

Once dried, orthodox seeds need to be stored in air-tight containers. If containers are not effectively sealed, seeds will gradually absorb moisture and their storage life will be reduced. A rise of just 10% in equilibrium relative humidity (RH) or 1% in moisture content will halve seed storage life.

This information sheet provides guidelines for selecting and testing containers for long-term seed storage

Container material

Seed banks use a variety of containers made of glass, laminated foil, metal or plastic.

- Glass containers are transparent, allowing seeds and humidity indicators to be seen. They are relatively heavy - cold room shelves and flooring must be able to bear the weight – and breakage is possible. It is important that the glass is manufactured to a high standard.
- Tri-laminate foil bags make effective containers if well-sealed, but may be punctured by sharp seeds and are not transparent. Use foil designed for long-term storage; put sharp seeds in a dry card envelope, and use a constant temperature heat sealer with a serrated sealing bar of at least 10mm. Vacuum sealing is used by some seed banks to remove air in the bag. This may increase the risk of puncturing and can also lead to creasing across the weld seam.
- Metal containers are not recommended. They do not allow the seed or humidity indicators to be seen. Millennium Seed Bank (MSB) experience suggests that most metal containers seal poorly.
- Plastic containers, though light, rarely seal effectively, and there is some concern about the potential long-term harmful effects of plasticizers on seed viability. For this reason, the MSB does not recommend plastic containers.



Above: Five types of glass container used at MSB - 3000cm³ storage jar, 1000cm³ storage jar, 100cm³ square bottle, 30cm³ universal bottle and 2cm³ vial

Lid and seal construction

Just as important as the container material is the seal that can be achieved between the container and its lid.

- If regular access to seeds is required, screw lids or clamped seals are better than permanent welded glass or metal seals.
- A good sealing compound can greatly improve the hermetic qualities of a container. In MSB tests, natural rubber, bromobutyl, chlorobutyl and flurotec seals proved effective, whilst silicone did not prevent moisture entry.
- Lids with natural or synthetic rubber seals, clamped or crimped onto the container, are much more effective than screw lids.
- Clamped containers such as storage jars and crimped containers such as freeze drying vials are very effective, but may not be available in the full range of sizes needed for diverse seed collections.

- Well-designed plastic lids without seals can perform equally well. Glass bottles fitted with polypropylene lids out-performed similar bottles with metal caps and butyl rubber seals in MSB tests.

- Screw lids may occasionally loosen during use, due to differences in thermal expansion or contraction between the lid and the container during freezing or thawing. This can seriously weaken the seal.

Cost and reusability

Cost may be a significant factor in choosing containers. Most containers, including tri-laminate foil, can be reused.

Container size and shape

Collections vary in seed size and number of seeds per collection, so a range of container sizes may be required, preferably with a wide aperture relative to volume.

Containers used at MSB

In MSB trials, the best performing containers were glass storage jars with natural rubber seals and clamped lids. Well-sealed tri-laminate foil bags are also suitable for long-term seed banking. The MSB currently uses the following:

- 3000cm³ glass storage jars
- 1000cm³ glass storage jars
- 100cm³ square glass bottles
- 30cm³ universal glass bottles
- 2cm³ glass vials
- Tri-laminate foil bags

The 2cm³ glass vials are ideal for very small seeds and two vials will fit into a 30cm³ universal bottle for easier storage. The 30cm³ plastic-capped universal bottles and the 100cm³ square bottles are the most commonly used containers, whilst the 1000cm³ and 3000cm³ storage jars allow for the storage of large seeds. Natural rubber seals on the storage jars are renewed every 10 years as a precaution against perishing. All of the containers are easy to label, have wide openings and are reusable.

Container leak test

Before using containers for long-term seed storage, test them for potential moisture leakage, using this sensitive colour-indicator system. Containers are screened over a four week period under high humidity conditions and then tested under cold room conditions for a minimum of one month. Due to possible manufacturing variation, each new batch of containers purchased should be tested using this protocol. This method is similar to that described by Gomez-Campo (2002).

- Add dry self-indicating silica gel (e.g. with orange/green indicator) to dry-room conditioned containers (1 gram per litre of container volume). Use ten replicates of each container type. Seal the containers by hand and hold in a sealed chamber for at least four weeks, maintaining an atmosphere of high humidity (approximately 100% RH).
- Check the silica gel colour each week. If the hermetic seal of the container fails, the silica gel will absorb moisture and the indicator will change colour. In the case of orange/green indicator, score orange silica gel as a "pass" and green as a "fail".
- Transfer containers that pass to cold room conditions for a minimum of one month, but preferably longer. The containers are scored as a "pass" if the silica gel remains dry throughout this period.
- A batch of containers should only be used to store seed if the replicates have achieved a 100% pass rate in this test.

Take seed/fruit size and shape and expected seed numbers into account when selecting containers.

- Banking whole fruits will increase the volume of collections.
- Containers with a wide neck allow easier access for large and irregular shaped seed.
- Containers with a square cross-section pack more effectively than those that are cylindrical.
- Labels must stick well to the smooth-sided containers and remain legible for indefinite periods of time at sub-zero temperatures.

Detecting leaks during storage

Self-indicating silica gel sachets added to seed collections are a highly effective and cheap method of detecting moisture ingress.

- Currently the MSB uses silica gel with an organic indicator, which changes from orange when dry to green when wet. This silica gel is available in transparent, permeable plastic sachets containing 1g of silica beads. The colour change begins at about 20% RH.
- When checking containers, look for non-orange sachets as an indicator of seal failure.

- Make sure that the indicator sachets are pre-equilibrated to the same RH as the seeds (usually 15%) so that the silica gel does not cause any further drying of the seed to potentially sub-optimal levels.

Further reading

Manger, K.R., Adams, J. and Probert, R.J. (2003). Selecting seed containers for the Millennium Seed Bank Project: a technical review and survey, pp. 637-652. In: R.D. Smith, J.B. Dickie, S.H. Linington, H.W. Pritchard and R.J. Probert (eds), *Seed Conservation: turning science into practice*. Royal Botanic Gardens, Kew, UK.

Gomez-Campo, C. (2002). Long-term seed preservation: the risk of selecting inadequate containers is very high. *Monographs ETSIA, Univ. Politecnica de Madrid* 163: 1–10.

Below: Heat sealer and foil bags for storage



Equipment specifications

Description	Model/Product	Supplier
Small vial with lid	<ul style="list-style-type: none"> • 2cm³ glass vial: LS32008-1232 • plastic lid with PTFE coated seal: LS5360-08 	Scientific Laboratory Supplies Ltd. www.scientific-labs.com
Universal bottle with lid	<ul style="list-style-type: none"> • 30cm³ glass universal bottle with polypropylene lid: LS128044F 	Scientific Laboratory Supplies Ltd. www.scientific-labs.com
Schott bottle with lid	<ul style="list-style-type: none"> • 100cm³ square glass Schott bottles with polypropylene lid: BTF-682-071Q 	Fisher Scientific Ltd. www.fisher.co.uk
Storage jars with lid, clamp and natural rubber seal	<ul style="list-style-type: none"> • 500cm³ glass storage jar • 1000cm³ glass storage jar • 3000cm³ glass storage jar 	Fisher Scientific Ltd. www.fisher.co.uk
Freeze-drying vials	<ul style="list-style-type: none"> • 10cm³ freeze drying vial: VIA1124 • rubber stopper: VIA1132 • crimp cap: VIA1138 	Scientific Laboratory Supplies Ltd. www.scientific-labs.com
Self-indicating silica gel	<ul style="list-style-type: none"> • 1g sachets containing orange/green silica gel impregnated with methyl violet 	Baltimore Chemicals Ltd. www.baltimoreinnovations.co.uk
Foil bags and heat sealer	<ul style="list-style-type: none"> • 160 x 240mm, 300 x 210mm and 500 x 250mm and tri-laminate foil bags • 750mm double heat constant temperature heat sealer 	Moore and Buckle Ltd. www.mooreandbuckle.com

Please note that the above equipment is used by the Millennium Seed Bank and has been chosen carefully using our many years' experience. The list of suppliers is for guidance only and does not represent an endorsement by the Royal Botanic Gardens, Kew. The manufacturer's instructions must be followed when using any of the equipment referred to in this Information Sheet.