

Knowledge Sharing on Best Practices for Managing Crop Genebanks

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ABSTRACT: The Crop Genebank Knowledge Base (CGKB) is an initiative of the Consultative Group of International Agriculture Research (CGIAR) System-wide Genetic Resources Programme (SGRP). The CGKB was created for sharing knowledge about best practices for managing plant genetic resources (PGR), and making effective decisions about genebank management. Genebank practices from CGIAR Centers and national genebanks were gathered for nine crops (banana, barley, cassava, chickpea, forage grasses and legumes, maize, rice and wheat). This information will help PGR professionals to participate in a global crop conservation effort. An interactive approach with many partners and stakeholders was used to gather published and unpublished information about genebank management. Information on crop-specific best practices was initially collected from crop experts using pre-defined forms. In parallel, a web portal was developed using the open-source content management system (CMS) Joomla!. The CMS allows several editors to maintain pages and update them. Other participatory tools such as wiki pages, a blog, a discussion forum and online forms have been set up to gather future contributions, including information on other crops. The site provides a one-stop platform for information on conservation, characterization, regeneration and safety duplication of each of the nine crops. It also provides information on general (non-crop-specific) genebank management procedures, as well as a comprehensive bibliography of online publications, a glossary, links to relevant external websites, video and photo materials, and training modules. This paper discusses a process of collective action to develop a multi-institutional web platform, highlights important criteria for success, challenges and major lessons learned, and proposes options for the way forward.

RESUMÉ: La Base de connaissances sur les banques de gènes des cultures (CGKB) est une initiative du Programme mondial sur ressources génétiques (SGRP) du Groupe consultatif pour la recherche agricole internationale (CGIAR). Le CGKB a été créé pour partager les connaissances sur les meilleures pratiques pour la gestion des ressources phyto-génétiques (RPG) et prendre des décisions efficaces sur la gestion des banques de gènes. Les pratiques des banques de gènes des centres du CGIAR et des banques de gènes nationales ont été recueillies pour neuf cultures (banane, blé, légumineuses et graminées fourragères, maïs, manioc, orge, pois chiche et riz). Cette information aidera les professionnels des RPG à participer à un effort mondial de conservation des cultures. Une approche interactive avec de nombreux partenaires et parties prenantes a permis de recueillir l'information publiée et inédite sur la gestion des banques de gènes. L'information sur les meilleures pratiques concernant

chaque culture a été initialement collectée par des experts de ces cultures en utilisant des formulaires prédéfinis. Parallèlement, un portail Web a été développé avec le système de gestion de contenu open source (CMS) Joomla!. Le CMS permet aux éditeurs de maintenir des pages et les mettre à jour. D'autres outils participatifs tels que les pages wiki, un blog, un forum de discussion et des formulaires en ligne ont été mis en place pour recueillir les futures contributions, y compris des informations sur d'autres cultures. Le site propose une plate-forme unique pour accéder à l'information sur la conservation, la caractérisation, la régénération et la duplication sans risque de chacune des neuf cultures. Il fournit également des informations sur des procédures générales (non spécifique à la culture) de gestion des banques de gènes, ainsi qu'une bibliographie exhaustive des publications en ligne, un glossaire, des liens vers des sites web utiles, des vidéos et des photos ainsi que des modules de formation. Cet article traite d'un processus d'action collective pour développer une plate-forme web multi-institutionnelle, met en lumière des critères importants pour son succès, les défis et les principales leçons apprises et propose des options pour l'avenir.

RESUMEN: La Base de Conocimientos sobre Bancos de Genes de Cultivos (CGKB) es una iniciativa del Programa de Recursos Genéticos (SGRP) del Grupo Consultivo para la Investigación Agrícola Internacional (CGIAR). Se creó el CGKB para compartir conocimientos acerca de las mejores prácticas para manejar los recursos fitogenéticos (RFG), y tomar decisiones eficaces acerca del manejo de bancos de genes. Se recopiló las prácticas de los bancos de genes de los Centros del CGIAR y los bancos de genes nacionales para nueve cultivos (banano, cebada, yuca, garbanzo, gramíneas y leguminosas forrajeras, maíz, arroz y trigo). Esta información ayudará a profesionales en RFG a participar en una iniciativa global de conservación de cultivos. Se utilizó un enfoque interactivo con muchos socios e interesados directos para recopilar información publicada e inédita acerca del manejo de bancos de genes. Inicialmente se recopiló información sobre las mejores prácticas específicas a diferentes cultivos de expertos en los anteriores cultivos utilizando formatos predefinidos. De igual modo, se desarrolló un portal en la Web utilizando el sistema de manejo de contenido de fuente abierto (CMS) de Joomla!. El CMS permite a varios editores hacer mantenimiento de las páginas y actualizarlas. Se han instalado otras herramientas participativas como las páginas wiki, un blog, un foro de discusión y formatos en línea para recolectar contribuciones futuras, incluyendo información sobre otros cultivos. El sitio provee una plataforma integrada para información sobre conservación, caracterización, regeneración y duplicados de seguridad para cada uno de los nueve cultivos. También proporciona información sobre los procedimientos generales de manejo de bancos de genes (que no son específicos a un cultivo en particular), así como una bibliografía comprehensiva de publicaciones en línea, un glosario, enlaces a sitios

Web externos que son pertinentes, videos y material fotográfico, y módulos de capacitación. Este artículo trata un proceso de acción colectiva para desarrollar una plataforma Web multi-insti-

tucional, destaca criterios importantes para tener éxito, indica los principales retos y las lecciones aprendidas, y propone opciones para el camino por adelante.

Introduction

Crop genetic diversity is used as a major resource by plant breeders and farmers to meet food production challenges for the growing number of poor and hungry people in changing environments. Genebanks were first established over 50 years ago to conserve threatened crop diversity in local land races that were being displaced by new improved varieties and destruction of natural habitats. New technologies and better practices have been introduced for more effective and efficient conservation of plant genetic resources in genebanks; in parallel, information technology has advanced allowing more efficient documentation and sharing of information.

Genebank management guidelines for different crops are scanty and hard to find; most are generic (Engels and Visser, 2003; Reed et al., 2004; Rao et al., 2006) and scattered in the literature. Many procedures are inaccessible in the public domain because they only existed as institutional manuals or guidelines. Earlier approaches focused on identifying rigid standards that curators were expected to follow in all genebanks (FAO/IPGRI, 1994). A new approach was required to collate individual crop best practices for germplasm management. The objective of this project is to make those best practices accessible to collection holders, with the desired outcome of conserving the genetic integrity and viability of crop germplasm.

The use of searchable web-based tools to exchange information, experiences, approaches and best practices is replacing traditional indexed publications such as encyclopedias and dictionaries. The development of technical knowledge bases requires quality content, content management systems and web development to address issues of design and usability that meet the needs of the target audiences (December, 1996). Conventionally accepted principles of knowledge organization and representation for learning tools are being combined with integrated semantic tools to develop models in concept-based digital learning environments, such as searchable databases, browsers, search engines, wikis, blogs, ontology and visualization (Bergman, 2007), and software (Smith et al., 2004).

Knowledge bases have been developed in several thematic areas in recent years. Those related to agriculture and development include the Global Knowledge Center on Crop Biotechnology (<http://www.isaaa.org/kc/default.asp>), the Food Security and Agricultural Production Knowledge Forum (http://www.fao.org/corp/knowledge_forum/en/), the International Fund for Agricultural Development (IFAD) Rural Poverty Portal (<http://www.ruralpovertyportal.org/web/guest/home>), the Pro-poor Live-

stock Development Knowledge Base (http://www.coppld.net/cop_knowledge_base/), the World Bank Institute for poverty reduction and development (<http://wbi.worldbank.org/wbi/>), the Cereal Knowledge Bank on rice, maize and wheat (<http://www.knowledgebank.irri.org/>) and the Global Plant Clinic on diseases of tropical crops (http://www.globalplantclinic.org/Html/About_Us.htm). Despite the number of crop-related knowledge bases however, none focus specifically on crop genetic resources.

The Crop Genebank Knowledge Base (CGKB) was developed to fill this gap. It provides dynamic, up-to-date information on peer-reviewed best practices for germplasm management of a number of major crops and genebank procedures (registration to distribution), protocols, guidelines, manuals, publications, training materials and other aspects of genebank management to support more efficient and effective conservation. The website is a balance of technical and practical genebank knowledge channeled through information technologies that facilitate knowledge sharing. The website uses the most current, appropriate web tools, communication platforms and interactive multimedia. The primary objectives of the CGKB are to:

- Provide user-friendly online access to procedures, standards and practices for managing clonally propagated and seed crops held in genebanks;
- Compile and adapt best practices in a learning platform;
- Provide a mechanism to update and develop new best practices for the management of a range of crops— This platform will allow for improvement of best practices in the future as well as provide a baseline for monitoring change;
- Strengthen capacity of genebank curators and technicians to manage genebanks, including new staff;
- Ensure the quality of genetic resources distributed from genebanks; and
- Provide links to other related information and training resources;

Approach in developing the Crop Genebank Knowledge Base website

CGKB was an initiative of the Consultative Group on International Agriculture Research (CGIAR) System-wide Genetic Resources Programme (SGRP). It was developed as part of a three-year project on collective action for crop genetic resources, focusing on the nine crops conserved and managed in the genebanks of international agricultural research centres (IARCs).

Partnerships – A participatory approach involving

crop experts from IARCs and national genebanks worldwide was implemented to collate and develop crop-specific best practices and associated information concerning genebank management. This information was compiled by training and communication experts, project collaborators and selected users, who co-developed the best practices and undertook technical and editorial reviews.

Website structure – Four major themes (crops, procedures, management strategies and learning resources) were chosen as an organizing structure for the core content of the website. The names, content and layout for these menus were fine-tuned during website development and adjusted as necessary to incorporate useful and practical features observed in similar websites. Sub-menus were identified for each main menu, harmonizing general genebank procedures with those for seeds and clonally propagated crops.

The structure was designed to have a simple and logical flow of content, with no more than three clicks to reach any page (Web Transitions, 2003). Navigation options were established, linking related pages across the site. Relevant content was repeated, for example, links were provided to visual aids for specific procedures, tables, files or references, where appropriate, to facilitate access to and enrich information. From the beginning, the CGKB website structure and layout were developed with the involvement of genebank experts; design and navigation features were fine-tuned based on feedback from user questionnaires. The training component of the website was validated through its successful use in a genebank training course co-organized by Bioversity International and the Rural Development Administration in Suwon, Republic of Korea (7–18 September 2009).

Tools – The CGKB was developed using an open-source (General Public License) content management system (CMS), Joomla! (<http://www.joomla.org/>), which does not require expensive licenses and can be used by different contributors. CMS software keeps track of every file (text, photos, videos and documents) on a site, thus making the overall management easy to oversee. A major advantage of using a CMS is that it allows different editors in multiple locations to manage content.

A separate platform linked to the CGKB was built using the wiki software Wikispaces (<http://www.wikispaces.com/>) to provide a space where contributors can post, edit and discuss possible content for the CGKB. A discussion forum and online form for uploading best practices were provided to gather contributions. The CGKB was enriched with multimedia products to illustrate content such as images, flipbooks, video clips and a photo database (<http://www.flickr.com/photos/cropgenebank/collections/>) using Flickr (<http://www.flickr.com/>). Website traffic is monitored and recorded using Google analytics (<http://www.google.com/analytics/>). A blog was established using WordPress to facilitate informal communication among collaborators and users, and to pro-

vide current information about the project and related activities.

Content – Practical information on best practices for managing plant genetic resources (PGR) was primarily provided by experts from IARC genebanks and partners using pre-designed templates. Information was edited and uploaded into the website. Information gaps were captured by the editors from literature reviews and appropriate websites. Experts regularly reviewed material uploaded onto the web portal and provided feedback, thereby ensuring that the information was correct, precise and up to date. A peer review was also carried out at the end of the project by external genetic resources experts.

A list of references was compiled for each web page with hyperlinks to the full text where available in the public domain. Key contributors were listed for each webpage and a focal point was identified to keep each page regularly updated and to respond to queries. Copyright issues for the various types of information (text, links, visual aids, publications) displayed on the website follow the policies of each collaborating institution.

Results

Features of the CGKB – The Crop Genebank Knowledge Base is now publicly available at <http://cropgenebank.sgrp.cgiar.org> and results of this project are summarized below:

Home – The Home section (Figure 1) provides general information about the website, how it was created, how it is expected to be updated and its main features. It includes the copyright policies of collaborating institutes and an editor login. It also provides information about contributors and sources of information. This page incorporates interactive communication features such as a forum and a blog, inviting users to interact and collaborate, register comments, pose queries or upload their own best practices. Users can also find the latest news from RSS feeds on genebank management and related topics. Wikis provide users with work spaces to update existing practices or develop new ones in a collaborative way. These tools contribute to dynamic learning and help to create networks and strengthen links with other organizations and individuals; according to Horton et al. (2003), this is becoming increasingly important in managing modern organizations.

Crops – The Crop section is the heart of the website and is particularly important for genebank managers because it provides crop-specific information, references and options on recommended procedures. This section describes best practices for germplasm management in genebanks for specific crops. Information is currently available for banana, barley, cassava, chickpea, forage grasses and legumes, maize, rice and wheat, together with additional information on regeneration guidelines for other major crops—the output of a related

project sponsored by the Global Crop Diversity Trust (Figure 1).

Each crop section starts with a general introduction about the importance and origin of the crop, available types and utilization, and information on how the best practices were compiled. Users can then access the detailed pages about conservation, characterization, regeneration and safety duplication practices. These pages have a similar structure within crops, making it easy to find and add information for new crops. Small-format variations were needed for clonal and seed crops, related to the conservation methods used.

Procedures – This section provides the reader information about general (not crop-specific) genebank procedures in an interactive manner. All procedures from registration to distribution, which were mainly derived from the *Handbooks for Genebanks* published by Bioversity International (Rao et al., 2006; Reed et al., 2004; Engels and Visser, 2003) are described. Each menu presents a procedure and explains why, when and how it should be followed. The relative advantages and disadvantages of different kinds of genebanks (seed banks, field banks, *in vitro* banks, cryobanks, vegetative banks and DNA banks) are discussed under the conservation subsection. A compilation of genebank equipment, supplies and main suppliers is also provided. This section was specially designed to help newcomers to access information and learn about genebank management procedures. The procedures found here can also be used by lecturers as handouts for training workshops and courses on genebank management or *ex situ* conservation.

Management strategies – This section covers genebank best practices on management issues such as risk and quality management using the following menus: genetic identity, quality management, safety duplication strategies, safe movement of germplasm, policies, risk management, inventory system, decision-support tool and performance indicators. This section is particularly useful for those looking for user-friendly support tools related to cost decisions and risk assessment, or broader guidance on genebank management strategies.

Learning resources – The Learning resources space provides a comprehensive electronic library relevant to teaching and learning about genebanks. This section

FIGURE 1 – Home page of the Crop Genebank Knowledge Base showing menus and links

The screenshot shows the home page of the Crop Genebank Knowledge Base. At the top, there is a search bar and the site's logo, 'Crop Genebank Knowledge Base', with the tagline 'Strengthening capacity to manage genebanks'. A navigation menu includes 'Home', 'Crops', 'Procedures', 'Management strategies', and 'Learning resources'. On the left, there is a sidebar menu with options like 'About this site', 'Contributors', 'Copyright', 'Contacts', 'Comments', and 'Send us your practices'. The main content area features a featured article titled 'Improving the management of genebanks' with a photo of a person working with grain. Below this is a 'Main sections of this site' section with a 'Crops' link and a list of categories: CROPS, PROCEDURES, MANAGEMENT, and LEARNING RESOURCES. The footer contains logos for various international agricultural research centers and a copyright notice.

aims to build the capacity of genebank curators and technicians. Its content differs from other sections of the CGKB: it is primarily a repository of publications and other learning resources on genebanks. This section adds considerable value to the CGKB. For the first time, it gives teachers and learners access to a one-stop genebank management library comprising training modules, handbooks and manuals, most of which are available full-text in pdf or html formats. It also provides an extensive bibliography on genebanks and genetic resources cited throughout the CGKB website. The learning resources section provides access to a collection of audio/visual learning resources including videos and slide shows, workshop presentations, and a photo database that is built within a social networking medium (Flickr). Finally, the section includes an extensive glossary and acronym list, and a list of useful links to other websites with information about genebanks or genebank management.

Challenges in CGKB development – The process of developing the CGKB as a multi-partner, multi-crop,

multi-location and multi-disciplinary project was complex. There were many lessons learned that can benefit others.

Partnerships – The large number of collaborators from various disciplines provided a broad range of expertise and rich content. However, the interdependent steps and multiple feedback loops involved in writing, uploading and reviewing the content authored by many resulted in high transaction costs and delays in completing the project in the required time frame. Contributions varied greatly-contributors did not always follow the proposed template and the depth of information, details of references and visual aids varied widely across contributors. Face-to-face meetings, workshops, surveys, questionnaires and personal visits by the project coordinator were extremely helpful to create awareness about the CGKB project and prompt contributions, as well as to collect visual materials to support and enrich the content provided.

Virtual collaboration with remote partners and team members – Discussing the site design by email with people across the globe was difficult and complex. It took some time for the editing group to achieve a common language. Communication through Skype and telephone during critical discussions of structure and design was helpful. Face-to-face meetings with important collaborators also helped to resolve problems or make difficult decisions.

Tools and training – The editors had to learn to use the IT tools (Joomla!) to edit and change web pages. Training tutorials were developed to facilitate distance learning for current and future editors and collaborators. Editorial rights were maintained within a restricted group of the CGKB team. Most collaborators were unfamiliar with web tools such as wikis, blogs or Google shared documents, and these were not used as extensively and effectively as anticipated. Wikispaces were used for a few activities to generate discussion on best practices; however they did not contribute to the majority of information gathered and were only effective with one group of contributors who had a specific, time-bound objective. In the near future, a facilitated wiki-space discussion will be organized to update best practices on plant exploration and collecting procedures that were originally published 15 years ago.

Content – Word Templates were initially prepared to collect information from contributors in a structured manner, similar to the website layout. These were useful but needed adjustment when information was uploaded. It was also challenging to convert text-based information into a meaningful and logical digital structure for access on the Internet. Reviewing the uniformity and layout of each web page was extremely time consuming and difficult until all pages were finalized.

Future opportunities – One major challenge for the CGKB was to develop a product that remains up to date, flexible and useful over time, particularly as regular up-

dating is critical to provide reliable knowledge on best practices and risk-management procedures. The CGKB was developed by a community of practice that should remain active for many years to come. Mechanisms to fund minimal maintenance of the site were established with SGRP, assuring the basic support and updating in the future. The system of assigning focal points for each best practice page should also guarantee that content is updated in the future. This website provides a platform to include new crops or translations into other languages, and information on new and emerging technologies.

This platform is already being used as a training tool for genebanks, such as in courses targeting genebank curators co-organized by Bioversity and the International Center for Agricultural Research in the Dry Areas (ICARDA) in Amman, Qatar and Aleppo in early 2010. Whether used for self-learning or formal training, the features found on the CGKB will contribute to narrowing knowledge gaps, help to create communities of genebank practitioners and strengthen their capacity to be effective custodians of the world's crop diversity for food and agriculture in the future.

Conclusions

This paper describes the process of developing a one-stop platform for best practices on crop genebank management and procedures. Synergies were created by many experts who gathered and transformed scattered information into knowledge that will improve the efficiency of conserving seeds and vegetative plant materials, making them available for future generations.

The CGKB is now a valuable interactive platform that can be used and expanded in new directions. Current crops and genebank information will be regularly updated. The crop focal points and their networks now have the responsibility of updating the knowledge and encouraging peers to provide feedback and new content to continue to expand and improve this tool. Channels of communication and collaboration have been established and will be easy to use in the future. This is an open invitation for the global genebank community to participate and provide feedback and new information on genebank issues and best practices for other crops.

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