Plant regeneration and seed saving

Pollination

To create a seed the male and female part of the flower must mate.

Flowers can be

Monoecious	male and female flowers on a single plant (eg courgettes)
Dioecious	separate male and female plants (eg spinach)
Perfect	male and female parts on one flower (eg peas)

Pollen needs to get from the anther (the male part) to the pistil (the female part) and pollinate the ovary. The practical difficulty with many plant families is ensuring that the pollen you want is the one that successfully pollinates.

For self-fertile plants (such as peas and tomatoes) this is easy, as they will usually self fertilise. For those that are not self-fertile an agent is required to transfer the pollen.

Wind	this pollen is usually very light and can travel vast distances (eg maize, spinach)
Animal	the vast majority of vegetable pollen is insect pollinated, often bees, flies or wasps
Water	this is not significant for vegetable crops

Preserving Purity

The goal of seed saving is to keep the characteristics of a variety reasonably constant from generation to generation. That means isolating the parents to prevent cross pollination. Plants that are naturally inbreeders are easy to keep pure; you simply need to make sure that no foreign pollen can gain access to the parent plants. Out-breeders may be more difficult, but there are techniques that can keep even obligate out-breeders pure without too much difficulty. (Plant breeding, where you are looking for new combinations of characteristics, reverses most of the techniques of isolation to deliberately cross varieties.)

To ensure your seeds come true you may need to isolate the flowers. There are two basic ways to isolate parent plants: in space, and in time.

Isolation in time

This is suitable for crops where all the plants flower simultaneously and for a short time – for example maize. The recommended isolation is 500 metres. If your plot is at least 500 metres away from other kinds of corn, you can save at least one variety. But if you choose an early, mid and late season variety, you may be able to save seed of all three, because they will flower at different times.

Isolation in Space

This is often the simplest technique, and may be the only appropriate technique for some plants pollinated by wind. You can get very pure seeds simply by making sure that no other varieties of that crop are in flower within a certain minimum distance, usually called the isolation distance. Unfortunately, it is impossible to be absolutely precise, because the isolation distance depends on many factors: the number of insects, what other foods are available for them, physical layout and even weather can influence how far pollen can travel from one variety to another. For this reason, experts often differ about isolation distances.

The best advice is to use the largest isolation distance that is practically possible. Keep good notes, and experiment to establish the minimum isolation distances for the crops you are interested in under your conditions.

A different kind of spatial isolation is to physically prevent insect access to parent plants. **Bagging** is useful if you need only a small amount of seed that is absolutely pure. Simply place a bag around the blossoms just before they have opened. This is good for plants such as tomatoes and peppers and other self-pollinating crops. Do not use plastic bags, which can cook the flowers inside; paper, agricultural fleece, or even an old pair of tights, are better. Wrap a piece of cotton wool around the flower stem to prevent insects crawling into the bag. Remove the bag once the fruits have set.

A larger version of bagging is **caging**. This consists of building a cage covered with some kind of mesh that prevents insects getting in or out. You can build small cages out of scrap timber and old net curtains, or make larger, purpose-built structures, such as a polytunnel covered with specific aphid-excluding mesh. For self-pollinating crops, all that matters is to keep insects out. For outbreeders, for example onions, carrots and cabbages, you will need to make sure that there are insects inside to pollinate the flowers. The best insects to use may not be the easiest, but for many purposes a large number of blowflies will do a good job, and they are easily obtained, either by rearing them yourself or by buying maggots or pupae from a fishing tackle shop.

A different kind of spatial isolation is to physically prevent insect access to parent plants. This can be by bagging flowers or “caging” them – covering them with a mesh or polythene (or growing them in a sealed tunnel).

Combination techniques

Alternate-day caging is sometimes used for two varieties that flower at the same time and that need insects to pollinate them. The idea is to have easily portable cages. You put these on Variety A for one day, remove them after the insects have stopped feeding for the day, and put them on Variety B on the second day.

The insects work Variety A but the cages keep them away from Variety B. Each evening the cage is swapped from one variety to the other. Because the bees clean themselves carefully at night, they do not carry pollen between the two varieties. This is a useful technique, but requires sturdy cages and great diligence by the seed saver.

Hand pollination is a very valuable technique that is especially useful for maize and cucurbits. In essence you isolate the female flowers and collect pollen from the male flowers, and then transfer the pollen from male to female (for instance with a fine paintbrush). In this way it is possible to be absolutely certain that the purity of the variety has been maintained.

In all cases, the seed saver does his or her best to prevent crossing between varieties, but it impossible to be absolutely certain that no foreign pollen has entered your parent population. For this reason, especially if you are working with very rare varieties, it is important *never* to use all the seed you have. That way, if something does go wrong, you will have some seed to try again. It is also important to keep good records (see below).

Breeding types

- **Self-pollinating** or **in-breeders**

Lettuce, and most tomatoes have the stigma so close to the anthers that the slightest movement makes the pollen drop onto the receptive stigma. In peas and some beans, self-pollination occurs before the flower even opens. This is called **cleistogamy**, from the Greek words for a hidden marriage, and it makes seed saving especially easy

- **Facultative outbreeders**

These produce viable seed even if the pollen comes from a flower on the same plant. Although they can **outbreed**, they are also **self compatible**, so they do not have to outbreed. (examples onions and carrots)

- **Obligate out-breeders**

These are self-incompatible, and must receive pollen from another plant. They have a biochemical barrier that does not permit self-pollination within the flowers of a single plant (example brassicas)

One plant on its own produces hardly any seed. In practical terms a single plant of cabbage, broccoli, kohlrabi, cauliflower or kale will produce only a very small amount of seed if grown alone, and that seed will be of very poor quality. The same plant will produce several hundred grams of true seed if other plants of the same variety are flowering.

Selection and Roguing

Mostly, you will be saving seed from the best plants. But you also have to ensure that unwanted individuals do not contribute to the next generation. This is roguing.

Removing unwanted parents plants before they flower will need to be done at least once. Often it is relatively easy; if you are growing a red cabbage, then any green seedlings should be removed as soon as you see them. Other qualities are more subtle, and may require more experience. Plants that are less tolerant of adverse conditions or susceptible to disease should be removed.

As you gain experience with a particular variety, you will develop an idea of the “typical” plant of that variety. Anything that does not conform to that typical plant should be rogued.

When you are preserving a variety, the idea is to keep it in a certain state, and that involves removing individuals that are different.

Of course, the other side of this is plant breeding; even without making deliberate crosses you can select individuals that have some desirable characteristics and start to create an entirely new variety. By continually selecting the most vigorous and productive plants on your site (irrespective of exact colour / size etc) you will end up with a “variety” that is perfectly suited to your own microclimate. This might even be different to another field 2 miles away.

There are two distinct sides to saving seeds. If you are preserving an existing variety, always select the most typical plants as parents of future generations. If, however, you are trying to create something new, or to adapt something old to new circumstances, then select as parents those plants that most closely match your goal.

Cleaning and storing

It is a good idea to clean seeds, for several reasons. Chaff can harbour insects that will attack the seeds in storage. Wet pulp can provide a home for diseases that will rot the seeds.

Wet Cleaning is used for those plants that carry their seeds in moist flesh, such as tomatoes, cucumbers and pumpkins. Scoop the seeds out of the flesh into a large container of water and rub them vigorously. Collect seeds with a sieve, and run water over them to remove all the little bits of flesh. The clean seeds then need only to be dried and labelled. Some crops should be fermented before cleaning.

Dry Cleaning is used for seeds in a dry container, — as with beans, peas, maize, radishes, lettuce, carrot, onion, beetroot and cabbages. Let the plant produce dry seeds on the bush if at all possible. If rainy weather starts, the whole plant can be pulled up and hung in a dry place. Dry pods will need to be **threshed**, to release the seeds, which will then need to be separated from the chaff before storage.

Large quantities of seed can be threshed using farm machinery, but it is important to clean the equipment thoroughly between different varieties of the same crop. Another method is to place dry seed pods (for example of beans, or cabbages) in a sack and either whack it with a stick or jump up and down on the sack. (This is an excellent way of dealing with the minor stresses that seed saving can cause.)

After threshing, you need to remove the bits of dry plant and dust to clean the seed.

Winnowing has an ancient, biblical feel to it; it is almost magical to see pure, clean seeds emerge from a mixture of old, dry debris. Slowly, toss the seeds and chaff into the air so that the chaff is blown away on a gentle breeze. The secret of success lies in the shape of the vessel used for winnowing. An elongated flat basket is good, but so are deep containers. Instead of throwing the seeds into the air, simply pour from one container to the other. Another method is to put the seeds into a bowl and shake them until the debris floats to the top. A gentle consistent blow, or a little fan, will lift the chaff away.

Screening is another way of cleaning seed. You may find it worthwhile to invest in a set of mounted screens of different gauges, especially if you are going to be cleaning a lot of seeds. Experience will quickly teach you the best sizes to use for different kinds of seed.

With a little ingenuity and practical skills it is possible to make all sorts of devices to assist with the business of cleaning seeds.

Drying

Making sure seeds are really dry is very important. Seeds should be dried as quickly as possible without damaging them. A good flow of air is more important than high temperatures, which can easily damage seeds. Use a thermometer to check, and never exceed 35°C. Some seeds may need to be dried twice, once after harvest to ensure that all the seeds are mature, and then again after winnowing.

Generally, large seeds need a much longer drying time than small ones. A simple test to see whether large seeds are ready is to try to bite one of the seeds. If no impression is made with a reasonable amount of jaw pressure, then the seed is ready. If you damage the seed, it needs to be drier.

There are many ways to dry seeds:

- Keep small quantities of seed in a bowl on the window-sill *out of direct sun* and turn them occasionally.
- Spread seeds out evenly on paper in a spot where they will not be blown away or spilled, and where they will not get too hot.
- Hang small quantities in paper bags in a breezy place.

Put seed in a closed container with indicator silica gel (which can be obtained from chemical suppliers). The silica gel will need to be replaced every day or two to begin with, then less frequently. Silica gel has the great advantage of being re-usable. When it has turned pink (which means it is loaded with moisture) put it in a very low oven, or on top of a stove, until it is blue again.

Diseases

There are some diseases that are spread in, or on seeds. You should try and avoid these if possible, especially if you are passing on seeds to others. Industrially, strong synthetic chemical dressings are used, but there are also methods suitable for organic farmers and home seed savers.

Hot Water Treatment is a safe method of treating seeds for diseases such as black rot, black leaf spot and black leg in cabbage, which spread and develop only in humid weather, as well as bacterial canker in tomato and downy mildew in spinach. Soak the seeds in water held at a constant temperature of 50°C for about 25 minutes. Make sure that the temperature does not rise too high. After the treatment, dry the seeds; it is important that they are well dried again before storing.

Fermentation is used for tomato and cucumber seeds especially, to get rid of seed-borne diseases, by the action of bacteria and yeasts. Cut the fruits in two. Remove the seeds and pulp and put into a container with a little water. Leave this to sit at warm room temperature. After three (no more than four) days, a foam or crust of mould will form on the surface, indicating that the fermentation has occurred and the pulp around the seeds has been digested, and with it germination inhibitors and diseases. Rinse with plenty of water. The debris and empty seeds float, and are slowly poured out. The rest can be washed under a tap in a strainer to give perfectly clean seeds that can be dried before storage.

Freezing is good to get rid of some seed-eating insects. This is especially true for pea and bean seeds and maize. The seeds should be very dry before being placed in a freezer for about 48 hours. This will kill any eggs that have been laid on the seeds.

Storage

The conditions in which you store seed are very important. Poor storage can kill seeds very quickly, and although different crops vary in how long the seeds last, all benefit from good storage.

Seeds need moisture and warmth to germinate. So to store them they need to be cool and dry. Moisture is more important than temperature, which is why it is important to dry seeds properly. But a steady temperature, preferably cool, is also valuable. For most vegetable seeds, 5°C is the ideal temperature. Darkness also prolongs storage.

Airtight containers, such as preserving jars, are good for small quantities of seed. If the seed is dry these can be kept in a refrigerator. Always allow the container to come to room temperature before opening, otherwise water will condense on the cold seeds, so when they are put back into storage they will be moist.

Most vegetable seeds should be stored at below ten percent humidity (five percent is better). At low moisture levels, seeds can handle fluctuations of temperature better. This cannot be emphasized too strongly.

Germination Tests

Careful storage will double or triple the life span of seeds. But you may still need to monitor their viability if you are handling a collection. Germination testing offers an easy way to ensure that seeds are viable and, all else being equal, to select which varieties need to be grown out and multiplied.

Use at least ten seeds and preferably more. Place them on several layers of moist paper towel and store them in a plastic bag for up to one week at 20 to 25°C. After a few days, check the seeds for germination. If a seed has sprouted, it can be counted as viable. It may be worth removing germinated seeds, as they can interfere with the ungerminated seeds. After a week or two no additional seeds will be germinating, and the percentage viability can be calculated. A germination rate of less than sixty percent indicates poor fertility; that batch should be quickly propagated. It is also useful to know the germination rate, because it can help you to decide how thickly to plant your seeds.

Record keeping

It is very important to keep good written records. Never rely on memory; it is guaranteed to fail. At the very least, a label should always physically accompany every batch of seeds, from sowing to growing to harvest, cleaning and storage. Write the name of the variety and the year the seed was harvested on every packet. A list of the contents of each storage jar can prevent much wasted time searching for a particular sample of seed.

Beyond this simple and most basic information, which should be kept for every variety from which you save seeds, keep as much information as you can. Even in these modern days of computers and databases, one of the simplest methods to use is also one of the best: a card file. Each card should contain the following information: Type of plant (species); variety name (with synonyms, if any); name and address of the source from whom you obtained the original material; date obtained; germination results (each time you test a batch); date the seeds were stored; year the seeds were grown out, and any relevant notes about history, use, or the characteristics of the variety. You may prefer to have a master card for the variety, and then separate cards for each time it is grown out.

It is good to describe a variety as accurately as possible, and this can also be done using record cards. The International Board for Plant Genetic Resources publishes lists of agreed descriptors for many crops, and these provide a useful standard method for listing the characteristics of a particular variety. But you can also devise your own list of descriptors. These should include such things as days to maturity; plant height and habit of growth; fruit size, colour and shape; productivity; response to diseases (susceptibilities and resistances); flavour; and storage qualities.

Photographs can also be useful, especially if you devise a system that makes it possible to produce accurate pictures that include scale measurements. Always include the date the picture was taken in the photograph itself. The best light outdoors is on a bright but overcast day.