The Millennium Seed Bank Partnership and low-tech seed conservation techniques

Kate HARDWICK, Conservation Partnership Coordinator (Asia)
The Royal Botanic Gardens Kew and the Millennium Seed Bank
Kew’s collections

- Over 7 million herbarium specimens, including 95% of vascular plant genera
- Over 19,000 plant species in the living collections at Kew and Wakehurst
- Over 2 billion seeds and c. 37,600 species of living seed in the Millennium Seed Bank
- DNA & tissue collections (35,000 species) Plus: Fungarium, microscope slides, economic botany
Kew’s collections

Biobank: “A large collection of biological samples for interest/research purposes. To be utilized for future needs”.

Dr Marzalina
The Millennium Seed Bank Partnership

Global Seed vault (Svalbard)
Crop species only (29 priority gene pools)
Back-up collections only (black box)
Un-manned
Built by the Norwegian Government

Kew’s Millennium Seed Bank (UK)
Wild plant species not crop cultivars
(>99% of plant diversity)
Active research and regular monitoring of viability of seeds
Built by the Lottery players of the UK!
The Millennium Seed Bank Partnership:

- Aims to combat potentially catastrophic threats to human wellbeing by **safeguarding wild plant diversity** in long term storage (100s years)
- Seeds supplied for research and use
- Protects species from extinction
- A global seed conservation network
- Provides ‘back up’ seed storage for collections held by MSB partners in source-country
- Builds the capacity of MSB partners through training and technical support

Kew's Millennium Seed Bank currently holds **81,533 collections of 37,614 species** from 189 countries
Over >100 active international partner institutions in > 50 countries.
Seed Banking: Why? Why not?
Species extinction

Diminishing habitat = diminishing diversity

20% of plant species are currently threatened with extinction

*Plants under pressure: a global assessment. The first report of the IUCN Sampled Red List Index for Plants.*

Royal Botanic Gardens, Kew, UK. 2010 and 2012
Is ex situ conservation really needed?
Seed Banking

The benefits of seed banks

• Can be used for most seed-bearing species

• Dried & frozen fresh seed can live many decades – millennia

• Huge concentration of diversity allowing curation & access

• Low technical input

• Generate skills, knowledge and data to support ecological restoration and sustainable utilisation

• Make seeds easily available for research

Seed banking provides long-term, relatively low-cost conservation
The limitations of seed banks

- A room of frozen seeds is not a forest! May be used as an excuse not to conserve natural areas.

- Many species are difficult to germinate and propagate. More research is needed.

- Frozen species are not evolving and may lose out in the evolutionary ‘arms race’ against pathogens and predators.

  - Can’t be used for desiccation sensitive or ‘recalcitrant’ species. Seed storage behaviour often not known.

  - Some species are short-lived in seed banks – e.g. Ericaceae, Ochidaceae.

  - Both these types of species need other ex situ solutions – cryo and/or living collections.

Seed banking must be part of an integrated conservation programme.
Seed storage behaviour

- **Orthodox / desiccation-tolerant species:** water can be safely removed.

- **Intermediate / partially desiccation tolerant species:** some water can be removed (Ellis et al, 1990).

- **Recalcitrant / desiccation-sensitive species:** removal of water is lethal.
Seed Banking

Ex situ conservation options for recalcitrant species

- **In vitro** tissue culture
- Pollen bank
- DNA bank
- Cryopreservation
- Botanic gardens
- Field gene banks

Community biobanks?
Seed storage behaviour of tree species

% woody species with recalcitrant seeds

Climate becomes drier

Is seed banking suitable for the Thai flora?
Recalcitrant seeds are more common in wet environments

Tweddle et al., 2003. J. Ecol. 91, 294-304
Seed storage behaviour of Thai flora

Is seed banking suitable for the Thai flora?
Seed storage behaviour of Thai flora

Seed storage behaviour of Thai flora

% of species

All species

Orthodox Recalcitrant Insufficient Info

c. 76% of Thai flowering plants are probably bankable!
At the 2014 Flora of Thailand Conference at Kew, HRH Princess Sirindhorn expressed her wish for a national seed bank for Thailand.

Dr Pramote Triboun outlined some preliminary plans.
The Thailand Biobank Seed Store project:

• Aims to be a national facility available to all to support Thailand’s Bio-economy
• Managed by Ministry of Science and Technology (MOST)
• Located at Thailand Science Park, Rangsit, Bangkok
• Automated sample store
• Stores dried seeds at -20°C
• Can store 130,000 glass tubes
• Extra cold rooms for large seeds
• Liquid nitrogen tanks for cryopreservation
• Initial focus on medicinal plants
• Ready to use around end of March 2019
Seed Banking: How?
What is a seed collection?
The Seed Banking Process

Collecting

Processing

Storage and duplication

Viability monitoring

Data management

Distribution

Seed Bank Management

The MSB Seed List
The Seed Banking Process

Access and benefit sharing

- Ownership
- Prior Informed Consent
- Activities
- Notification of transfer
- Benefit sharing (e.g. training, joint research, data sharing)
- Non-commercialisation
- Transfer to third parties
- Duration
Seed Drying
Seed longevity doubles for every 10% reduction in humidity

We dry seeds to 15% equilibrium relative humidity (eRH)
The Seed Banking Process

Seed drying

Dry rooms

Drying cabinets

Incubator dryers
The Seed Banking Process

Seed drying (low tech)

- Use a suitable container with a tightly fitting lid (e.g. a plastic box or plastic / metal drum).
- Add dried silica gel (below 10% RH) to the container, to fill 20% of the total volume.
- Place bags of seed in container (allowing air circulation).
- Check the Relative Humidity of the silica gel every week.
- Once silica gel becomes wet, it must be re-dried in an oven at 100°C.
- Check the humidity of the seeds every day or two.
The Seed Banking Process

Seed drying (low tech)

- Sun-dried charcoal or dried rice can be used to dry seed
- First dry the seeds under ambient conditions for 2-3 days
- Then transfer the seeds to a sealed container with the desiccant. Use 3 parts dried charcoal to one part seeds
- Change the desiccant regularly to speed up drying time.
- Re-dry the desiccant in the sun during the day and then use to maintain seed drying at night, in sealed containers.
- Seeds may take at least one month to dry
Measuring seed moisture

Digital hygrometer / data logger
The Seed Banking Process

Measuring seed moisture (low tech)

• Dial hygrometers
• Moisture indicating strips
  - Cards chemically impregnated with range of concentrations of indicator
• Indicating silica gel
  - 1g sachets with methyl violet
  - Colour change either side of approximately 25% RH boundary
The Seed Banking Process

Measuring seed moisture (low tech)

Salt test

• Cheap and simple to carry out
• Dry common salt mixed with the seed sample in a glass jar and shaken
• Salt forms clumps above 70-75% RH
• If salt adheres to the walls of the glass, it has absorbed moisture from the air which must therefore have been at a RH greater than 70-75%
• This means that the seeds are not dry enough to store for 1-2 years
The Seed Banking Process

Seed storage containers

• Glass jars ✓
  + transparent
  - heavy

• Foil bags ✓
  + light
  - not transparent
  - can be punctured

• Plastic containers ❌
  + light
  - poor seal

• Good quality containers with good quality air-tight seal
• Pack seeds in a dry environment
• Moisture-proof, low-temperature labels
The Seed Banking Process

Cold storage

High tech

• Robotised storage at -20°C
• Walk-in cold store at -20°C
• Liquid nitrogen:
  - -160°C (vapour)
  - -196°C (liquid)

Low tech

• Domestic deep-freezer (chest / upright) at -20°C
Data management
All seed collection data is recorded on Kew's Seed Bank Database
Available to partners on the MSBP Data Warehouse (BRAHMS)
MSB Data Warehouse: overview of global MSBP collections
### MSB Data Warehouse:
Accession data, Botanic records, Germination tests

<table>
<thead>
<tr>
<th>Accession</th>
<th>Seedbank</th>
<th>Taxon</th>
<th>Steps Summary</th>
<th>Sown</th>
<th>Germinated</th>
<th>Result</th>
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<tbody>
<tr>
<td>374303</td>
<td>MSB</td>
<td>Barleria albostellata</td>
<td>*Step 1: T25/25(24/0); L8/16; 7d; Standard Medium: Agar 1%;</td>
<td>10</td>
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<tr>
<td>564582</td>
<td>MSB</td>
<td>Barleria elegans</td>
<td>*Step 1: T25/25(24/0); L8/16; 7d; Standard Medium: Agar 1%;</td>
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<tr>
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<td>*Step 1: T20/20(24/0); L8/16; 28d; Standard Medium: Agar 1%;</td>
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<td>*Step 1: T20/20(24/0); L8/16; 7d; Standard Medium: Distilled/Deionised water 5ml; Standard Medium: Sand 50g;</td>
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<td>390101</td>
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</tbody>
</table>
Use of MSB seed collections
Use of MSB seed collections

2000 – 2017

• 11,182 seed samples representing
• 4,811 taxa (including subspecies and varieties) and 200 families were supplied to
• over 410 organizations across
• 57 countries
Use of MSB seed collections

Adapting Agriculture to Climate Change Project (Crop Wild Relatives project)

- Co-managed by the MSBP and the Global Crop Diversity Trust
- $50 million over 10 years (Norwegian Government)
- Kew responsible for collecting and processing seeds from CWRs of **29 major crop genepools** including rice, wheat, potatoes, bananas).
Use of MSB seed collections

1 Research (Gap Analysis)
2 Collecting
3 Seed Conservation
4 Pre-breeding

Crop Wild Relatives
New Crop Varieties
Use of MSB seed collections

The UK Native Seed Hub

• Providing **larger quantities of seed** of UK native species for habitat restoration, species reintroduction and research in the UK

• Improving the **quality, availability and appropriateness** of UK native seed
Role of Community Biobanks in wild plant conservation?
Ex situ living collections of recalcitrant species?
Active seed banks for medium-term use?

National seed banks (Long term storage)

• Small quantities of seed for research and conservation
• Technical support, data, research

Community biobanks (Medium term storage)

Providing larger quantities of seed for immediate use
Thank you!

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