3. **Propagating fruit trees**

3.1. Introduction

There are two main modes of plant reproduction in nature: sexual reproduction through seeds, which give rise to new plants after dispersal; and asexual reproduction through roots and other underground organs, which branch out to produce lateral shoots that become independent plants or shrubs. However, the success rate of these methods can be low, particularly due to the rarity of optimal conditions or the advanced age of the mother plant. Additionally, adaptation to the environment can sometimes inhibit seed production.

This is why humans intervene to help nature and ensure the survival and propagation of species. Gardeners use artificial vegetative propagation techniques, such as grafting, layering and taking cuttings, to increase the number of offspring and preserve the desired characteristics of varieties.

3.2 Methods of propagation

3.2.1. Sexual reproduction

This agricultural method involves using available seeds to grow new plants of the same species from which they were collected.

3.2.1.1. Seed selection and harvesting

Seeds should be harvested once they reach maturity, as this is essential for successful sowing. Signs of maturity include natural seed shedding, dry outer shells or soft pulp surrounding the seeds. Some seeds fall off naturally or remain attached to the fruit, such as melon, berry, capsule, acorn and cone seeds. In this case, a colour change can be observed at the point of contact. Seeds that remain attached to the branch can be picked by hand or with a stick; sometimes, part of the branch is pulled along with them. It is advisable to place cloths under the plant to catch the falling seeds.

Seeds are best harvested and handled in good, dry weather. Seed farms employ teams of specialised 'collectors' who know the best plants or ripe seeds and the optimal harvest times. The strength of the next generation depends on the quality of the harvest: strong, healthy parent plants that are carefully selected ensure the production of offspring with the same desirable traits, thus maintaining the variety's purity.

A. **Seed preparation, storage and germination**

The way seeds are prepared and stored varies depending on the type of fruit. Careful selection and storage are essential for successful germination.

A. 1. Seed treatment and storage:

- **Fresh seeds (from citrus fruits, for example):** Sow them immediately in spring in a sunny spot. Germination will begin quickly, within about two weeks.
- **Seeds from firm-fleshed fruits such as apples, pears, grapes and stone fruits:** Spread the pulp out, expose it to the air, clean it, and then separate the seeds. Seeds with hard shells (such as cherries, peaches and apricots) should be stored in a cool, dry place mixed with light potting soil to soften the shell and ensure germination. This process is preferable to opening the shell, as this can damage the seed.
- **Conifer seeds (fir, pine):** Pick pine cones before they fall and dry them to release their seeds.
- **The cones of some species (such as the stone pine) germinate slowly.** Rice and pine seeds take 18 months to mature and the cones remain on the trees for a long time.

A. 2. Factors influencing germination:

- **Pollination:** In dioecious plants, such as date palms, seed production depends on manual pollination between male and female plants.
- **Storage conditions:** Moisture is the main enemy of seeds. After drying, cleaning, sorting and packaging in labelled bags or boxes, the seeds must be stored.
- **Germination rate:** It is difficult to determine the exact germination time as this depends on various factors, including the condition of the seeds at harvest, storage conditions, temperature, the age of the mother plant and the environment.

A. 3.Seed stratification

Stratification is an essential temporary storage step for seeds between harvest and sowing. It preserves their germination capacity and stimulates slow or delayed germination, particularly for hard, fibrous, or starchy seeds that attract rodents (such as nuts, acorns, and almonds).

Stratification involves arranging the seeds in successive layers and covering them with a moderate amount of soil. They should then be stored in a place that is protected from drought and frost. Storing the seeds in containers such as troughs, trays or terracotta pots is preferable to facilitate sorting and transport. A cellar, dry storage room or wall base is suitable.

To protect sensitive varieties, it is advisable to transfer them to a greenhouse or place them under cold frames. Hardy varieties that are available in large quantities can be sown outdoors in the shade (e.g. under evergreen trees) and protected from the sun and flooding.

The soil must drain well; therefore, a layer of gravel or pottery shards is necessary. After spreading a layer of loose topsoil, sow the first layer of seeds, followed by a layer of sandy soil (the recommended main component), then another layer of seeds. Repeat this process until you have reached the desired depth. Five or six layers should be sufficient.

River sand is ideal for composting. To prevent mould, it is advisable to aerate and turn it regularly before use.

Outdoor storage areas which are slightly lit should be watered intermittently. It is also important to take all necessary measures to protect the soil from rodents and other pests.

A. 4. Seed preparation and planting:

Seeds should be planted gently at a depth determined by their size, taking care not to reach the bottom layer. It is important to ensure that the seeds are not planted too densely (to avoid tangling) or too sparsely (to avoid attracting fungal pests)

The ideal time for planting is immediately after harvesting and drying, which is usually in late summer and autumn. Stratification first begins outdoors, where germination is slower, and the actual growth phase usually begins in spring, once the soil has warmed up. If the outdoor soil is still cold, the seedlings are transferred to greenhouses to speed up germination.

Some species only germinate the following year. It is therefore advisable to expose them to cold immediately after harvesting and store them in a cool place.

3.2.2. Asexual reproduction

3.2.2.1. Layering

Layering is a method of vegetative propagation that produces new plants by stimulating root development on a branch or root that is still attached to the parent plant. The new plant then becomes independent once it has been separated from the parent plant.

Most fruit trees can be grafted, provided the roots are allowed to grow for between six weeks and six months. This produces an adult plant that carries the same characteristics as the parent plant.

⇔ **The importance of layering:** Layering is a reliable method for:

- Propagating sterile varieties or those that lose their characteristics when grown from seed, such as certain hazelnut tree varieties.
- Propagating species that are resistant to cuttings, such as trembling aspen.
- Propagating species that are difficult to graft, such as mulberry.

⇔ **Care of mother plants (propagation):**

Only robust, healthy mother plants should be selected and grown under optimal conditions at a low density to facilitate layering. Unused branches should be pruned to encourage new growth and unpruned shoots should be removed to limit sap flow. During the growing season, thinning, pruning, watering, weeding and insecticide spraying are carried out to control pests. It is important to allow mother plants to rest for an entire season to avoid overworking them.

3.2.2.2. **Types of layering**

3.2.2.2.1. Underground or bud layering

A) Simple layering

In this method, rooting is stimulated from a single point within the layer.

- Select a branch close to the ground and bend it until it touches the soil or the surface of a pot filled with soil.
- About 30 cm from the tip of the branch, make a 5 cm cut that penetrates the branch without cutting it completely.
- Apply rooting hormone to the cut to encourage root growth.

- Secure the branch in place with a hook, wire or stone, ensuring the cut remains in contact with the soil.
- Cover the cut with soil or another moisture-retaining material to form a mound. Leave the tip of the branch exposed. If desired, make a 7.5 cm deep hole and insert the cut end of the branch into it before covering with soil.
- Water the plant well.
- Cover the mound with leaves or moss to prevent it drying out too quickly.
- Water the plant regularly.
- Once the cutting has formed roots, cut it from the parent plant and leave the new plant in the same place for a week. This allows the new plant to recover from the separation.
- After a week, transplant the new plant to its desired location.

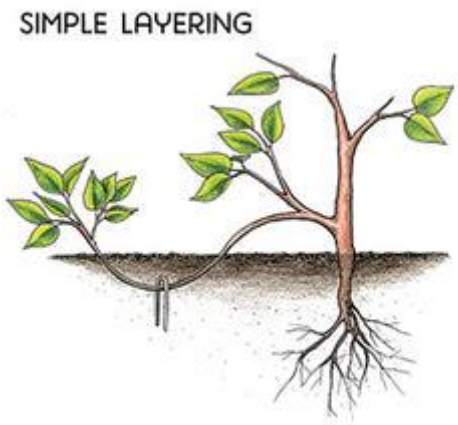


Fig.1. simple layering. https://www.groworganic.com

B) **Compound layering**

This method is similar to simple layering, but it allows us to obtain a large number of seedlings in a short period. The short stem is bent completely downwards and buried in the soil several times, ensuring that the tip remains above the surface. The stem should be kept moist to encourage the formation of new seedlings. This method is commonly used for apples, pears and walnuts to produce a large number of seedlings.

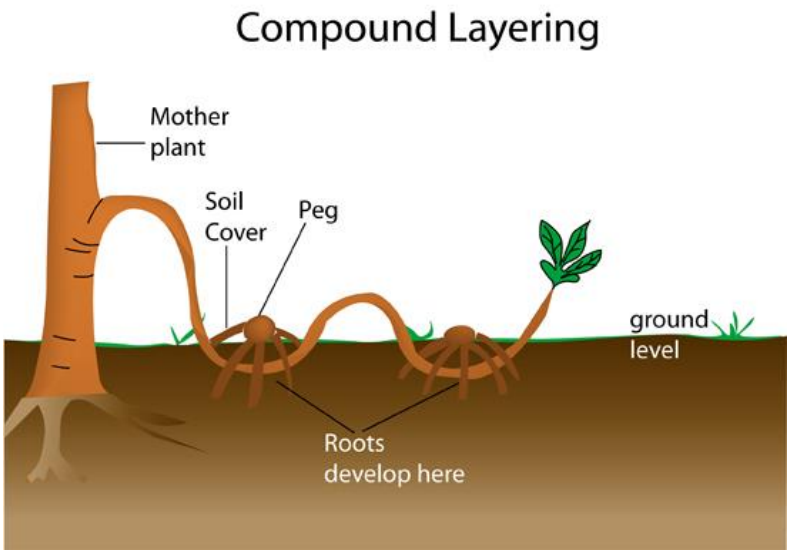


Fig.2. compound layering. https://overallscience.com

C) **Improved Mound Layering**

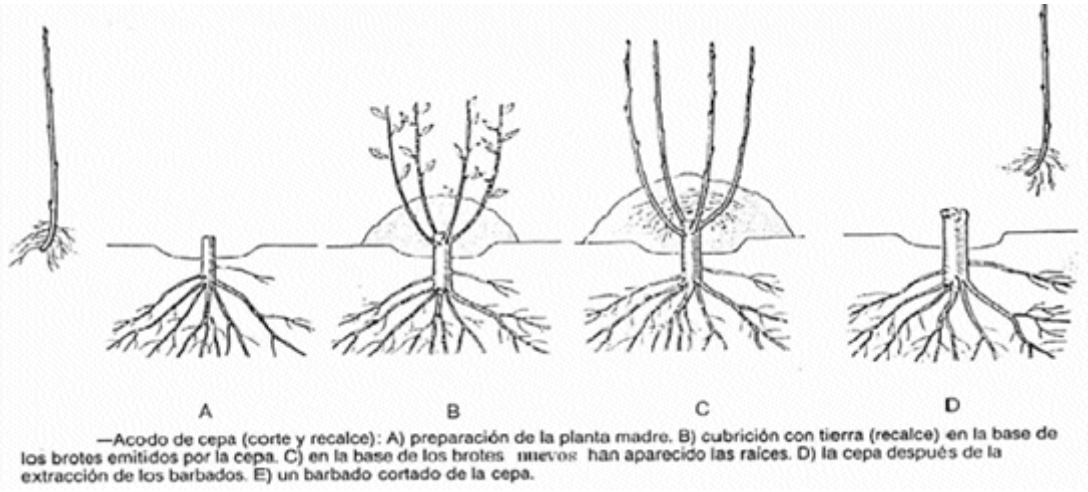
It is an advanced propagation technique, particularly for fruit trees such as apples, that is prominent in Spain. It is based on the principle of 'strangulation' to stimulate the production of natural rooting hormones. Metal wires are placed under slits in the branches, which are then treated with rooting hormones. This process traps and concentrates auxins (growth hormones) in the incision area, thereby stimulating the rapid development of a strong, dense root system.

A detailed explanation of the method is provided below

This strategy manipulates plant physiology through the following steps:

1. Stimulating the mother plant by cutting it near the ground during the dormant season. This procedure forces the plant to produce new, strong side branches from the base.

2. The 'wounding and strangulation' stage Once the new branches have grown to about 30 cm in length, the leaves are removed from the lower part of the branch. Two simple longitudinal incisions are then made in the bark using a sharp knife and coated with rooting hormone. Next, a metal wire is tied tightly around the branch just below the incision area. This compresses the vascular tissue (bark) as the branch grows, preventing the hormones (auxins) and nutrients produced in the leaves from returning to the roots. This forces the plant to produce roots from that point, as these substances accumulate in the area of the incision just above the wire.
3. Cover the 'strangled' and wounded area with fertile soil or peat moss. Strong and dense roots will grow at the incision site due to the high concentration of auxins there. By winter, there will be several branches (about 10), each with its own strong root system.



—Acodo de cepa (corte y recalce): A) preparación de la planta madre. B) cubrición con tierra (recalce) en la base de los brotes emitidos por la cepa. C) en la base de los brotes nuevos han aparecido las raíces. D) la cepa después de la extracción de los barbados. E) un barbado cortado de la cepa.

Fig.3. Mound Layering. https://growingfruit.org

3.2.2.2.2. Air layering

1. We clean an area measuring about 30 cm from the tip and remove leaves and branches from an area measuring 7–8 cm around the node.

2. Incision and hormonal shock

We make two parallel circular incisions 2.5–4 cm apart and remove the ring of bark to expose the white wood. We then carefully scrape the exposed area to remove the cambium (the green layer), which prevents the bark from reforming. Apply rooting hormone to the top of the incision (where the roots will emerge).

3. Prepare the root wrap. Soak a large handful of peat moss in water, squeezing out the excess (it should be moist, not wet), then wrap it around the incision. Then wrap the moss in cling film (or aluminium foil) and secure the ends with string or ties. This helps to maintain the moisture necessary for root growth.

4. Monitoring and weaning. Leave it in place for six to eight weeks (until the roots clearly fill the wrap). Once the roots are well formed, cut the branch just below the root wrap. Carefully remove the plastic wrap, keeping the moss around the roots to avoid stressing them, and plant the new branch in a pot with suitable soil.

This technique is similar to the one I described earlier (the Spanish system), but instead of using wire to 'strangle' the branch, the bark is manually removed to stimulate the accumulation of auxins and root formation in that specific spot.

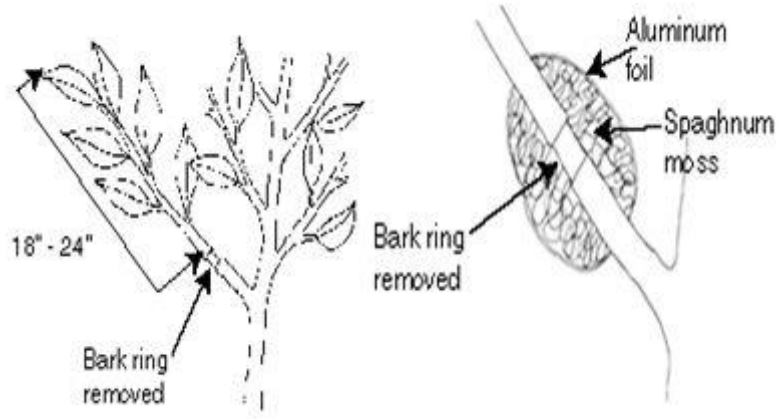


Fig.4. Air layering. https://uk.pinterest.com

3.2.2.2. Cutting

Propagation by cuttings involves stimulating parts of the plant, such as the stem, bud, root or leaf, to grow as an independent entity. This requires careful balancing of soil, moisture and temperature conditions to ensure a viable response from the cutting.

A) Stem cuttings.

This method uses branches (up to three metres long in some species) taken from the mother tree. The base of the cutting is sharpened to facilitate penetration, and the side branches are pruned while preserving the growing tip. The branch is then fixed in the ground manually or using a peg and immediately watered to ensure the soil adheres to the base. The seedling is secured with wind support and the soil is compacted with the foot to allow air in. Finally, the bark is coated to protect it from drying out too much.

B) root cuttings Propagation

Propagation by root cuttings is an easy and effective way to grow certain types of plants, particularly shrubs, without requiring complex skills. Although this method is simple, it requires caution to avoid exhausting the parent plant. Therefore, it is advisable to take a limited number of cuttings to preserve its strength.

- Cuttings are taken during the winter (when the plant is dormant), avoiding days when frost is severe. When it comes to shrubs, there is no need to uproot the entire plant;

digging around it to reach the side roots is sufficient. Smaller plants can be carefully lifted using a garden fork.

- 2. Using sharp, sterilised pruning shears, cut off a section of the root and divide it into pieces between 3 and 10 cm long depending on the variety's size, ensuring that each piece has at least one bud. Then immediately replant the mother plant, covering the roots to prevent them drying out or becoming exposed to the air.
- Cuttings can be planted directly in the ground, such as comfrey, or in dedicated trays.
- Keep the trays in a frost-free, unheated location and spray them regularly with water to maintain moisture. Avoid overwatering to prevent root rot.
- Sprouts usually begin to appear between April and May. If the seedlings show strong root growth, they can be transferred to permanent soil in spring. If growth is slow, it is best to wait until the following autumn to ensure successful establishment.

C) Propagation cuttings in water

This method involves placing cuttings in clean water until roots appear. This step takes place in spring and summer. It is used for certain plants, such as mint and willow.

D) Leaf Propagation Techniques

This method involves placing leaves in the centre of the pot and is effective for a variety of plants. To ensure successful propagation, it is important to provide adequate light, heat and water.

E) Heel cutting

A small secondary branch is cut, leaving the part that connects it to the main branch from the previous year. This results in an area suitable for root formation. While this increases the chances of success, taking the heel may damage the parent plant. This method is used for woody plants. Cuttings are taken in spring, late summer or autumn.

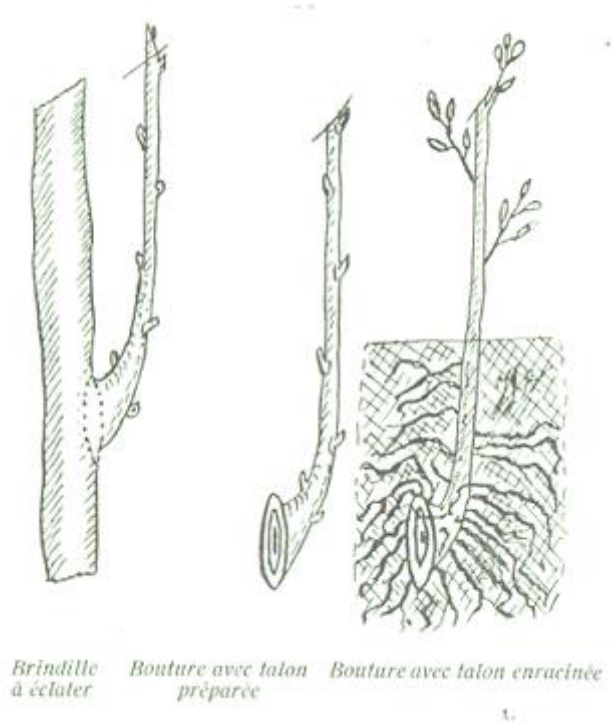


Fig.5. Heel cutting. https://www.lharmonydesjardins.be

F) Cross-cut

This is a type of heel cut where a complete section of the main branch, around 1.5 cm long, is retained, giving the cutting the shape of a small stick. This method is especially useful for plants that are slow to root or have hollow or pithy stems, as the cambium protects the fragile tissue from pathogenic fungi. It is carried out in summer or at the beginning of autumn.

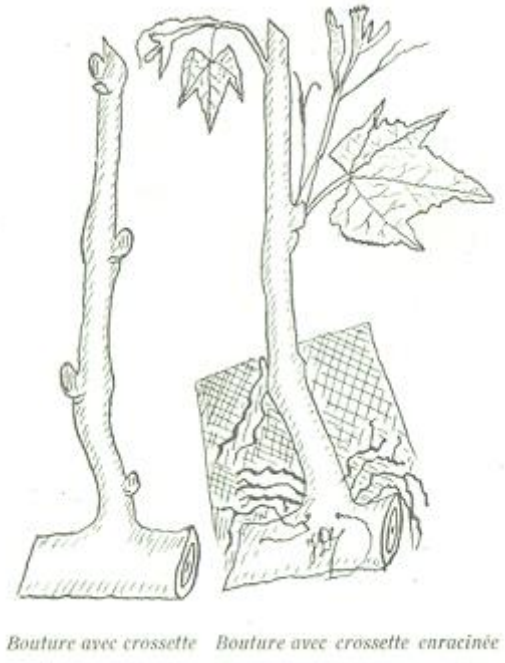


Fig.6. Cross-cut. https://www.lharmonydesjardins.be

G) Eye cuttings

It consists of a small piece of branch (2–5 cm long) with an axillary bud (in the leaf axil) that can grow and form a stem. This technique enables you to obtain multiple cuttings from the same stem, though it takes time for the cuttings to grow into plants. This process is carried out at the end of summer and the beginning of autumn.

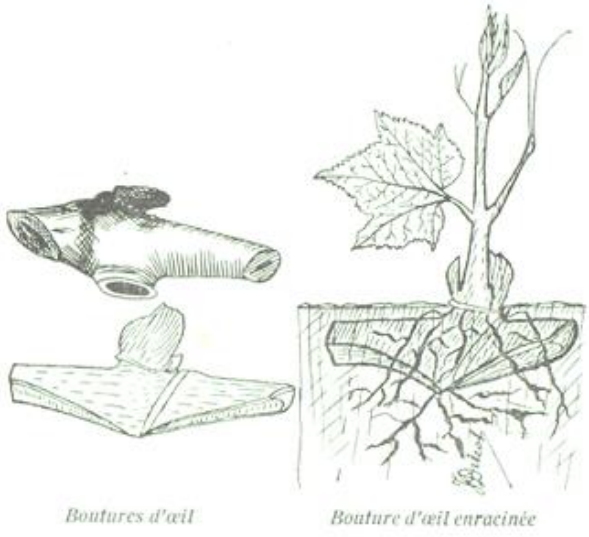


Fig.7. Eye cuttings. https://www.lharmonydesjardins.be

3.2.2.3. Division

For perennial plants that grow in 'clumps' or carpets and have been in the garden for several years, dividing them will allow them to multiply and give them more strength. This process aerates the roots and centre of the plants, giving them more space and rejuvenating them to improve flowering.

3.2.2.4. Grafting

Grafting is a propagation process that involves attaching a scion (a plant or part of a plant) to a rootstock (another part of a plant), which provides support and nutrients for the scion's growth. The term 'grafting' refers to the entire process.

One of the conditions necessary for success, particularly with woody plants, is that the two parts being joined are close together. The two species being grafted must belong to the same plant family; however, this does not mean that all plants in the same family can be grafted. Similarities in the sap and bark of the plants, as well as their strength, also contribute to the process's success, as do moderate temperatures and skilled hands using precise tools.

⇔ Reasons for grafting plants is to:

- To produce strong, reliable plants that are disease-resistant and bear fruit and flowers more quickly.
- Grafting also provides an opportunity to develop new varieties that produce more fruit per tree or are more resistant to insects and diseases.
- Producing dwarf plants makes harvesting easier and is a better option for home gardening.

⇔ Grafting methods

Although there are many different grafting methods, they can be grouped into three main categories:

- Approach grafting
- detached branch grafting
- Detached eye or bud grafting

3.2.2.5. In vitro culture

In vitro culture is a laboratory technique that enables a complete plant to be regenerated from plant cells or tissues that are cultured in a sterile, biologically controlled environment. This technique is performed in a sterile environment under carefully controlled growth conditions. It is based on the principle of totipotency, whereby each plant cell has the potential to develop into a complete plant if it is provided with the correct nutrients, hormones and a sterile, controlled environment.

In vitro culture is used in micropropagation to produce a large number of genetically identical plants from a small piece of tissue, such as a node or bud. This process is similar to grafting. It can also be used in meristematic culture, which uses undifferentiated cells capable of forming all plant tissues. This method is used to produce virus- and disease-free plants as these cells typically do not contain viruses or diseases. This method also produces somatic embryos (plant embryos formed from non-reproductive cells through hormonal stimulation) and is used to produce genetically identical plants.

Embryo rescue involves extracting very small embryos immediately after fertilisation and culturing them in a sterile medium in a laboratory. This is either to accelerate the development of the next generation or to complete their growth when they are unable to develop within the parent fruit.

Another application is the obtaining of haploid plants, which have a single set of chromosomes. These chromosomes can then be chemically duplicated (for example, using colchicine). This is important for rapidly accessing pure lines in plant improvement.

Obtaining a protoblast (a cell from which the cell wall has been removed by enzymes): It can be combined with another protoblast to form hybrid plants or introduce genetic material. For example, new genes can be introduced via electroporation to produce genetically modified plants.