGROSCOPE)
Agroscope Changins (AGROSCOPE)	Nyon, Switzerland	25-26 September 2024	Patrizia Vaccino (CREA-CI), Maja Boczkowska (IHAR)

The cycle of mutual visits was unanimously regarded as a worthwhile investment of both effort and time. “As a host, although the initial sensation was that our genebank was under evaluation, this feeling disappeared as soon as the review started because it was carried out in a friendly atmosphere and we quickly realized that we could take profit of many of the reviewers’ suggestions.” The feedback provided by reviewing peers was generally perceived as constructive and encouraging. “The opinion of colleagues that are dealing with equivalent responsibilities and problems in another country has given us a better understanding of the strengths and weaknesses of our institution and has served as a starting point for identifying areas of improvement.” Moreover, for the reviewing genebanks,

the opportunity to closely examine a colleague’s genebank proved to be a valuable learning experience. Observing different practices and methodologies served as a source of inspiration, stimulating improvements in approaches and protocols within their own institutions. Furthermore, it strengthened the contacts between genebank managers, or as formulated by one of the participating genebanks: “The two days spent at each genebank not only offered us an opportunity for in-depth discussions on plant genetic resources with a team of experts but also provided an opportunity to strengthen professional relationships with colleagues committed to the same field. We were truly aware of the advantages of being part of a genebank community.”

The reports contained between 2 and 21 recommendations by the reviewers. The recommendations addressed very practical issues such as “In order to have unique identifiers for the accessions digital object identifiers (DOIs) should be implemented.” or “Consider establishing a lower ceiling to the amount of seeds to be stored of one accession to avoid unnecessary use of space in the -18°C storage room.” to policy-oriented recommendations such as “Consider the possibility of introducing handling fees to reduce the requests of hobby growers as the genebank seeds are too expensive to distribute to that category.” The reports are available on the peer review website hosted by ECPGR (ECPGR, 2025b).

Assessing the impact of follow-up actions following the review cycles is challenging, as numerous additional factors have also influenced the development of the genebanks involved. Most genebanks utilized the reports to set priorities for their activities and/or to advocate for funding to support specific infrastructural improvements. Additionally, the publicly available Operational Genebank Manuals and review reports (available on the ECPGR/AQUAS website (ECPGR, 2025a)) may have provided valuable insights to other genebanks, potentially inspiring improvements in their operations. At a broader level, these reviews and resulting resources can be expected to have also contributed to increased transparency in genebank practices and methodologies. However, the extent of this influence remains difficult to quantify, although the overall impression is very positive. When asked, one of the genebanks concluded “After several years, participating in the peer review process has led to a substantial improvement in the germplasm bank”, a conclusion that is shared by most participating genebanks.

Discussion and conclusions

The conclusions that can be drawn after 15 Genebank Peer Reviews, are largely consistent with those derived from the initial cycle of reviews (van Hintum et al, 2019). Firstly, these peer reviews have demonstrated their cost-effectiveness as a means of enhancing the quality of genebank operations. Beyond offering a comprehensive evaluation of various operational aspects, the reviews also play a vital role in motivating and inspiring staff members, thereby promoting continuous improvement.

The reviewers, in general, expressed appreciation for the process, particularly valuing the opportunity to observe and discuss the operations of their colleague genebanks. The social aspect of briefly working alongside international colleagues was also highly regarded.

The functioning of the review teams was generally effective. It became evident that, ideally, one of the genebanks involved should be a well-established institution, capable of serving as an inspiration for others. The review cycle, which involved three genebanks and two or three reviewers for each review, was particularly successful as it allowed for a sufficient level of intimacy, ensuring both confidentiality and trans-

parency. The reviewers were typically sufficiently senior and experienced, enabling them to critically assess their colleagues’ work.

The duration of most reviews ranged between one and a half to two days, a timeframe that was deemed short but appropriate. Shorter reviews risked remaining superficial, while longer reviews would have allowed for more in-depth feedback but would also consume more time from the experts involved and thus resources.

The self-assessment process, particularly the preparation of the Operational Genebank Manual prior to the review, emerged as a crucial component in fostering transparency and expanding the hosting experts’ own understanding of the procedures within the genebank. In some instances, this process revealed issues that had previously gone unnoticed by the genebank manager. Since the manual does not refer to genebank standards explicitly, the evaluation of the procedures in the context of e.g. the FAO Genebank Standards (FAO, 2014) was one of the aspects of the review.

The Genebank Peer Review approach holds potential for further development into a comprehensive tool not only for enhancing but also for sustaining the quality of genebank operations. To this end, it could be formally integrated into the quality management systems of genebanks, contingent upon its institutionalization within the framework of ECPGR or a comparable overarching body, potentially extending beyond the European context. Such institutionalization would necessitate stable financial support and the establishment of a semi-permanent pool of expert reviewers. Moreover, the systematic follow-up on review recommendations could be embedded as a structural component of genebank quality management, including formalized reporting mechanisms. However, these developments may affect the currently appreciated informal character of the peer review process.

At a broader level, the outcomes of genebank reviews could serve as a valuable resource for informing the prioritization of funding initiatives aimed at strengthening the global system for the conservation of plant genetic resources.

Overall, the Genebank Peer Reviews have had a significant positive impact on the quality of the genebanks involved and have strengthened the connections between genebank experts. They were considered by the reviewers as a cost-effective tool for quality improvement. However, a key challenge remains the reliance on the availability of senior experts, particularly those from well-established institutions. Setting up a pool of experienced genebank experts to ‘mentor’ the reviews could be a solution.

Supplemental data

Supplemental Material 1: Template for Operational Genebank Manual

Supplemental Material 2: Checklist of Key Discussion Points

Acknowledgments

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This work was supported by two projects that received funding from the European Union's Horizon 2020 research and innovation programme: the GenRes Bridge project under grant agreement No. 817580 and the AGENT project under grant agreement No. 862613.

The authors wish to express their gratitude to their colleagues in the genebanks for their invaluable support in managing daily operations and ensuring the effective functioning of these institutions. Their willingness to provide full transparency regarding protocols, activities, and experiences during the review process was instrumental in shaping the foundation of this study.

Author contributions

TvH developed the concept of the paper, all other authors commented on the draft and contributed to various extents to the writing.

Conflict of interest statement

The authors declare that they have no conflicts of interest.

References

- ECPGR (2010). Template for the preparation of operational genebank manuals (Final version formally approved by the AEGIS Advisory Committee - 24.09.2010) 28p. url: https://www.ecpgr.org/fileadmin/templates/ecpgr.org/upload/AEGIS/Documents/Procedures_examples/Template_for_the_preparation_of_operational_genebank_manuals.doc. accessed date: 2025-03-04
- ECPGR (2025a). AQUAS: Quality System for AEGIS. url: <https://www.ecpgr.org/aegis/aquas/overview>. accessed date: 2025-02-26
- ECPGR (2025b). Genebank capacity building peer visits. url: <https://www.ecpgr.org/aegis/aquas/peer-visits>. accessed date: 2025-03-04
- Engels, J. M. M. and Ebert, A. W. (2021). A Critical Review of the Current Global Ex Situ Conservation System for Plant Agrobiodiversity. I. History of the Development of the Global System in the Context of the Political/Legal Framework and Its Major Conservation Components. *PLants* 10, 1557–1557. doi: <https://doi.org/10.3390/plants10081557>
- Engels, J. M. M., Maggioni, L., and Lipman, E. (2019). Assessing current practices and procedures to strengthen AEGIS, the initiative for A European Genebank Integrated System. Report of a Workshop, 10-12 December 2018, San Fernando de Henares, Madrid, Spain (Rome, Italy: European Cooperative Programme for Plant Genetic Resources). url: https://www.ecpgr.org/fileadmin/bioversity/publications/pdfs/AEGIS_Workshop_report_-_final_01_03_2019.pdf
- EU (2014). Regulation (EU) No 511/2014 of the European parliament and of the council of 16 April 2014 on compliance measures for users from the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization in the Union. url: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0511>.
- FAO (2009). International Treaty on Plant Genetic Resources for Food and Agriculture. Food and Agriculture Organization of the United Nations. url: <https://www.fao.org/3/i0510e/i0510e.pdf>.
- FAO (2014). Genebank Standards for Plant Genetic Resources for Food and Agriculture (Rome) 167p. url: <https://openknowledge.fao.org/server/api/core/bitstreams/612be5af-72cc-4017-afc2-936e9be6c6ed/content>.
- FAO (2025). World Information and Early Warning System on Plant Genetic Resources for Food and Agriculture (WIEWS). url: <https://www.fao.org/wiews>. accessed date: 2025-01-23
- GenRes Bridge (2021). Genres Bridge deliverable D15: A peer review system is designed and tested in three pilot cases; reports of these cases are published on the project, ECPGR and ERFPP websites. Report compiled by Theo van Hintum, Centre for Genetic Resources, The Netherlands (CGN). url: <https://www.genresbridge.eu/fileadmin/templates/Genres/Uploads/Documents/Reports/D.3.5.pdf>.
- Lusty, C., Van Beem, J., and Hay, F. R. (2021). A Performance Management System for Long-Term Germplasm Conservation in CGIAR Genebanks: Aiming for Quality, Efficiency and Improvement. *Plants* 10(12), 2627. doi: <https://doi.org/10.3390/plants10122627>
- van Hintum, T., Díez, M. J., Vicente-Valcárcel, J., and Podyma, W. (2019). Pilot: Genebank Peer Reviews - Observations and conclusions based on one cycle of three genebank peer reviews. Report. url: https://www.ecpgr.org/fileadmin/templates/ecpgr.org/upload/AEGIS/PEER_REVIEW/Pilot_Genebank_Peer_Reviews_-_observations_and_conclusions_rev.pdf.
- van Hintum, T., Engels, J. M. M., and Maggioni, L. (2021). AEGIS, the Virtual European Genebank: Why It Is Such a Good Idea, Why It Is Not Working and How It Could Be Improved 10(10), 2165. doi: <https://doi.org/10.3390/plants10102165>
- van Hintum, T. and Wijnker, E. (2024). Quality management in a genebank environment: Principles and experiences at the Centre for Genetic Resources, The Netherlands (CGN). *Genetic Resources* (S2), 6–12. doi: <https://doi.org/10.46265/genresj.RFXB3570>