



millennium
seed bank
project
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Technology Transfer & Co-operation

under the Convention on Biological Diversity:
The Millennium Seed Bank Project Experience



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& Co-operation under
the Convention on Biological
Diversity: The Millennium Seed
Bank Project Experience

Executive Summary

Seed banking is an international co-operation to meet the objectives of the Convention on Biological Diversity, the conservation and sustainable use of biodiversity and the fair and equitable sharing of benefits arising from the use of genetic resources. Seed banking involves an insurance against the loss of plant species and populations in the wild. The Paris Agreement, a cornerstone of the international biodiversity regime, provides a framework for the identification and management of biodiversity hotspots and the recovery of threatened species. Farms and seed banks are closely associated to the safety of the material which enables the fair and equitable sharing of benefits.

While people have used seeds from one season to the next for millennia, the systematic collection and long-term preservation of seeds from wild species is a specialised technology which has only emerged in the last 40 years and is practised by relatively few institutions. It consists mostly of an understanding of the scientific processes at work, and knowledge of the techniques and procedures that have been developed based on this understanding.

The Royal Botanic Gardens, Kew (RBG Kew) have operated a seed bank for over 40 years. In 1997 it started work on the Millennium Seed Bank Project (MSBP). The MSBP is a global Project which runs from 2001 to 2010, and is a partnership between RBG Kew and 100 other institutions, principally from Africa and South America. The MSBP is a partnership of scientists, technologists and policy-makers, and by involving scientists from both the developed and developing world, international co-operation and by involving scientists from both the developed and developing world.

To date the MSBP has been successful in securing the seeds of over 1000 species of plants. The MSBP aims to use technological and training to increase the capacity for ex-situ conservation in these countries and to provide training and capacity building on a legally binding Access and Benefit-Sharing Agreement framework of technology transfer and technological co-operation, including education and training, joint research and co-operation, as stated as benefits to be shared.

The MSBP offers a wide range of training and research opportunities to its partners in order to mobilise and enhance their skills and knowledge. Activities are also undertaken to develop their technological infrastructure. Much time is spent on the provision of information and advice on suitable equipment and procedures. Applied research is directed towards improving seed conservation in partner countries - for example by investigating low-tech options for seed banking. The Project also facilitates access to data and information to aid collecting, conservation and research.

Only three years into the Project some impacts of the technology transfer activities can be seen. Already over 2,800 plant species have been conserved at the MSB. Partners say the experiences offered by the MSBP have improved their confidence in the procedures they employ and their understanding of the underlying principles. Some partners have begun their own studies into improving the technology to meet local needs, and others have used their MSBP training to develop their own training materials and courses.

A number of lessons have been learnt, including the importance of matching training given to training needs, and the value of taking time in the project development stage to build trust and commitment to the project. The Kenyan 'Seeds for Life Project' is used to illustrate the breadth of technology transfer and co-operation activities carried out under the MSBP.

Wild Seed Banking Technology

The 'technology' of seedbanking has been developed over thousands of years. It does not belong to anyone and it is not possible to buy a seed bank on the open market. Yet seed banking is an important technology to meet all three objectives of the Convention on Biological Diversity: The conservation and sustainable use of biodiversity and the fair and equitable sharing of benefits arising from the use of genetic resources.

People have been saving seed from one season to the next for millennia, but systematic collections of crop seeds were first established in the 1920s. The collecting and long-term conservation of seeds from wild species is a newer and specialised technology, which has emerged only in the last 40 years and is practised by relatively few institutes. Compared to crop species, wild seed banking has to take account of wide variations between species with respect to, for instance, fruit and seed morphology, seed longevity, response to desiccation and seed dormancy.

The technology consists mostly of an understanding of the scientific processes at work, and knowledge of the techniques and procedures that have been developed based on this understanding. Such 'soft' technology includes:

- Understanding the relationship between seed maturity and storability, to time collection, and use appropriate collecting techniques, to ensure high quality seed collections
- Understanding how genetic diversity is distributed in populations of wild plants, to select appropriate sampling strategies to ensure that the seed collection includes the maximum genetic diversity
- Understanding of seed moisture relations and how to achieve the right seed moisture content for long-term storage
- Knowledge of seed morphology and how to clean the seeds without harming them
- Understanding seed storage behaviour so that ideal storage conditions can be selected
- Understanding both general germination requirements and the specific ecological characteristics of different species, in order to use appropriate techniques to break the dormancy of seeds

Seed banks also use 'hard' technology but most of this has been developed for wider uses and identified and adapted for use in seed banks. For example, the moisture content of seeds has traditionally been analysed using oven-drying experiments. This is both slow and destructive. To overcome these problems, the Millennium Seed Bank Project has recently adopted as an alternative the non-destructive measurement of equilibrium relative humidity using hygrometers. This is possible because measurement of relative humidity of the atmosphere above seed samples at equilibrium can be directly related to seed moisture content by reference to isotherms.

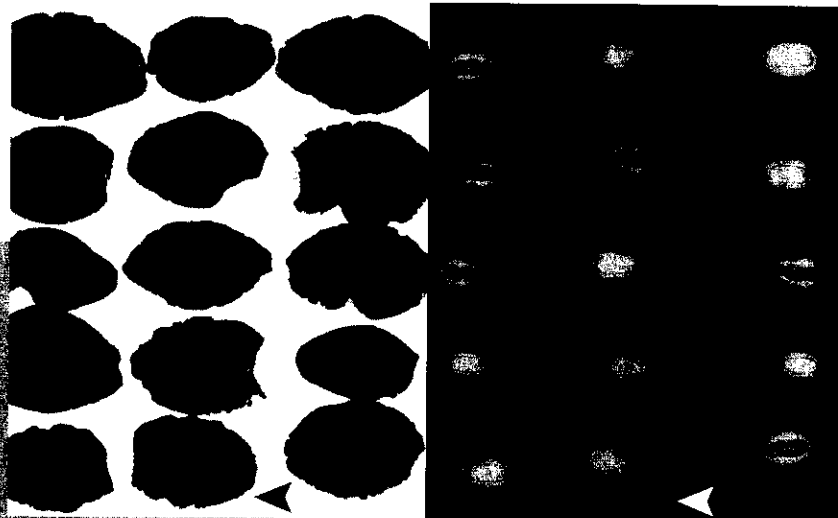
The 'hard' technologies include:

- Databases and Geographical Information Systems to manage data on species to be collected and to track the collections
- Drying facilities to reduce the moisture content of seeds prior to storage. These may be purpose-built walk-in facilities, or smaller cooled incubator dryers provide a smaller, cheaper alternative
- Aspirators to separate the mature seeds from empty, poorly developed seeds and surrounding plant material
- X-ray machines to assess the proportion of empty or damaged seeds in a collection
- Hygrometers for non-destructive measurement of seed water status
- Hermetically sealed containers to store the seed
- Cold rooms to store the collections. These can be purpose-built, walk-in facilities or simple commercial freezers
- Cooled and illuminated incubators for germination testing

Such technologies must be bought in and adapted to meet identified needs. Many of the technologies listed above are not available in developing countries. However, not all of them are necessary in order to assemble a successful wild seed bank. Some of the technologies listed can be replaced with locally available and/or traditional technologies. For example, aspirators can often be replaced by traditional winnowing technologies. These issues underline the importance of knowledge and understanding of the processes at work and local circumstances in order to understand and meet local seed bank facility needs.

Finally, a fully functioning seed bank makes use of a range of supporting technologies. These include; herbarium techniques, ecological knowledge to predict species behaviours, databases to track the collections, and horticultural technologies to ensure the seeds can be grown for living *ex situ* collections, restoration projects and (re)introduction schemes.

X-ray images can be used to assess seed quality.

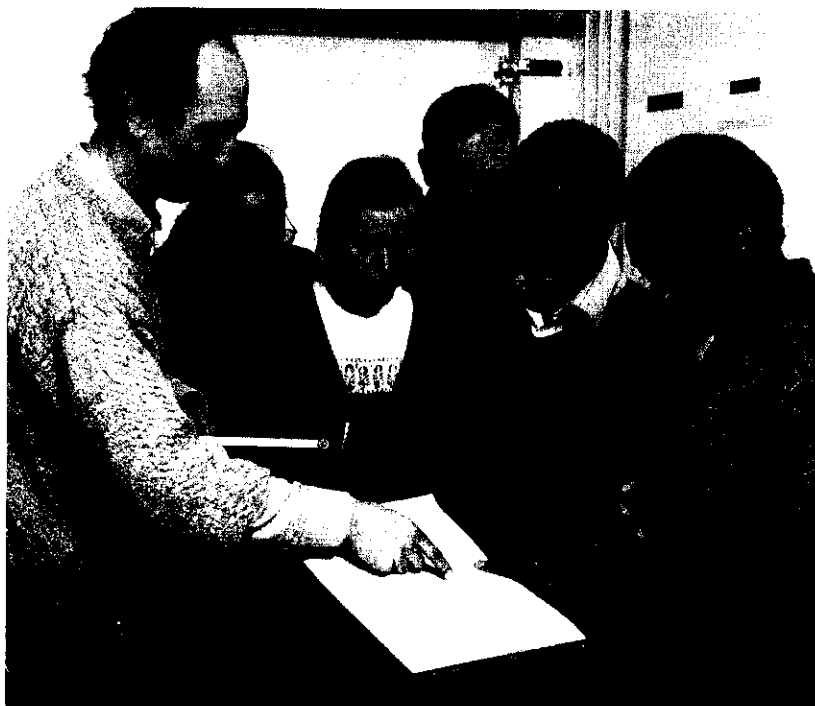


Hand cleaning of seeds in Burkina Faso.

Applications & Opportunities

Seed banking technology can be applied widely to the *ex situ* conservation of wild plants. Of the 9000 plant species whose storage characteristics are known, over 90% are thought to have desiccation tolerant seeds, and are expected to remain viable in storage for at least 200 yearsⁱ.

Banking the seed of wild plant species provides an important complementary tool to *in situ* conservation. Seed banking provides an insurance against the loss of plant species and populations in the wild. This is important given the many threats that face plants in the wild, even in protected areas (including habitat loss, invasive alien species and climate change). Seed banking has considerable advantages over other methods of *ex situ* conservation, including ease of storage, economy of space, relatively low labour demands, and consequently the capacity to maintain large samples, with wide genetic representation, at an economically viable cost.



Explaining the principles of seed drying.

Seed banks provide a controlled source of material, of high quality and genetic diversity, for research and for the rehabilitation and restoration of degraded ecosystems and the recovery of threatened species. Terms and conditions can be attached to the supply of this material which ensure the fair and equitable sharing of the benefits of its use.

In addition, seed banks generate a range of valuable data and research findings which support wider plant conservation aims. For example, germination and propagation protocols developed for species in seed banks are vital to the success of recovery and restoration programmes.

Like zoos, seed banks can help raise public awareness about the value of plants and the threats they face. For example, over 330 000 visitors a year visit Wakehurst Place, home of the Millennium Seed Bank in the UK. This seed bank building includes a public gallery with education facilities covering plant conservation and seed banking.

Wild seed banking technology is relatively under-utilised meaning many opportunities exist for its application. The 1996 FAO Report on the State of the World's Plant Genetic Resourcesⁱⁱ stated that only 15% of *ex situ* collections world-wide were of wild or weedy species or crop relatives. Most wild species collections are held by botanic gardens. In a BGCI survey of botanic gardens, 152 gardens reported having a seed bankⁱⁱⁱ. However, only 20% of these aimed at long term storage and most did not have a drying room, undertake moisture content testing or store seeds below -15°C . Not all had computer databases and only about half carried out germination testing. The report concludes that most gardens do not dry the seeds adequately to achieve long term conservation and few keep them in hermetically sealed containers. Most of the seed banks are found in warm temperate climates.

The Millennium Seed Bank Project

The Royal Botanic Gardens, Kew (RBG Kew) have operated a wild species seed bank for over 30 years. Over this time staff in the Seed Conservation Department have increased understanding of the processes at work, and refined the equipment and procedures to further extend the longevity of the banked seeds. In the last decade alone the Seed Conservation Department have published 181 papers on many aspects of seed biology, seed collecting and conservation.

In 1997 the Millennium Seed Bank Project (MSBP) was established. It was facilitated by funding from the UK lottery agency, the Millennium Commission. Phase I, the UK Programme, comprised building the new seed storage, processing and research facilities of the Wellcome Trust Millennium Building that houses the MSB, and collecting and conserving the UK flora.

The International Programme, which runs from 2001 to 2010, aims to collect, research and conserve seeds from 24,200 species, principally from arid and semi-arid regions of the world. This is to be achieved through international collaboration, and by facilitating access to and transfer of technology.

To date the MSBP has developed partnership projects with organisations in sixteen different countries, see right. The partnership projects vary from country to country. Some include only one partner institute, while others include up to five partner institutes. Almost all partners are public sector agricultural, forestry or botanical institutes, although connections have also been made with the private sector and non-governmental organisations. In terms of total number of species to be collected, the projects range from less than 100 to over 4000.

The specific objectives of the partnership projects vary depending on national and institutional priorities. Several partners are prioritising the conservation of threatened plants, while others are focused on conservation of species for restoration of damaged habitats. Some partners are looking at working with local communities on the conservation and sustainable utilisation of indigenous species and several are focused on developing quality research capacity within their institutes. However all partners are collecting and conserving seed from wild plant species, together with associated field data and herbarium vouchers, and sending duplicate material for safe storage at the MSB.

Department of Conservation
& Land Management
The Botanic Gardens and Parks Authority
Botanic Gardens of Adelaide
National Plant Genetic Resources Centre
National Herbarium and Botanical Garden
Veld Products Research and Development
Centre National de Semences Forestières
Instituto de Investigaciones Agropecuarias
Desert Research Center
National Center for Agricultural Research
& Technology Transfer
National Museums of Kenya
Kenya Agricultural Research Institute
Kenya Forestry Research Institute
Forestry Department
Kenya Wildlife Service
Lebanese Agricultural Research Institute
Silo National des Graines Forestières
Forestry Research Institute of Malawi
National Plant Genetic Resource Centre
National Herbarium and Botanical Gardens
National Research Council of Malawi
L'Institut d'Économie Rurale
National Autonomous University of Mexico
National Plant Genetic Resources Centre
National Commission for Wildlife
Conservation & Development
National Botanical Institute
Bureau for Land Management
Chicago Botanic Garden
Lady Bird Johnson Wildflower Center

Approach to Technology Transfer & Access and Benefit Sharing



The facilities of the Wellcome Trust Millennium Building are used for formal and informal training. Here Kenyan partners on a technical training attachment are demonstrating seed processing to MSc students from the University of Birmingham.

Some earlier projects to transfer seed banking technology have taken the 'turn key' approach. This involves the construction, demonstrated operation, and commissioning or handover of a facility by technical experts from the supplying country to the recipient country^{iv}. This is not the approach taken by the MSBP. Rather it aims to use technological and scientific co-operation to help establish and strengthen capacity for *ex situ* conservation. Combining partners knowledge and understanding of their native plants with the seed banking technologies developed by RBG Kew is the essence of the MSBP. Technology is transferred from RBG Kew to its partners, between the partners (both inter and intra nationally) and from partners to RBG Kew. In addition to the formal project partners, the MSBP has developed a wide range of additional international collaborators.

In this context we recognise the definition of technology transfer used by the Inter-governmental Panel on Climate Change^v which refers to 'a broad set of processes covering the flows of know-how, experience and equipment...it comprises the process of learning to understand, utilise and replicate the technology, including the capacity to choose and adapt to local conditions and integrate it with indigenous technologies'.

The Project partnerships recognise states' sovereign rights over their own biological resources. Each MSBP partnership is based on a legally binding Access and Benefit Sharing Agreement (ABSA). This is the means by which RBG Kew and the partner(s) set out the mutually agreed terms under which RBG Kew and the partner will access, use and transfer the material and will share fairly and equitably all resulting benefits. Each ABSA is unique in order to reflect national and institutional circumstances but they all include a clause which states that the partners will work together to share, fairly and equitably any benefits that arise from the collection, study and conservation of the material. Elements of technology transfer and technological co-operation, including education and training, joint research, and publications are stated as benefits to be shared. The ABSAs do not allow any commercialisation of the material by RBG Kew.

The MSBP was designed from the start to facilitate technology transfer. This included the creation of a full-time Training Manager post to co-ordinate all training activities. Many MSBP staff have participated in Train the Trainer courses to improve their delivery of both formal and informal training. The Wellcome Trust Millennium Building includes 14 study bedrooms, and a visitor kitchen and lounge so it can easily host visitors on research and training attachments and courses. Visitors also have access to library and IT facilities.

Implementation

Mobilising and enhancing skills and knowledge

Given the importance of scientific and technical understanding to seed banking technology, training and research opportunities form a large part of the MSBP technology transfer activities. The range of opportunities offered is outlined below.

Between January 2000 and June 2003, 35 partners and 32 other international visitors have participated in training at the Wellcome Trust Millennium Building. Many more have benefited from in-country training activities: 73 people have taken part in formal country training courses delivered by RBG Kew and partner staff, 11 have followed diploma courses, and more than 80 others have received seed collecting training under the auspices of the project.

The subjects of training and research activities cover a broad range of subjects. This is illustrated on page 15 which outlines technology transfer activities associated with one of our projects, Kenyan 'Seeds for Life'.

MSBP Training & Research Opportunities

- **In-country training courses** delivered by RBG Kew staff, and key resource persons in partner countries, provide practical-based seed conservation training for MSBP partners and other invited participants.
- **In-country workshops** provide a less structured means to exchange information on key areas relevant to the project. They can address technical issues, such as collecting techniques or other associated needs, such as the development of ABSAs.
- **Joint collecting expeditions** allow RBG Kew staff to pass on their collecting skills, whilst learning from partners about local geography, ecology, flora and collecting techniques.
- A 2-week **residential course** in Seed Conservation techniques is run every other year at the Wellcome Trust Millennium Building, which houses the MSB. This provides theoretical and practical training in seed collection, conservation and management. It is also an opportunity for partners from different countries to share experiences and reflect on best practice. MSBP partners can also participate in RBG Kew's IUCN-endorsed eight-week course in Plant Conservation Techniques or its other International Diploma courses.
- Scientists from partner institutions undertake **short-term placements** working alongside staff at the Wellcome Trust Millennium Building, usually on material from their own country. This mainly focuses on the seed processing, seed viability testing and data management areas. In July 2001 the Seed Conservation Department organised a 'theory to practice' **workshop** with all partners represented and a range of other invited participants. This was an opportunity to share experience and knowledge across a range of topics relevant to the project.
- Opportunities for higher level **academic study** may be offered to graduate scientists expected to play or already playing a significant role in the MSB partnerships. Registrations usually sought with in-country universities, although supervision is often provided by RBG Kew scientists and a **research attachment** at the Wellcome Trust Millennium Building often forms part of the programme.
- **Collaborative research** is undertaken not only with partner institutes but a whole range of scientific collaborators world-wide and visiting researchers spend time at the laboratory facilities at the Wellcome Trust Millennium Building. RBG staff assist visiting scientists in finding and understanding relevant literature, in developing research priorities and experimental designs, in recording and assessing research results, and in preparing publications.

Developing the technological infrastructure

All partners had some kind of seed collecting and/or banking facilities in place at the start of the Project although their capacities and remits were highly variable. Many were focused on agricultural or forestry needs. The aim is not to provide all partners with the extensive facilities found at the Wellcome Trust Millennium Building. Rather to make these available to partners, and to ensure the development of their own facilities, so that they can collect and store seed to an appropriate standard for long-term conservation and to meet their own national and institutional goals.

A technology assessment is carried out during the project development stage to consider what, if any, equipment or infrastructure improvements need to be included in the project plan and budget. This has varied from the provision of small pieces of equipment such as hygrometers to the installation of drying facilities where this is deemed necessary to meet the project objectives.

An important part of this activity is the provision of information and advice, often informally, on suitable equipment and procedures. This may be as simple as advising on the types of bags used to store seed during field trips, or the best containers to store seed in the bank, but has also covered seed bank design. Between January 2000 and June 2003 28 partner staff have benefited from in-country technical support. Focusing on partners own facilities and equipment, and adapted to local conditions, this type of training is particularly valuable.

Much of the applied research carried out by the Seed Conservation Department is directed towards improving seed conservation in partner countries. For example, staff have recently developed low-cost drying solutions for small-scale seed conservation. These are based on the discovery that cooled incubators, at certain temperatures provide a suitably constant, low relative humidity. The cooled incubators are smaller and cheaper than conventional dry rooms, and when not in use for drying the temperature and lights can be adjusted for use in germination testing.

Facilitating access to species data and information

Seed banks generate and use a large amount of data on the species they seek to store. This is generally sparse and/or disparate for the wild species that are the focus of the MSBP and overcoming this obstacle is a substantial part of the technology transfer activities.

With regard to collecting, the MSBP is pulling together information on target species for collecting, including species locations, characteristics and threat ratings. Much information is available to partners in-country, and this can be supplemented by the information available from RBG Kew's Herbarium. RBG Kew's GIS Unit is working with several partners to develop useful tools from this data.

RBG Kew shares with the MSBP partners all data related to the collections it banks. Of particular importance is the provision of germination test data. This allows the partners to know under what conditions the seeds are most successfully germinated. In some cases, usually for highly threatened species, RBG Kew is also developing propagation protocols, which will allow the partner to use the collections to bolster living *ex situ* collections, or for research and conservation projects. Similarly partners provide RBG Kew with information which they acquire on the species conserved under the Project.

The MSBP's Seed Information Database (SID) is being developed to collate most of the available information on seed characteristics, and provide it via the internet. This includes data on seed storage behaviours, germination protocols, as well as seed weight, oil content, dispersal mechanisms and morphology. This allows a wide audience to study trends across the wide range of species conserved.

Evaluation of Progress

MSBP scientists have investigated the optimum storage containers for their collections.

All MSBP partners are now independently collecting seed from wild plant species. Most are conserving these seeds in their own country's facilities, although some partners prefer to store their collections in trust at the MSB while their own seed banks are developed. In all cases these activities are a significant extension of the institutes' previous work.

This has already resulted in the banking of over 2,800 species at the MSB (January 2000 to March 2003). Furthermore, partners say that the experiences offered by the MSBP have improved their confidence in the procedures that they employ and their understanding of the underlying principles. For some partners, participation in the Project has led to increased support for their work, both within their own organisation and at a national level.

However, a more true measure of the success of technology transfer activities than the quantity of material, is the quality of the seed, herbarium vouchers and data sheets arriving at the Wellcome Trust Millennium Building. This is difficult to measure quantitatively.

It is generally acknowledged^{VI} that technology cannot be considered transferred until the transferee understands and can utilise the technology. A test is the ability of the transferee to choose and adapt the technology to local circumstances, and to improve the original technology. Some MSBP partners are already starting to demonstrate such understanding of the technology. For example RBG Kew staff have spent a great deal of effort investigating the optimum storage containers for their collections^{VI}. These studies led to the selection of 5 different glass containers for use in the MSB. Kenyan partners have now also carried out studies to identify optimum containers from those that are locally available and suitable for the large seeds that they plan to collect. These studies point to the preferred use of foil containers in Kenya.

Another important indicator of success is that several partners have used their MSBP training to develop their own training materials and courses, to further develop and transfer the technology within their countries. For example, with RBG Kew, partners in Chile have developed a seed collecting manual, which will be of use not just in Chile but across Latin America. Following research and training attachments at the Wellcome Trust Millennium Building, an Australian scientist from the Western Australia Department for Conservation and Land Management ran a seed conservation course for 10 scientists from across Australia.



Partners at Kings Park and Botanic Garden in Perth, Western Australia have gone one stage further. They have used seed banking knowledge gained from MSBP training to improve the effectiveness of both their own habitat restoration programme, and a mine restoration project in Tanzania. As a result the Tanzanian mine now has a seed store, herbarium and basic drying facilities, and the staff have a good understanding of how to collect, store and use their indigenous species. In this way technology transfer has extended beyond the MSBP partner countries. It is hoped that such flows of impacts of the MSBP will multiply as the Project matures.

Collaborative research is also already building research capacity in other countries and in some cases resulting in new knowledge and the further development of wild seed banking technology. For example, Wen Bin from Xishuangbanna Tropical Botanic Garden in China recently completed a year-long stay at the Wellcome Trust Millennium Building, studying potential cryopreservation of palm seed embryos, based on research previously carried out by RBG Kew scientists. This research has enhanced our understanding of seed conservation methods for this important, but hard to store, group of plants. In addition, Wen Bin has developed a range of technical skills that were not previously found within his organisation.

RBG Kew has benefited from work carried out by Fred Vegarra from UNAM in Mexico. Fred came to the Seed Conservation Department with strong biochemistry skills and experience in Diffuse Reflectance Near Infrared Spectroscopy (DIR/NIRS). An introduction to seed biology and seed ageing experimental methods by RBG Kew scientists enabled him to develop a new technique for testing seed viability based on this non-destructive technique.

Lessons Learnt

Project Development

At this relatively early stage in the Project, most effort has been spent in developing the project partnerships. It has taken approximately two years to negotiate each formal project document and legally-binding ABSA. This has been a technology transfer activity in itself, as understanding and use of the Access and Benefit Sharing systems and tools has been developed and transferred.

The long project development phases have proved important for the subsequent success of the country partnerships. We have learnt that this phase is vital to build trust and a strong commitment to the project, and mutual understanding of what is to be achieved, both with partner institutions and with governments.

The importance of developing trust and commitment to the project is supported by our finding that those partners that have regarded the Project as essentially a flow of resources and training from RBG Kew to their organisation have gained less than those that have fully embraced its scientific and conservation potential. This depends on the support from senior management to integrate the Project with their core activities. It is probably no co-incidence that this has happened to the largest extent with those partners with whom RBG Kew has a long tradition of working. For example, the National Botanical Institute (NBI) in South Africa has recently agreed a draft Ex Situ Conservation Strategy which includes an objective to have 50% of South Africa's threatened plants represented in their National Botanic Gardens and/or the MSB by 2010. NBI has started to target species for seed banking to meet this objective. NBI and RBG Kew have historically had good links, and this was one of the first MSBP collaborations to get underway with activities starting in 1998.

Obviously the extent to which the Project has been welcomed at a national level, depends on the national priority given to biodiversity issues, and the confidence of national institutions of their roles in conserving biodiversity. In many cases the national priorities and technology needs for biodiversity conservation have not been assessed. In such cases it has been important for staff from RBG Kew and the partner organisation to contact and influence relevant government representatives.

Given the challenging targets facing the Project, it is important that partnerships reflect institutional capacity and tackle any constraints. The approach has generally been to ensure each partnership project is managed by an in-country co-ordinator, with the skills and means to carry out this role. This has included the provision of IT hardware and software, internet access, and vehicles.

Regular review is an important function. The national co-ordinators work with RBG Kew's UK-based International Co-ordinators to regularly monitor progress against the mutually agreed targets in the project document.



Training

One challenge for successful technology transfer has been the difficulty in ensuring that the right people receive the right training to meet the stated partnership projects' objectives.

For this reason, a training needs assessment at an early stage of the project development process has proved very useful. Rather than agreeing numbers of places on courses, and attachments, and then finding people to fit the places, it is better to identify general training needs at the beginning, and more specific needs as the project progresses, and then find ways to meet these needs. Sometimes this is a difficult process, particularly where the understandable desire of individuals and their institutes to gain formal qualifications has to be balanced against project needs which are often better met by informal training.

We have discovered that it is vital for us to clearly agree, disseminate, and stick to the objectives of, and criteria for participation in, individual courses. We have had problems where this has not been done with participants attending courses which are either too basic or too difficult for them, resulting in little direct benefit to either the project, the partner institute, or the individual. This has also proved true for technical attachments at the Wellcome Trust Millennium Building, particularly where they are taken up by partner staff that do not actually carry out routine processing work. For example, the quality of partners' seed cleaning has not always improved, even where training has been given at the Wellcome Trust Millennium Building, if staff receiving the training do not share this with those responsible for this work when they return. Similar problems have been discovered in relation to research attachments involving senior staff, who get bogged down in management responsibilities on their return and are so not able to realise the full potential of their training.

One answer has been to be creative in the delivery of training, both at the Wellcome Trust Millennium Building and in-country. Standard training materials (lesson plans and background papers) are developed and adapted for each training course, to meet the needs of different audiences and skills levels.

Training has been successful where it is highly targeted. For example in Mexico, RBG Kew staff gave partners on-site, informal training in seed drying and processing techniques. This training was held back until all the agreed drying and processing equipment was installed and operational in the partner's seed bank, and until partner training needs had been assessed, discussed and refined. In this case the new facilities are now an integral part of the seed processing operation and are being used to full advantage.

In other cases broad, shallow training workshops have been useful, in particular to introduce concepts and basic skills to a wide range of students from a number of collaborating institutes. However, it was found following a course in Mexico in 2000 that the immediate impact in terms of knowledge and skills put into practice and developed was small, as few of the participants remained closely associated with the project after the course. A number of lessons were learnt in time for a workshop in Chile in 2002. This seed collecting workshop was followed by joint collecting missions, which reinforced skills gained on the course. A range of participants from different backgrounds (foresters, seed scientists, ecologists and agronomists) took part in the course, and many have stayed in contact and interested in the project, which has led to cross fertilisation of ideas which is both stimulating and productive.

Given that it is always preferable to learn from one's peers, the Chile workshop invited local academics and lecturers to contribute. This worked well, but the downside was that the lectures tended to be more academic than usual for MSBP courses.

Collections of crop species and their wild relatives have been held at the National Genebank of Kenya since its establishment in 1983. Facilities include a dry room and -20°C cold chambers. Rare, endemic and threatened species were collected and stored at the National Museums of Kenya in a single deep freezer. A programme for collecting and short term storage of forestry seed was well established, but there were no facilities for their long term storage. A key objective of the Project is to strengthen this national capacity. As well as strengthening the national institutions, the medium to long term objective is to ensure that this capacity is passed on to local communities, in particular to support on-farm utilisation of indigenous species.

As with all MSBP partnerships, the bulk of the technology transfer has been through training programmes and research and technology collaborations. These are described briefly below.

Three Kenyans have undertaken technical training attachments at the Wellcome Trust Millennium Building. These have covered all aspects of seed processing and banking. The training has facilitated the entry of these technicians onto the diploma course at Maseno University in Kenya. In addition RBG Kew staff regularly visit Kenya. In 2001 RBG Kew scientists demonstrated the use of Rotronic equipment for taking relative humidity measurements. In 2002 RBG Kew curation staff participated in a joint collecting mission, and worked with the Kenyan partners to process these collections. The latter allowed RBG Kew staff to learn how to process and handle more effectively Kenyan collections duplicated at the MSB.

Six in-country workshops have been run, on subjects including seed collecting, data and documentation, species prioritisation, project development and the science programme. These have been led by Kenyan experts, sometimes following research or training attachments at the Wellcome Trust Millennium Building.

A number of technical staff have undertaken formal studies in Kenya: 11 undergraduate diplomas (including 8 on the Maseno course mentioned below), 1 MSc and 1 PhD have been supported by the SfLP.

Three Kenyans participated in the RBG Kew Plant Conservation Techniques Diploma in 2001. This course includes a project assignment. One Kenyan developed a community-based element to the SfLP - work furthered during a visit by a RBG Kew staff member with expertise in this area. Another developed a standard operating procedure for X-ray examination of seed at KEFRI and the third started work on the SfL species prioritisation list.

With regards to research collaboration, four Kenyans have undertaken research attachments at the Wellcome Trust Millennium Building. Research topics have included studies on the germination and storage for both Kenyan orchid seeds and African tree seeds, and data management issues. The latter led to an in-country workshop on the harmonisation of passport data gathering and recording. Participants in research attachments at the Wellcome Trust Millennium Building have gone on to assist other Kenyan scientists in the development and delivery of an undergraduate diploma course in seed conservation techniques at Maseno University. Collaborative research with these personnel, and their colleagues, is on-going. One current area of collaboration involves studies on the suitability of locally available storage containers.

Finally, working together under the Seeds for Life Project has allowed the five partners to develop a harmonised 'best practise protocol' for collection and handling of plant genetic resources for long-term storage.

References

- i Seed banks: *Ex Situ* is Not Out of Place, Simon H Linington, Clare Tenner and Roger D Smith, *The Biologist* (2003 in press)
- ii Food and Agriculture Organisation of the United Nations (1996) *Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture*, FAO, Rome
- iii Laliberte B (1997) *Botanic Garden Seed Banks / Genebanks Worldwide: Their Facilities, Connections and Network*, *Botanic Gardens Conservation News* 2(9)
- iv Promoting and Facilitating Access to, and Transfer and Development of Technology Note by Executive Secretary (UNEP/CBD/COP/3/21). 15 September 1996
- v The Intergovernmental Panel for Climate Change (2000) *Summary for Policy Makers Methodological and Technological Issues in Technology Transfer*, A Special Report of IPCC Working Group II
- vi Keith R. Manger, John Adams and Robin J Probert (2003) *Selecting seed containers for the Millennium Seed Bank Project: A Technical Review and Survey*, In *Seed Conservation: Turning Science into Practice*, Smith RD, Dickie JB, Linington SH, Pritchard HW, Probert RJ (eds), Royal Botanic Gardens RBG Kew, UK (2003 in press)
- vii The Intergovernmental Panel for Climate Change (2000) *Summary for Policy Makers Methodological and Technological Issues in Technology Transfer*, A Special Report of IPCC Working Group II



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