Florabank Guidelines

Module 8

Seed Processing: Post-harvest Drying, Seed Extraction and Cleaning

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Key points

Seed collections generally need to be processed following harvesting and prior to storage or use.

This processing removes non-seed material (leaves, chaff, etc.), removes unfilled seed, and extracts seed from fleshy or dehiscent fruit.

Processing techniques differ between fruit types, and equipment can vary from basic to specialist.

Good processing practices will:

- reduce the volume of the seed lot to be stored,
- help maximise seed longevity,
- better estimate the number of seeds,
- remove/kill insects.

Introduction

Seeds are rarely fit for immediate storage without some form of post-harvest processing. Any techniques used must ensure that seed is not damaged and should take place as soon as possible after collection to maximise seed viability and storage longevity. Maximising longevity is particularly important for short-lived species. Two rules of thumb which illustrate the importance of processing conditions on longevity are:

- Seed longevity will approximately double for every ~10% reduction in RH (below 85–90%) (Roberts and Ellis 1989).
- Seed longevity approximately doubles for every 5°C reduction in temperature (Harrington 1972).

Seed processing, extraction and cleaning enable seeds to be easily handled, assessed for viability, efficiently packaged and stored for future use. The type and level of processing is often determined by the type of fruit (the structure that contains the seed during development), seed morphology as well as the purpose of the collection (i.e. research, conservation seed banking or ecological restoration).

The overall procedure once seed arrives at the processing facility (Figure 1; Box 1) is as follows:

- Place seed bearing material into appropriate storage area for post-harvest drying (dry and free from pests) to allow material to dry and for seed to be released from fruit.
- Separate seed and non-seed bearing material.
- If necessary, extract seeds from fruits.
- Clean seeds to remove chaff and non-seed material.
- Dry the seed prior to storage and then store the seeds under appropriate conditions (see Module 9 – Seed Drying and Storage).

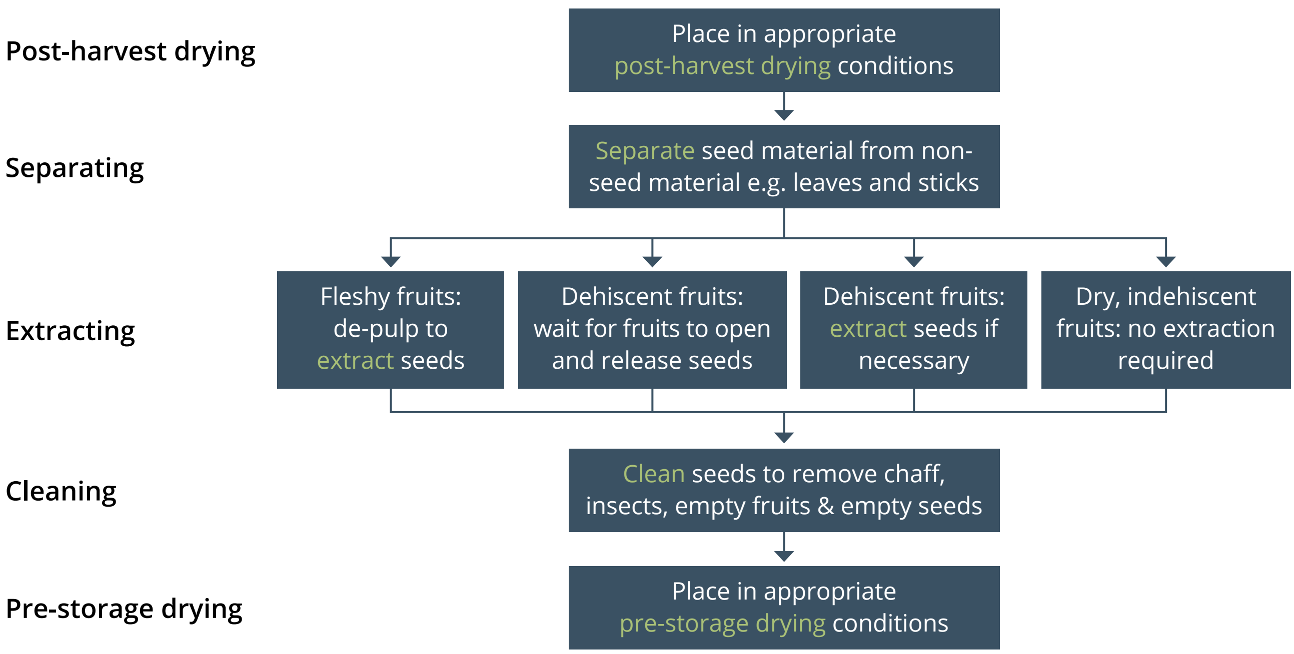

Figure 1. Procedure for post-harvest drying, separating, extracting (which depends on the type of fruit), cleaning and pre-storage drying.

Box 1. Drying seeds – when, why, and under which conditions?

Seeds need to be stored under dry conditions at different points in the processing procedure for different reasons. When designing a seed processing and storage facility, these conditions need to be taken into account. Here's a brief overview of the different reasons for drying seeds and the options for how to do this:

- Post-harvest drying
  - For mature seeds, as soon as the collection arrives at the processing facility it should be stored under dry conditions to prevent mould and maximise longevity. Ideal conditions are 15-30°C and <50% relative humidity (RH).
  - For immature fruits/seeds, retain seeds within fruits and on stems or branches if applicable. Hold material under (natural) ambient conditions for 1–2 weeks until signs of maturity are evident, then dry as for mature seeds.
- Drying fruits to facilitate seed extraction (if required)
  - Fruits that contain seeds may need to be stored under dry conditions to allow the fruits to open to release the seeds. Ideal conditions are 15-30°C and <50% RH.
- Pre-storage drying
  - Seeds need to be dried prior to storage to maximise longevity and allow seeds to survive if they are to be stored in sub zero temperatures. (see Module 9 – Seed Drying and Storage).
  - Ideal pre-storage drying conditions are:
    - Prior to long- or medium-term storage: 15-20°C and 15-20% RH.
    - Prior to short-term storage: ~23°C, <50% RH.

Depending on the size of the collection, and the end use of the seeds, either several different drying facilities may be needed for each stage of the process, or just one drying facility will be sufficient. For instance, if collections are small, then a room with an air conditioner and dehumifier set at 15°C and 15% RH may be sufficient for drying both during processing and prior to storage. Also, for short term storage, one drying facility at 23°C and <50% RH may be suitable. However, for large or bulky collections and long-term storage, initial drying may require a large covered area at, for example, ambient temperature and 30% RH, followed by drying in a smaller room once cleaning has reduced the volume of the collection.

Fruits and seeds

Fruit types

There are broad categories of fruit types that can be useful in determining the appropriate technique for processing the seeds (Box 2).

Fleshy fruits: The seed/s are contained in a moist pulpy covering that is attractive to birds and/or mammals and aids in dispersal. The flesh generally breaks down or is removed by dispersal vectors and then germination can occur.

Dry fruits: Either a woody, fibrous or paper structure that contains the seed during development. In some cases, the seeds remain in the fruit until an appropriate environmental cue occurs e.g. fire, and the seed is released. Fruits from many *Banksia* spp. (Figure 2) and most *Leptospermum* spp. are persistent and can be collected at any time once mature. Other types of dry fruits open shortly after seed maturity and the seed is dispersed. Seeds in this category such as *Acacia* spp. need to be collected immediately when the structure starts to split. Fruits that open to release their seeds are termed **dehiscent**. It may be necessary to place a mesh bag around dehiscing fruit prior to dispersal in order to achieve a high yield seed collection. For other dry fruits, for example *Eremophila* spp., seeds are not released, and remain within the fruit structure. Fruits that retain their seeds inside are termed **indehiscent**.

Figure 2. *Banksia* spp. have dry, dehiscent fruits. (Photos: L. Commander)

Identifying the seeds

Fundamentally, the most important part of seed collecting is to ensure that the material being collected contains seed. A cut test (see Module 10 – Seed Quality Testing) on a sample of several seeds or fruits will allow seeds to be identified and help determine the most appropriate approach to processing. This can be done with simple equipment such as a pair of secateurs and/or scalpel, and hand lens to check. However, make sure that operators are trained and necessary PPE is worn to ensure safety. When the seeds are cut, the embryo within the seed should be firm and white, although some species can vary so it is important to research the species prior to collection.

Box 2. Fruit types

Indehiscent fruits (fruits that don't open to release their seed/s).

- Fleshy
  - Berry e.g. *Citrus* (Rutaceae); *Dianella* (Hemerocallidaceae); *Rhagodia* (Chenopodiaceae), *Solanum* (Solanaceae).
  - Drupe e.g. *Eremophila, Myoporum* (Scrophulariaceae); *Leucopogon* (Ericaceae); *Persoonia* (Proteaceae); *Santalum* (Santalaceae).
  - Syconium e.g. *Ficus* (Moraceae).
- Dry
  - Achene e.g. Asteraceae.
  - Achenetum e.g. *Clematis* (Ranunculaceae).
  - Caryopsis e.g. Poaceae.
  - Drupe e.g. *Astroloma* (Ericaceae).
  - Nut e.g. *Lepidosperma* (Cyperaceae); *Thryptomene* (Myrtaceae).
  - Schizocarp which splits into mericarp or cocci e.g. *Hemigenia, Prostanthera, Westringia* (Lamiaceae); *Sida* (Malvaceae).
  - Utricle e.g. *Atriplex* (Chenopodiaceae).

Dehiscent fruits (fruits that open to release their seed, some species are dehiscent on the plant and other species retain their seed from a number of years but the seed from both types is released when collected and dried).

- Dry
  - Follicle e.g. *Banksia, Hakea* (Proteaceae).
  - Legume e.g. *Acacia, Daviesia* (Fabaceae).
  - Capsule
    - woody and generally cannot be broken down; seed is released from dried open capsules e.g. *Callistemon*, *Eucalyptus, Melaleuca,* some *Leptospermum* (Myrtaceae).
    - non-woody, membranous or leathery e.g. *Dodonaea* (Sapindaceae); *Wahlenbergia* (Campanulaceae); *Goodenia* (Goodeniaceae).
  - Siliqua e.g. Brassicaceae.
  - Schizocarp e.g. *Geranium* (Geraniaceae).

Box 2. Fruit types (continued)

See Figure 3 for some images of different fruit types.

Fruits can also be classified as simple (formed from one ovary e.g. nut), aggregate (formed from the merger of several ovaries from a single flower e.g. achenetum), and multiple (formed from the merger of a cluster of flowers, or inflorescence, e.g. syconium).

Fruits may contain one or more seeds. This is important to note when assessing seed quality, especially for indehiscent fruit, as even after cleaning and processing, the fruit may contain multiple seeds (e.g. *Leucopogon* and *Styphelia* (Ericaceae)) (Figure 4).

For further information on fruit types see Spjut (1994) and PlantNET.

Figure 3. Examples of different fruit types.
Top, left to right: follicle e.g. *Hakea* (Proteaceae); woody capsule e.g. *Eucalyptus* (Myrtaceae); legume e.g. *Senna* (Fabaceae); caryopsis e.g. *Amphipogon* (Poaceae); utricle e.g. *Atriplex* (Chenopodiaceae)
Middle, left to right; non-woody capsule e.g. *Goodenia* (Goodeniaceae); achene e.g. *Streptoglossa* (Asteraceae); berry e.g. *Solanum* (Solanaceae).
Bottom, left to right: fleshy drupe e.g. *Nitraria* (Nitrariaceae); schizocarp e.g. *Diplolaena* (Rutaceae); dry drupe e.g. *Eremophila* (Scrophulariaceae). (Photos: L. Commander, A. Quarmby)

Figure 4. Some indehiscent fruits contain multiple seeds, such as *Eremophila* spp. (Scrophulariaceae). These photos show intact dehiscent fruits, dissected fruits, and extracted seeds of two *Eremophila* species. The seeds are white and contained within locules within the fruit. (Photos: L. Commander)

Post-harvest drying

Maturity

It is of course important to collect the material (seed/fruit) when it is mature (see Module 6 – Seed Collection for a description of mature seed) (Figure 5). But in some instances, if the material is not mature at collection the maturity can also be noted at collection and may determine post-harvest drying conditions and handling.

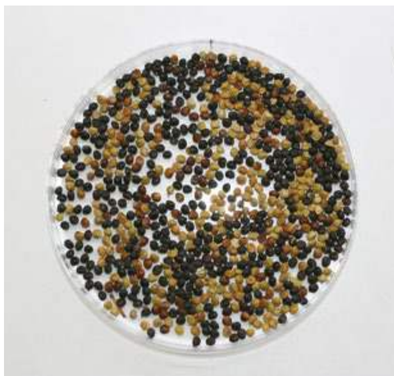

Figure 5. A mixture of mature and immature seeds. The black seeds are mature and the green and pale brown seeds are immature. (Photo: L. Commander)

If fruit was collected while immature by necessity, it is wise to keep seeds within fruits, and even keep fruits on branches or stems. This material should be initially dried under ambient conditions for 1-2 weeks, or until fruits show signs of ripening (e.g. a colour change or the opening of capsules). Once the material is mature it can then be dried as described below.

Post-harvest handling of fleshy fruit

Between collection and seed extraction, fleshy fruits can be stored in plastic bags, and should be opened periodically to remove excess moisture and prevent fungal development.

Post-harvest drying of non-fleshy fruit

Non-fleshy fruit often require post-harvest drying to allow seeds to be freely extracted and/or separated from the fruit. In some cases, dehiscent fruits open shortly after collection and release their seeds, so do not require further post-harvest drying to open the fruits.

The post-harvest drying process is used to avoid the development of mould, open the fruit and prepare the seed for extraction. Whatever method is used, it is important to ensure that **seed lots** are not mixed during the drying process. It is important to use containers that allow air circulation, particularly when the material is enclosed. Plastic bags or sheeting should be avoided as they encourage condensation, which may initiate germination and reduce viability and seed storage life. Calico or other open weave materials and paper bags are preferable as they encourage air flow and speed up the drying process (Figure 6).

For large quantities, fruit can be spread out on sheets or tarpaulins, but it should be turned regularly to avoid uneven drying. It should be spread out where there is shelter from adverse weather conditions or packed away when necessary.

Shade cloth can be used instead of tarpaulin under the seed material as it allows small debris and dust to fall through (not appropriate for species with small seeds). It can also be placed on top of harvested material to prevent wind removing seed and light weight fruits e.g. *Atriplex* spp. (saltbush, bluebush, etc.) or in very windy conditions.

Figure 6. Calico bags containing seeds can be placed in a well-ventilated area for post-harvest drying. (Photo: L. Commander)

Natural drying

The collected material is dried by spreading it out in a thin layer to allow free air circulation. This can be done by either laying the fruit out on ground sheets or suspending it in racks in the open or under shelter (Figure 7). Special attention will need to be paid to local temperature and humidity, and material should not be dried in the open if ambient conditions are too hot or too moist. Locations unsuitable for natural drying of mature fruits at certain times of the year may include coastal locations in subtropical and tropical areas (Probert et al. 2007). Check the relative humidity with a relative humidity meter. Open exposed conditions may be useful in assisting with opening of fruits, but low humidity and air flow are more critical in regard to drying seed (Figure 8). A careful watch on the weather is required where material is dried in the open and sheets should be packed away at night (when condensation may occur) where several days drying are required.

Do not underestimate the amount of condensation that can be produced by collected plant material and be careful to leave the sheets open as much as possible. Turn the material regularly to encourage even drying and discourage mould outbreaks (especially where there is a thick layer of material containing leaves). Ensure that the seed is not accessible to pests. Ants, birds and rodents can remove or eat the seed and other animals can be a nuisance.

Avoid re-wetting of the fruit during drying since this can retard or prevent seed drop and lead to a rapid loss in viability in extracted seed. Seed can tolerate reasonably high temperatures for short periods but only if the humidity is low. Severe damage to seed lots can occur if air circulation is poor and the humidity and temperature within the drying material rises. Natural drying is ideal for warm to hot dry conditions but may not be suitable for less reliable climates and during the winter months. In such cases it may be necessary to spread the material out in a dry area, such as an enclosed shed with a concrete floor.

Post-harvest drying conditions chosen should on the maturity of the collections, seed moisture at the time of collection, species and fruit type. For more information, see Probert et al. (2007).

Figure 7. Material containing seeds can be placed in trays on shelves to dry. (Photo: L. Commander)

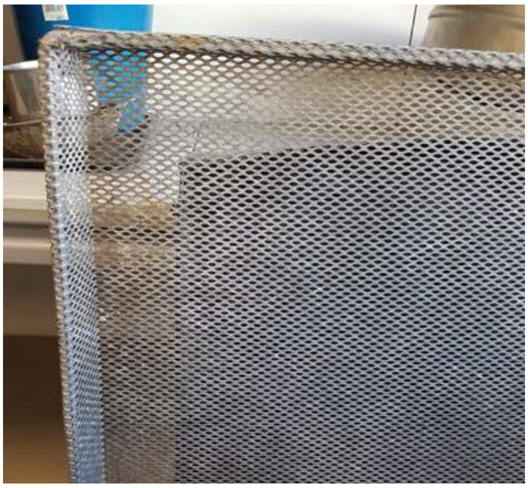

Figure 8. To facilitate air flow, trays can be perforated, so long as seeds are larger than the perforations so they do not fall through. (Photo: L. Commander)

Figure 9. Various methods of natural drying. (Photos: P. Gibson-Roy)

Artificial drying

An alternative to natural drying is using solar extractors, glasshouses or artificial heat from ovens or drying rooms (Figure 10). One popular and low-cost method for drying seed is to use a greenhouse or purpose-built propagation igloo. These are available in kit form and typically involve plastic stretched over a metal frame. Good air circulation is essential in keeping the temperature and humidity down inside such structures and a shade cloth cover may be required

Containers with false bases, such as trailers and silos, can be used in conjunction with fan forced air to dry large amounts of material prior to further processing (pers. comm. Paul Gibson-Roy).

Drying temperature and time are dependent on several factors, for example, the volume of material, initial moisture content and the structure of the fruit. Seed drying can take 3 to 5 days but may take a week or more where there is a large volume of leaf and fruit material or woody fruit.

For most species, drying seeds at temperatures of 15-35°C is recommended, and good air circulation is needed to quickly reduce humidity as the fruit dries. Drying seeds at higher temperatures may result in rapid decline in seed viability, especially if seeds are exposed for extended periods. Where information on temperature tolerance is not known then samples of seed should be tested. A simple digital thermometer can be useful in monitoring temperature in the drying facility.

Figure 10. A drying oven used for drying seeds. (Photo: L. Commander)

Separating seed and non-seed bearing material

Manually removing non-plant material (e.g. sand and soil), leaves, twigs and obviously empty seeds prior to further processing may be beneficial. Also, some freshly collected woody/dry fruit types, and collections with leafy material, can have a relatively high moisture content and the seed can be susceptible to mould if stored inappropriately for even a few days. For species that have very small leaves or branchlets (e.g. *Callitris* and *Casuarina* spp.), or for species with leaves that become brittle and break into small pieces, separating the fruit from the branches and leaves prior to or during post-harvest drying can simplify the later cleaning process. Fruit that remains secured on branchlets (*Eucalyptus* and *Hakea*) does not need to be removed, but removing fruits from branchlets may reduce the amount of space required for drying and storage.

Extracting seeds from fruit

Extracting seeds from fleshy fruit

It is often recommended that fleshy fruits have flesh removed (**de-pulping**) immediately after collection so the separated seed can be dried and further processed. This is generally for fruits that contain multiple seeds. However, de-pulping is not always necessary, especially for fleshy fruits containing a single seed and/or fruits that can be dried readily without incurring mould damage. The seeds of some species such as the *Acmena* / *Syzygium* group are likely to dehydrate readily when the flesh is removed and proper care and refrigeration will then be necessary.

De-pulping may include some or all the following:

- Storing the fruit in a plastic bag under cool conditions or soaking in water until the flesh becomes soft (changing the water regularly to avoid fermentation), then washing through an appropriately sized sieve to remove the flesh but keep the seed.
- Manual de-pulping using high-pressure water stream or maceration using a rubber bung to squash flesh, taking care not to damage seed (a sieve can be used to retain seed).
- Fruit with a hard **endocarp** can be put into a blender set at low speed and filled with water, although the blades may need to be padded and care taken not to damage seed, alternatively, use a magnetic stirrer.
- Soak in an enzyme that breaks down the fruit, such as pectinase (see Martyn Yenson et al. in prep).

The pulp of some fruits may contain toxins or coloration, in which case, personal protective equipment (e.g. gloves) may be required.

For fruits such as bush tomatoes (*Solanum* spp.) which have been collected at maturity/natural dispersal (often indicated by the fruit changing colour, or fruit which comes off the plant easily when touched or picked), pierce the fruit coat with scissors and squeeze out the pulp and seeds, then rinse immediately in a sieve. This separates the fruit coat from the seeds, and if left to dry, the flesh may become difficult to remove. Processing whole fruits sometimes results in seed sticking to undissolved fruit coats.

After the pulp is removed, seed can be separated by flotation in water or sieving, or aspirated (Figure 15) once dry. Sometimes, those that float are deemed to be empty (a cut test should be performed on a sample as confirmation as some seeds, such as those that are dispersed by water, will naturally float) and therefore can be discarded. Once the seed is separated from the fruit it is ready for drying before final cleaning and storage.

In declared fruit fly areas, ripe fleshy fruit may already be infected with fruit fly eggs and/or larvae when collected. Ensure suitable protocols are followed to avoid the translocation of fruit fly to other areas and to avoid seed damage.

Extracting seeds from dehiscent fruit

After post-harvest drying, some type of extraction may be required to separate the seed from fruit. Shaking or beating of the dried material will release all the seed in some species. In other species, the seeds can remain locked or attached to the fruit, requiring additional processing. A careful inspection should be made to ensure that the fruits have fully opened before starting the extraction process, although it is unlikely that any further opening will occur after a week or so of drying. It is possible that any seed that is not naturally released after this period is infested or immature. A check of unreleased seed will determine if further extraction is required.

Threshing the fruit by hand with an implement, or using a machine is often required to release seed from pods. Some hand tools may be useful, such as a vice, blowtorch, nutcracker, hammers, screwdrivers and pliers. However, it is essential to check the seed regularly whilst processing to ensure they are not being damaged by the extraction.

In order to break up some fruits or pods, rubbing fruit between a gloved hand and a corrugated rubber mat to abrade the fruit will allow seeds to drop into the gaps once they have escaped the fruit structure (Figure 11).

Mechanical threshers are essential for handling large quantities of plant material efficiently. Where they are used, care must be taken to ensure that the seed is not damaged. Even hard-coated seed can be cracked under severe threshing resulting in a shorter storage life.

Generally, the longer the material takes to go through the thresher, the more likely that it will be damaged. It is preferable to run the material through quickly several times. There are many types of mechanical threshers available commercially and also many home-made versions produced through innovation and adaptation of existing equipment, such as garden threshers and blowers.

Extreme heat extraction may be used for certain species, including *Banksia* and *Hakea*, which have very woody follicles. High temperature treatment (35-45°C for 30 minutes, or just until the follicles open) in an oven can be used. Care should be taken if using ovens for drying, as embryo damage can occur if fruit are left for too long in an oven at a higher temperature. An often incorrectly quoted method of placing the fruit in a hot oven until the follicles 'pop' open, often up to an hour, is generally detrimental to the seeds. Alternatively, exposure to fire for a short period of time such as 60 to 90 seconds (home barbeques are suitable for small seed lots or an LPG heating torch / blowtorch) may be used to open the fruit (Figure 12). Any flames or embers must be extinguished, then fruits allowed to cool, when the fertile follicles will generally open. This process simulates what happens in nature where during a bushfire, very high temperatures may be reached, but the fire front passes very rapidly. Care is needed when the fruit opens to ensure that the more delicate seed is not damaged. PPE needs to be worn, and care taken to ensure that the surroundings are not exposed to heat or flames.

Fruit of some *Banksia* species may be submerged briefly in water following exposure to fire, although some require soaking without burning. As soon as the valves begin to open during fire exposure, submerge fruit in water for a few minutes, take them out, then drain and dry them.

Figure 11. A corrugated rubber mat is useful for cleaning seeds. (Photo: L. Commander)

Figure 12. An LPG heating torch may be useful to open dehiscent fruits such as *Banksia*. (Photo: L. Commander)

Cleaning seed lots to improve quality

The aim of cleaning is to separate the full, viable seed from impurities, such as non-viable seed, non-seed material and chaff (Figure 13). The level of purity to which the seed lot is cleaned is usually a compromise between time, effort and loss of viable seed through unnecessary processing. For some species the difficulty of removing impurities and limited advantages of separation may make further cleaning unnecessary or not cost effective. Whether the seed lot is cleaned further or not, the important point is that the quality should be determined and reported (see also Modules 10 – Seed Quality Testing and 15 – Buying and Selling Seeds).

There are several methods for achieving clean seed including manual cleaning, sieving, blowing, vacuuming, winnowing and flotation. The purity of cleaned seed is influenced by the amount of care taken in the removal of impurities following collection and prior to pre-storage drying.

Screens or sieves are frequently used where the seed is either smaller or larger than most of the impurities. Sieves can also be slotted or round to separate material that is differently shaped. A set of screen and sieve sizes and configurations are essential tools for seed extraction (Figure 14). Sieves range from kitchen sieves to pieces of domestic flyscreen to purpose-built, mechanised screens. A combination of different screen sizes is often used to progressively remove the non-seed material. Different screen shapes (round, oblong or square) and materials (mesh or perforated plate) suit different species and some trial and error is required to identify what works best on a species.

Winnowing and vacuums are used where there are weight or shape differences between the seed and impurities (Figure 15). These methods are particularly useful for separating out empty seed. A simple method is to pour the material in front of a regulated air current (such as a domestic fan) located on a clean floor. If the method works properly, the good seed falls in one area and impurities in another. A vacuum cleaner or garden vacuum/blower with some form of suction control is effective in separating light fluffy seed. Screens can be used to control what is sucked into the vacuum. The same basic principles are adapted and developed in a range of machines built for seed extraction. Sometimes the air column/vacuum is combined with vibrating sieves in a single-pass cleaning machine.

A quick immersion in water can be an effective treatment for cleaning species with water-impermeable seed coats. Impurities tend to float to the surface including pest damaged or empty seeds (immersion can also kill pest larvae) while filled seed sinks. After removal of the impurities, the water is drained off and the seed thoroughly dried before storage. This technique can only be used for species with water-impermeable (hard) seed coats (e.g. most legumes) and should not be used after seeds have been threshed (as seeds that have been damaged by a thresher may absorb water, which is not desirable).

Sticky seeds, such as *Pittosporum spp.,* can be coated in talcum powder or ash to allow for ease of handing, counting and storage.

Spherical seeds can be separated from chaff by placing at one end of a tray, then putting the tray on a slight incline and tapping it, so the spherical seeds roll down to other end of the tray, leaving the flat chaff.

Once clean, the seed needs to be securely bagged and labelled to ensure identification at a later stage.

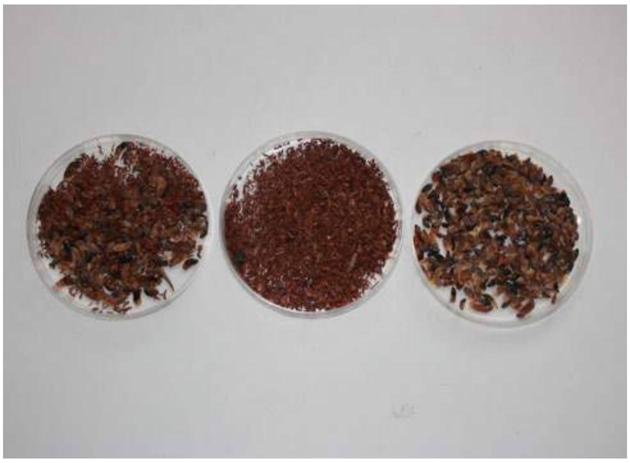

Figure 13. Seed cleaning can improve the quality of the seed lot. Left to right: uncleaned seed lot; chaff; pure seed. (Photo: L. Commander)

Figure 14. A set of sieves is useful for separating seed from non-seed material. (Photo: L. Commander)

Figure 15. A zig-zag aspirator or vacuum separator can separate material based on weight. The seed lot is placed in the funnel at the top, and is fed into the main part of the machine via a vibrating channel. The lighter material (in this case the chaff) falls down the column shaped like a 'zig zag' and into the removeable Perspex tray on the left, whereas the heavier material (the seeds), are sucked over the top of the channel and fall down into the tray on the right. (Photos: L. Commander)

Pre-storage drying

Depending on the seed moisture content following cleaning, seeds may need to be dried further prior to storage to slow the rate of deterioration of seeds and enable them to survive storage at sub-zero temperatures. Pre-storage drying is critical for seed longevity – for every 1% reduction in moisture content, storage life doubles. Pre-storage drying is outlined in detail in Module 9 – Seed Drying and Storage.

Silica gel or silicon dioxide is a low cost and easy method for final drying of small quantities of seed (Figure 16). After air drying, place a sachet of silica gel with the seed in a sealed container. Use a ratio of about 2:3 silica gel to seed, or more silica gel for a greater drying capacity. At room temperatures (25°C), 100 g of silica gel can absorb about 7 g of moisture. Indicator dye is usually included in the silica gel to signal when the gel has absorbed as much moisture as it can. At this point the silica gel should be redried in an oven. See also Kew (2020).

Figure 16. Silica gel.
(Photo: L. Commander)

For drying larger quantities of seed, a purpose-built room, with controlled temperature and relative humidity can be used (Figure 17). The facility can be a single room, with humidity of 10-25% RH and temperature set at 5-20˚C. For long-term storage, seeds are dried in facilities which maintain 15-20% RH and 15-20°C.

Figure 17. A purpose-built seed drying room, with controlled temperature and relative humidity. (Photo: N. Emery)

Changes in seed moisture content during drying can be measured by weighing a seed parcel at regular intervals using an accurate digital balance. Seeds can be considered dry when the weight of seed no longer changes significantly. Be careful that the seed parcel contains the same number of seeds throughout drying, for even minor losses of seed can mask the comparatively small changes in weight due to moisture loss.

An instrument used to assess seed moisture content is a hygrometer, which measures the moisture content in the atmosphere surrounding the seeds. A rule of thumb is that when the seed 'crackles' as it passes through your hand, it is dry. (See also Module 9 – Seed Drying and Storage)

Desiccation sensitivity

It should also be noted that there are some species with seeds that do not tolerate drying, or tolerate very little drying. These seeds are referred to as **recalcitrant** and often occur in wet and humid environments such as mangroves, seagrass meadows and rainforests (Offord and Makinson, 2009) and usually have a high moisture content. It is important to identify these prior to collection as a different method of storage will be required. These will need to be kept moist at around 40-60 % seed moisture content and then used as quickly as possible for their intended purpose, and may have a shorter storage life than orthodox seed. For further information see Module 9 – Seed Drying and Storage.

Hygiene and biosecurity

Ensure that all equipment is thoroughly cleaned before and after use to ensure that the next seed lot to be processed is not contaminated with seeds from the last batch. Paint brushes or high-pressure air can be useful to clean out equipment. Check regularly for pests. Surfaces should be wiped down after use and disinfected if required. Ensure that strict quarantine procedures are in place for initial handling of material infected with Myrtle Rust.

Safety issues

Some plants are toxic (e.g. *Gastrolobium*), may cause allergic reactions (e.g. some *Grevillea*), or may have fine hairs which can be irritating when dry (e.g. *Anigozanthos, Ptilotus* or *Brachychiton*). Grasses such as *Bothriochloa* may cause irritation too. Contact should be avoided with plant material such as sap, dust or hairs during handling and processing. The pulp of some fruits may contain toxins. Be aware of the potential for sensitisation if exposed to the same species over an extended period. Cleaning should be done in well ventilated areas or under a dust extractor (Figure 18) and appropriate personal protective equipment such as long-sleeved shirts, dust masks or respirators, gloves, eye protection, etc., should be worn. A first aid kit should be available, with appropriate medicines such as anti-inflammatory cream.

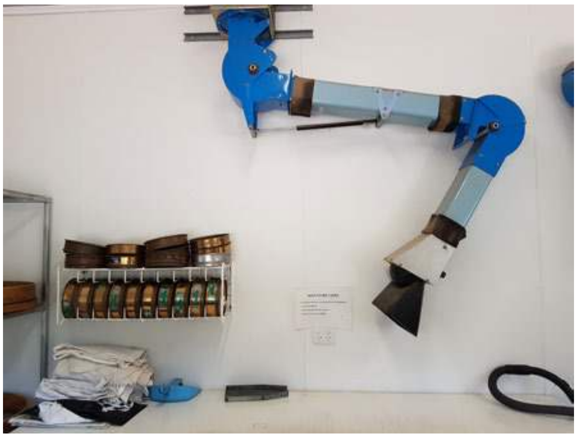

Figure 18. Dust extraction is useful when cleaning seeds. (Photo: L. Commander)

Record keeping

It is also critical to maintain the identity of collections during processing, for example by only handling one collection at any time and having multiple labels within the collection so they can be moved into each cleaning container or sieve. Keep records of the methods and equipment used to separate seed from non-seed material, how seeds are extracted from fruits and how unfilled seeds are removed. That way, knowledge can be recorded and passed on from person to person. It may be useful to develop a set of processing guidelines for the seed facility, and some instructions for commonly processed species. See also Module 4 – Record Keeping.

Concluding remarks

This guideline outlines general principles and ideas, but seed extraction and cleaning are areas ripe for the use of initiative and invention. The tools required can be very basic (Box 3) or very complex and will depend on technical expertise, experience and budgets. There is equipment available for cleaning and drying agricultural crop seeds that, while often designed for specific crops and relatively expensive, may be suitable for adaptation to native seed. Facilities required for drying can depend on the scale of seed processing and the financial resources available (Box 1). Seedbanks in some areas may be able to utilise the seed cleaning facilities of some of the larger agricultural seed cleaning operations on a contract basis. It may be worth investigating a collaboration in which several volunteer groups or NRM groups invest in one seed facility, and develop a roster system for its use.

Box 3. Basic equipment needed to set up a seed processing area (Figure 19)

- Sieves.
- Secateurs for pruning off leaves etc.
- Large trays for drying.
- Smaller trays for sieving over. Cafeteria / buffet self-service trays are useful.
- Bins to contain waste and bins that fit under large sieves.
- Containers for seeds (e.g. buckets, ice-cream or yoghurt containers).
- Extra labels – ensure every container has a label, especially if you split a collection over multiple trays/containers.
- Temperature and humidity measurement equipment.
- Seed dissection kit to assess seed quality: scalpel, forceps, magnifying glass or microscope.
- PPE: Gloves, dust masks, P3 masks, eye protection, long sleeved shirts/lab coats, coveralls.
- Recording sheets to record how to process each species.
- A pedestal or desk top fan.
- Permeable bags for drying: calico bags, paper bags, paper ‘seed pocket’ envelopes, ‘tin tie soil sample’ envelopes.
- Impermeable bags/containers for storage: laminated foil bags.
- Broom, dustpan and brush for cleaning up.

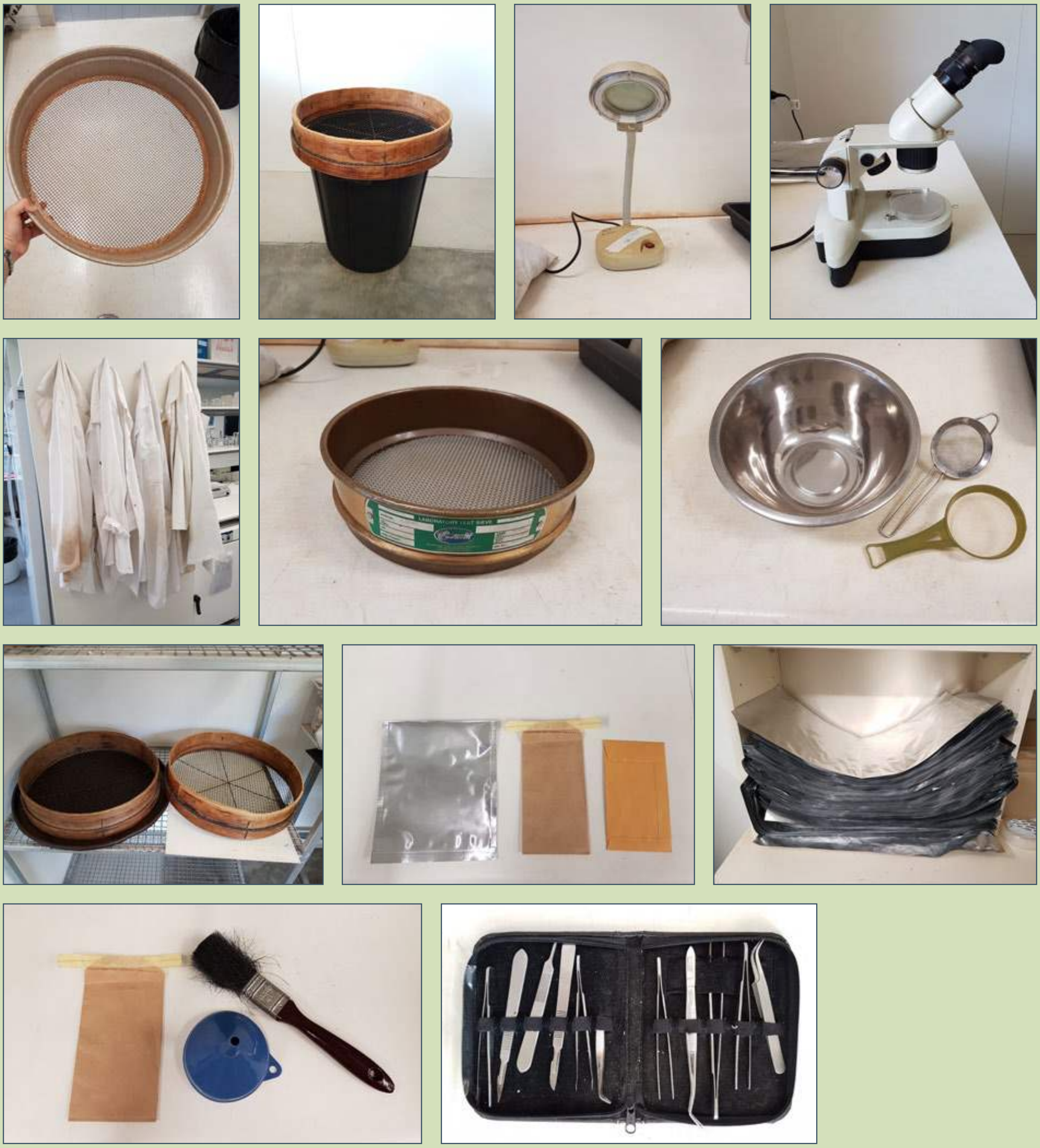

Figure 19. Basic equipment to set up a seed processing area. (Photos: L. Commander)

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Glossary

Dehiscent: fruits that open to release seeds.

De-pulping: removing the flesh of fleshy fruits.

Endocarp: the innermost layer of the pericarp (the wall of the ovary at the fruiting stage, consisting of epicarp, mesocarp and endocarp).

Indehiscent: fruits that do not open to release seeds.

Orthodox: desiccation tolerant seeds, i.e. seeds that survive drying, and for which longevity increases with a decrease in storage temperature (cf. **recalcitrant**).

Recalcitrant: desiccation intolerant seeds, i.e. seeds that do not survive drying (c.f. **orthodox**).

Seed lot: a unique batch of seed of a species from a location.

Online resources

PlantNET (The NSW Plant Information Network System). Royal Botanic Gardens and Domain Trust, Sydney. http://plantnet.rbgsyd.nsw.gov.au [30/07/2020] http://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&glossary=yes&term=fruit&ill=Fig.+18+

Millennium Seed Bank Partnership, Technical Information Sheets http://brahmsonline.kew.org/msbp/Training/Resources

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