IV. GRAFTING FRUIT TREES

1. Introduction

Grafting techniques are one of the most important methods of propagating woody plants, increasing their diversity and enhancing their characteristics. These techniques have evolved over centuries through the experimentation of gardeners and nurserymen. In his book L'Art de greffer, Charles Pelt explains that there are many different grafting methods, which vary according to circumstances and needs. In fact, they often originate from random experiments or the judgement of farmers. Nevertheless, these methods have evolved into systems that are of great benefit to modern horticulture.

the classifying these methods is challenging due to their diversity and the overlap in their commonly used names. However, they can be broadly divided into three main groups:

- Approach grafting (greffage par approche), where one part of the plant is brought close to another until they stick together;
- Grafting using a separate branch (greffage par rameau détaché), which includes classic methods such as bark grafting and cleft grafting.
- The third group is grafting using a separate bud or eye (greffage par œil ou bourgeon), which involves separating a bud with part of the bark.

These methods are used in different situations, depending on factors such as the type of plant, the size of the rootstock, the condition of the sap and the season. However, they all share the same objective: to successfully fuse two living parts of a plant to produce a new plant that combines the characteristics and taste of the rootstock.

2. Conditions for successful grafting (Conditions de succès du greffage)

Successful grafting depends on several basic conditions that directly affect the likelihood of the grafts integrating properly with the rootstock, as well as the skill with which the cutting and assembly are performed:

- **Skill:** the gardener's ability to make precise cuts, prepare and match surfaces well, and join them correctly is the most important condition for success.

- **Compatibility between the two types:** there must be biological harmony between the scion and the rootstock, i.e. a close taxonomic relationship or living compatibility, because incompatibility leads to grafting failure.
- **Strength of the rootstock and scion:** both the rootstock and scion must be strong and vigorous; weak or exhausted plants reduce the chance of successful integration.
- The success of grafting also depends on the condition of the sap inside the plant, as integration is faster and more effective when the sap is active. If the sap is stagnant or dry, the graft is less likely to take.
- Close proximity of tissues: the cut surfaces of the scion and rootstock must be tightly joined so that the cambium (the growth layer) of both is in contact with no gaps or displacement.
- Season and weather conditions

- The season affects the success of the process.
- A moderate climate, without hot winds or severe cold, promotes successful grafting.
- Moderate temperatures are best because they stimulate sap flow within the plant.

- Surrounding environment during grafting: A calm, relatively warm environment that is protected from drought or severe cold facilitates successful grafting. Grafting in very hot weather or heavy rain can hinder the process. In very cold areas, it is preferable to graft in a greenhouse.

3. The different grafting methods

The grafted are divided into three main group**s:**

- Approach grafting
- Grafting using a separate branch
- The third group is grafting using a separate bud or eye

A. Approach grafting.

This involves joining two plants, either in the same soil or in any container, by their stems or branches. The grafting season runs from March to September, when the sap is flowing.

⇔ **Types of Approach Grafting**

a) **Side grafting**

The scion is the wild tree or other plant that you wish to transform. The rootstock is a nearby tree or branch. The scion and rootstock must be as close to each other as possible so that they can be joined together by incisions that fit neatly into each other.

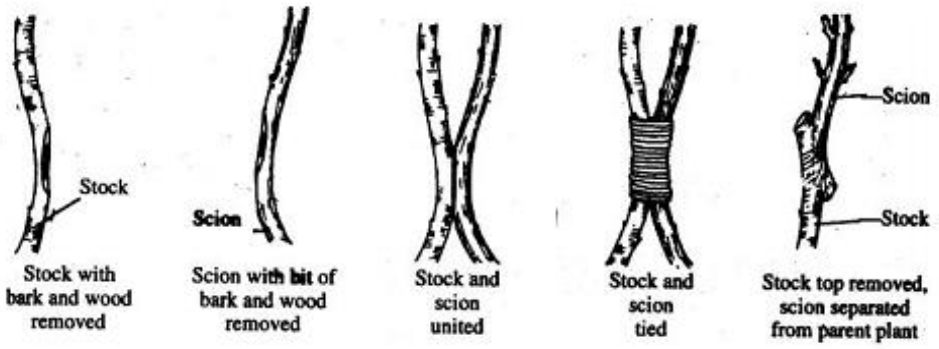

Fig.1. Approach grafting. https://www.expertsmind.com

b) Top grafting

This method is used when side grafting is difficult or slow to heal. The top of the rootstock is cut off (étêtage), and the scion is inserted at the top to ensure good contact.

c) Grafting by approach with an arch (arc-boutant):

The scion is cut and inserted under the bark of the rootstock in an arch-like manner, leaving the upper end wedge-shaped. It is secured with string and glue, and the part exposed to the sun can be protected. This method is only performed during the sap flow period.

B. Grafting with a separate branch

The rootstock can be a whole plant or just a part of one. It is grown on site, in a nursery or in a pot if this is not possible. Whole plants are usually grafted outdoors, except for small potted plants, branches and cuttings intended for glasshouse grafting. Plants are often dug up from the nursery, grafted in a protected location and then replanted immediately in a healthy, well-ventilated and relatively cool spot.

During grafting, a bud preserved at the top of the seedling attracts sap to the scion and accelerates adhesion. The scion, which can be a branch or part of a branch, has at least one bud and is between 4 and 15 centimetres long.

B.1. Side grafting under bark.

Side grafting under the bark is an effective propagation technique for trees and shrubs, mainly involving inserting the scion between the bark and wood of the rootstock

There are two methods, depending on the condition of the bud and sap activity. It is performed at the peak of sap rise. A scion from the previous year's growth is used, provided it has been stored in a cool, shady place (buried in sand) to preserve its vitality.

Alternatively, shoots from the current year's semi-woody growth taken from the base of the branch can be used. Ensure the buds are fully developed and prepare them as follows:

- ⇔ Pick them right before grafting.
- ⇔ Remove the leaves, leaving only the petioles.
- ⇔ For evergreen species, cut half the leaf area to reduce transpiration, then tie and cover the scion well.

The technical method varies depending on how the scion is cut and how the rootstock is prepared.

- ⇔ **Flat-cut grafting:** The tip of the scion, which contains several buds, is cut at a long angle and inserted into a shallow slit in the rootstock, between the bark and the wood. It is preferable to preserve the terminal bud of the scion.

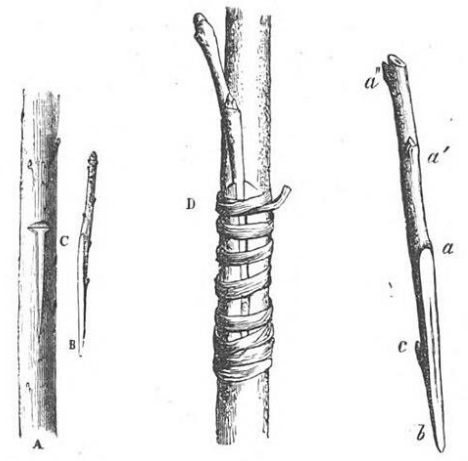

Fig.2. Flat-cut grafting. Charles Baltet 1869

⇔ **For English grafting** (also known as tongue grafting), a small longitudinal slit (or tongue) is made in the slanted wild stock of the scion and a similar slit is made at the point of contact with the rootstock. This overlap increases the stability of the union, followed by binding and waxing.

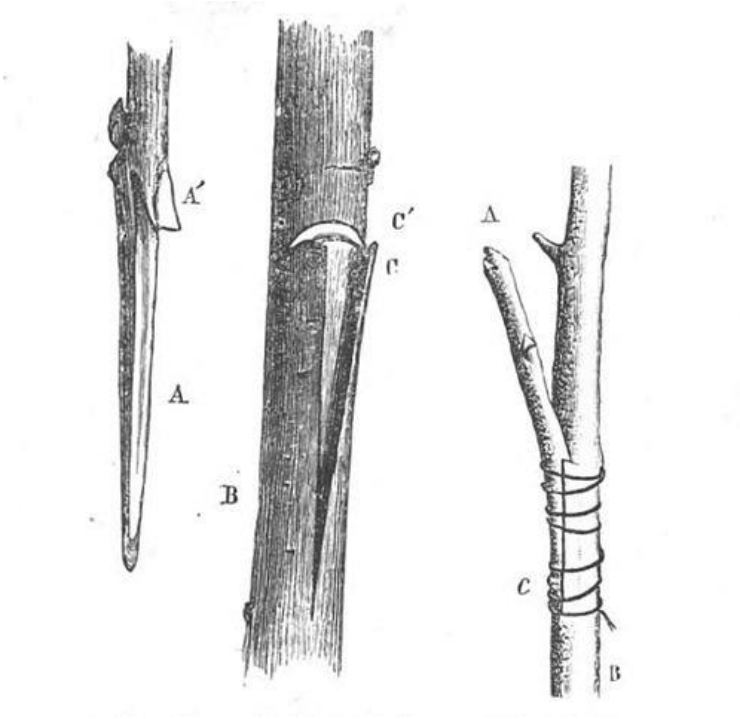

Fig.3. For English grafting. Charles Baltet 1869

⇔ **For base grafting**, the scion branch is taken with a part of the bark (the cortex base), resembling a shield. This is then inserted into a T-shaped incision in the stock and tied in place, before being protected from the sun with a leaf or paper cover.

For successful grafting, the following must be done:

- The binding must be tight to ensure tissue contact and prevent the graft from drying out.
- In sunny areas, it is advisable to shade or cover the graft until it is completely fused.
- Use sharp, sterile blades to make a clean cut that does not tear the vascular tissue.

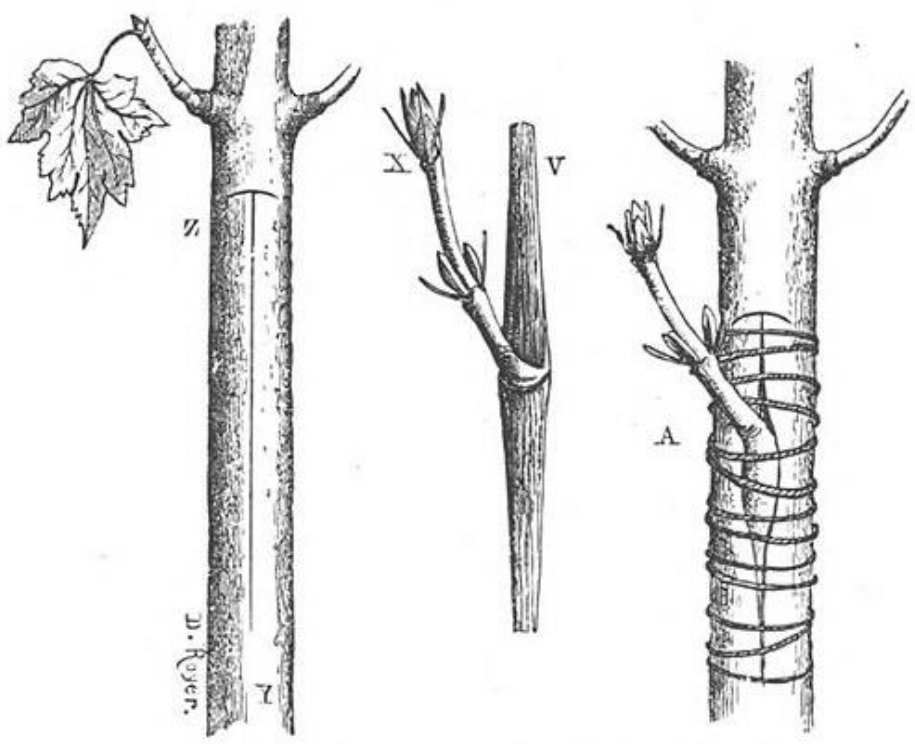

Fig.4. For base grafting. Charles Baltet 1869

B.2. crown grafting

Crowning grafting is one of the most effective methods of regenerating large trees and shrubs. It relies on sap flow in spring to ensure the scion bonds with the rootstock. To ensure success, the rootstock must be prepared by 'top pruning' (pruning the top) three to four weeks before grafting, or even in the previous autumn. At the start of the process, the cut sites are thoroughly cleaned with a sharp knife to remove any damaged tissue.

- The scions are cut in winter and stored in a cool place to keep them dormant while the rootstock begins to become active. The scion should be 5–12 cm long and have two or three buds at the top.
- The lower end of the scion is cut flat in a flute-like fashion. This cut starts at bud level and passes through the pith, reducing the thickness of the scion and ensuring complete adhesion to the rootstock wood.

- To prepare the site, a pointed wooden or ivory tool is used to create a small gap between the bark and wood, allowing the position to be tested and preventing tissue damage when inserting the scion.
- The graft is then inserted between the bark and wood using hand pressure. If the graft is thick, it is advisable to make a small longitudinal incision in the rootstock bark to facilitate sliding without tearing.
- The greater the diameter of the branch to be grafted and the greater the number of grafts, the more distance should be left between each graft, with at least 5 cm being ideal.
- The grafts should be tied tightly to ensure stability without strangling the bark.
- All exposed wounds should be coated with grafting paste (mastic) to prevent them from drying out and to stop diseases entering.
- If the graft is close to the base of the tree, the surrounding soil can be piled up to cover the lower buds. This preserves moisture and encourages the grafts to take root.
- This method is ideal for large trees as it enables multiple grafts to be planted simultaneously, helping the tree absorb and distribute strong sap from the roots.

⇔ **Standard crown graft**

Given that subject B has been severely pruned, we insert three grafts (c, c', c'') in proportion to its diameter. It would be difficult to place several grafts without splitting the bark in at least one place, as the tension produced by inoculating several branches would eventually cause the cortical layers to crack. This is prevented by a longitudinal incision (D), which facilitates the sliding of graft C' and allows the others (C and C') to sit comfortably without threatening to split the bark of the subject. The stem is then ligated and glued at the top of the grafted branches and on the bark opposite their backs. Fig. 5

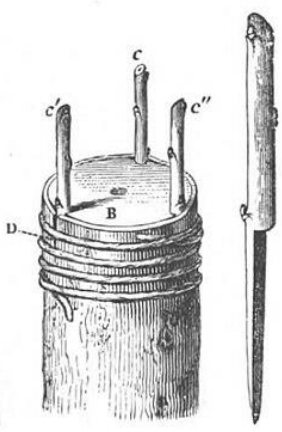

Fig.5. Standard crown graft . Charles Baltet 1869

⇔ **Improved crown grafting**

This graft differs from the previous one in two key ways:

1. Improved: Firstly, subject A is cut at an oblique angle (B), and the graft (F) is inserted at the top with a sharp-angled tongue (H) that fits snugly onto the slant of the cut.

2. The subject must be incised: once the grafting knife has been applied, only one side (C) of the incised part is lifted with the spatula. The graft is slid in so that the sharpened inside of the bevel is applied against the sapwood (E) and the back (G) is covered by the lip (C).

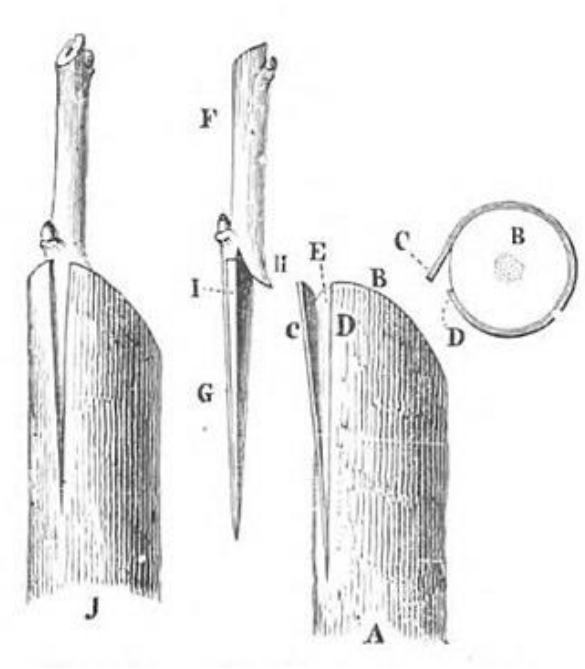

Fig.6. Standard crown graft .Charles Baltet 1869

C. in-situ grafting

This method is ideal for grafting evergreen trees and shrubs, and is favoured for 'under cover' grafting (à l'étouffée). The following are the key factors for its success:

Farmers practise this type of grafting outdoors or in greenhouses. It is best performed at the beginning of the sap rising period, particularly for evergreen plants. The 'stock' should have moderate sap flow and the 'scion' should be fully woody ('aoûté').

Depending on when the grafting is done (fall or spring), the scion should be from the current or previous year's growth. It should be between 5 and 15 cm long. The lower end should be cut flat and precisely, without any zigzags, to ensure it fits perfectly onto the rootstock.

The process involves placing the scion directly on top of, or to the side of, the rootstock. Sometimes, to increase stability, the 'tongue and groove' technique is used, or the scion is placed under a strip of bark.

The buds at the top of the rootstock help draw sap towards the grafting area, promoting union.

Avoid moistening. This method is not recommended if the grafting area needs to be covered with soil (terrage), as soil moisture could prevent the tissues from bonding properly.

C.1. The normal (lateral) grafting

This method involves integrating the scion with the outer layers of the rootstock (the sapwood) in order to ensure fusion of the vascular tissues.

- No pre-pruning is required. If the plant is evergreen, only the leaves at the grafting site are removed by cutting them from the neck or middle of the blade.
- The graft is prepared while preserving its leaves and the lower end is cut straight (flat), starting from the side opposite the bud.
- Using a grafting knife, make two precise marks on the rootstock to determine the boundaries of the required 'gap'.
- The bark is then scraped off and the first thin layers of sapwood between the two marks are removed.
- The scion is then inserted into the gap so that its sharpened surface adheres completely to the rootstock wood; its back should appear as a natural extension of the rootstock stem.

A special grafting knife with a spoon is preferred for its precision in measuring and hollowing, but a regular grafting knife or a very sharp pruning knife can be used instead if necessary.

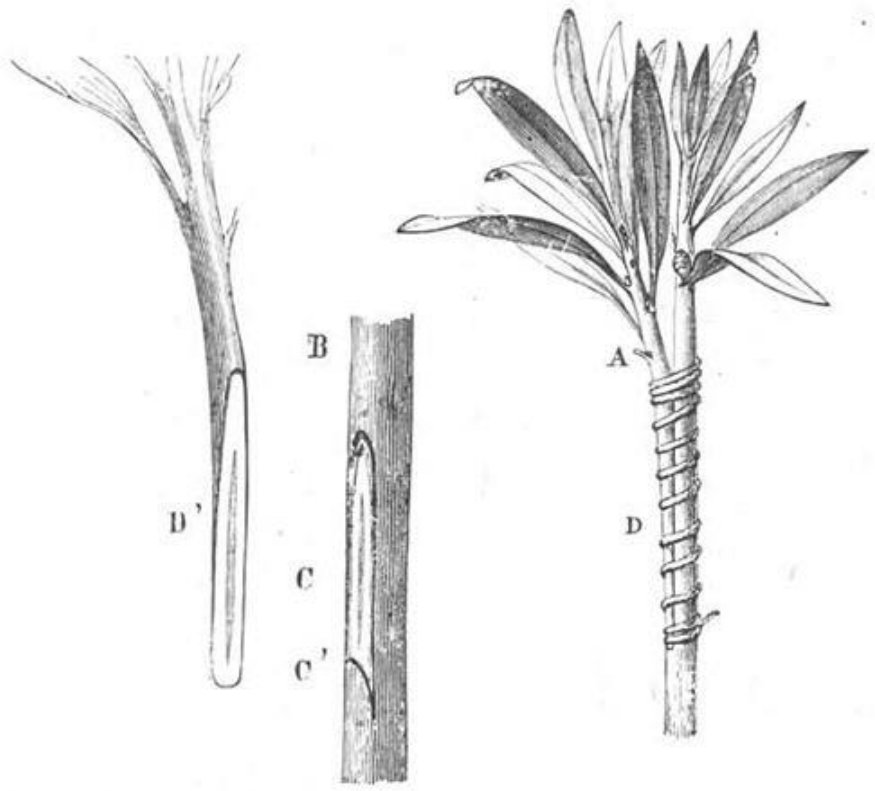

Fig.7. The normal (lateral) grafting. Baltet 1869

C.2. English-style grafting

This method is characterised by the presence of 'tongues' (languettes) that increase the stability of the graft and double the contact area between the cambium tissues (bark and wood).

- **Prepare the scion:** Cut the lower end at a flat angle and then make a longitudinal slit from bottom to top with a knife to form a 'tongue'.
- **Prepare the rootstock** by making an identical cut. Make an identical cut on the side of the rootstock with two slits, one at the base and one in the middle.
- **Assembly:** Insert the tongue of the scion into the slit in the rootstock (and vice versa), ensuring the parts fit together and the wood is completely covered to prevent the scion from slipping.

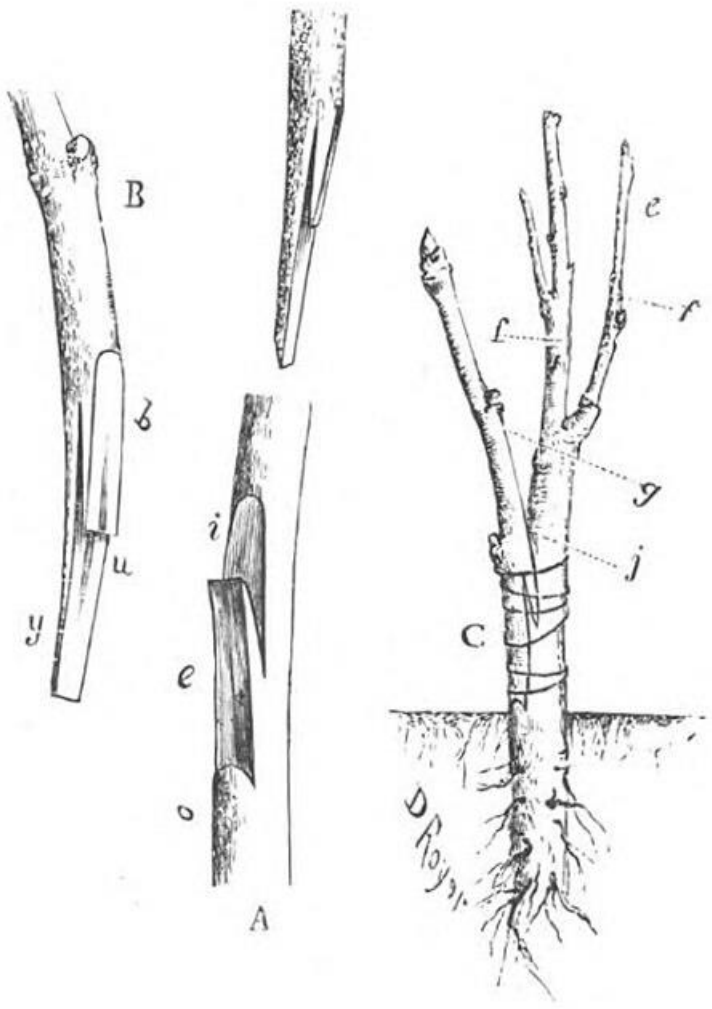

Fig.8. English-style grafting . Baltet 1869

C.3. Apical grafting technique (apical placage)

This method involves fixing the graft at the top of the cut rootstock, featuring a 'shoulder' or upper notch to ensure perfect stability.

Rather than cutting the graft at a sharp angle, a small transverse incision (the shoulder) is made at the top of the cut area (the scion). This incision enables the graft to rest firmly on the edge of the rootstock, preventing it from slipping and ensuring that it remains perfectly vertical.

Using a spoon grafting knife, the width of the grafted part of the scion is accurately measured. The scion is placed on the side of the rootstock and four points (d1 to d4) are marked to define the boundaries of the 'gap' that the scion will occupy. Thanks to the knife's sharpness, the bark is cut precisely according to the measurements taken and then removed from that area to prepare the 'bed' in which the graft will be placed. The same procedures as for crown grafting are then

applied to secure the graft well and cover the wounds with grafting paste (mastic) to prevent them from drying out.

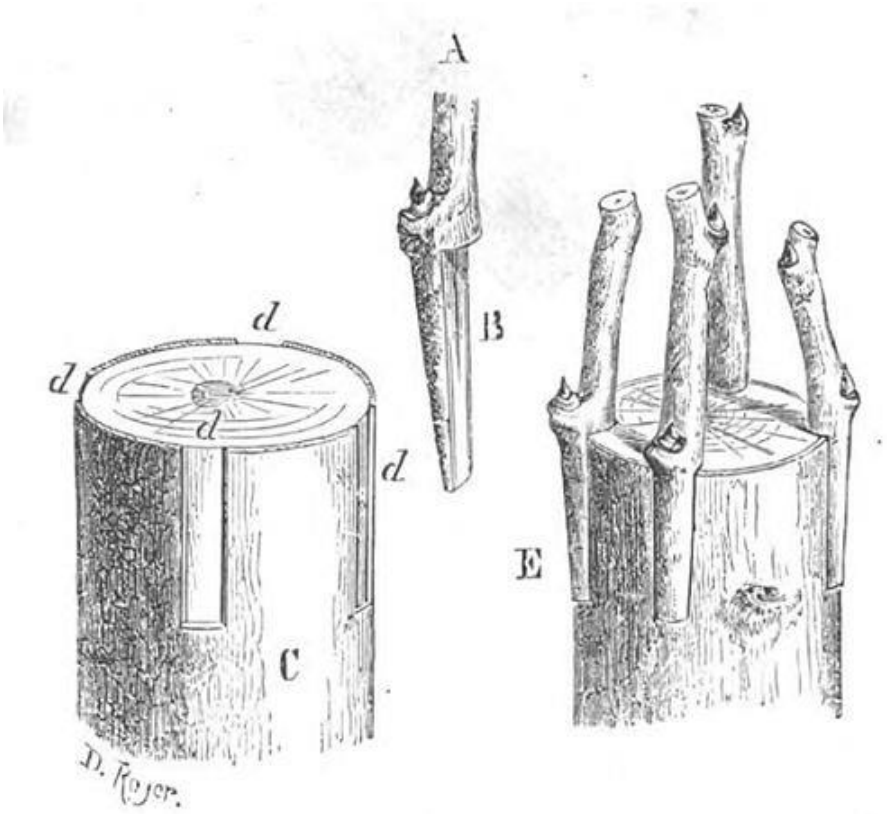

Fig.9. Apical grafting. Baltet 1869

C.4. Bark grafting technique using bark tape

This method involves covering the base of the graft with a 'tongue' or strip of bark from the rootstock, which provides natural protection and speeds up tissue union.

- Preparing the scion (V): Cut the lower end of the scion at an angle with a slight curve at the base to ensure a good fit.
- Preparing the stock (X): Use a grafting knife to measure the width of the scion. Cut the bark of the stock lengthwise to create a 'strip' (lanière), then pull this strip down to expose the wood. Place the scion directly onto the exposed wood and lift the bark strip to cover the cut base of the scion.
- Fixing (Y): Tie the grafting site tightly and apply grafting paste (mastic) to any exposed gaps to prevent air from entering.
- Monitoring: The ties must be checked regularly to prevent the stem from being 'strangled' as the scion grows.

- Pruning in spring grafting: Gradually cut back the head of the rootstock, leaving 10 cm as a support. Then, completely remove this support in August.
- Pruning in August: Leave the rootstock as it is throughout the winter and prune it the following spring, removing the excess part after a full year of growth.

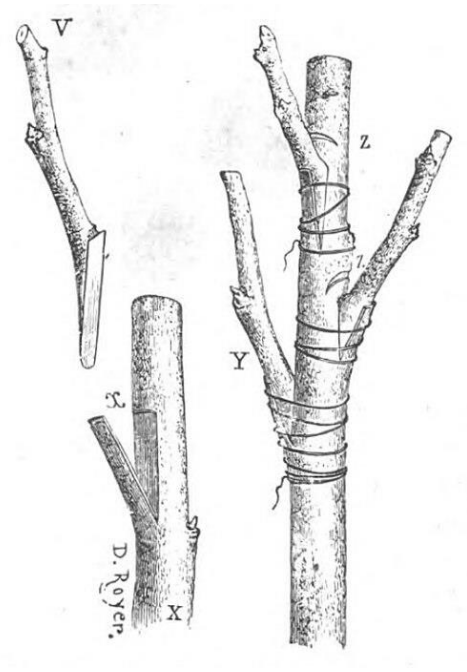

Fig.10. Bark grafting technique using bark tape. Baltet 1869

D. inlay grafting

Take a scion bearing two or three buds. Cut it at the base to form a short wedge and insert it into the rootstock at an angle, ensuring that the cut surface of the rootstock matches the wedge-shaped surface of the scion. Tie the graft tightly and cover the cuts with grafting wax to ensure protection and adhesion. Spring, when the sap begins to flow, is the best time for grafting. Grafting can also be done in summer using semi-woody branches or in August and September using semi-mature grafts. Late March and April are also preferable times for grafting.

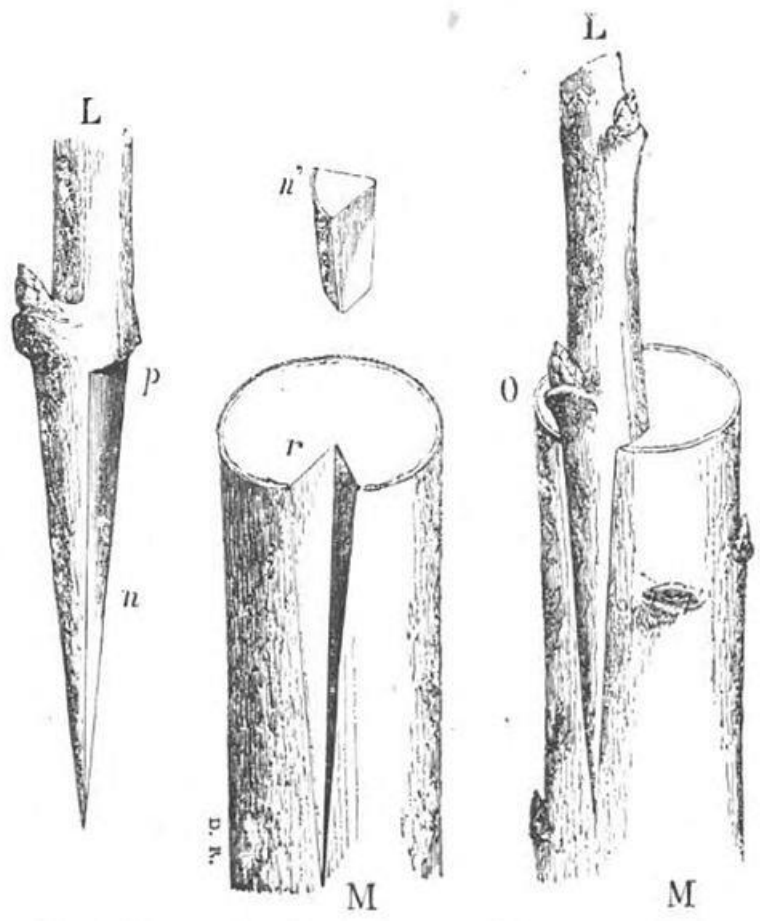

Fig.11. inlay grafting. Baltet 1869

D.1. Grafting at the top

The scion is shaped like a triangular wedge with a small protrusion to help stabilise it on top of the rootstock. The graft is placed on the grafting site on the rootstock to determine its shape. Then, the bark and wood are cut to form a suitable, wedge-shaped opening. The scion is then fitted tightly into this slit, tied securely and the grafting area is covered with insulating material, such as wax or paste.

D.2. Side grafting

This type is used when a branch is to be inserted into a side position on the stem. Both the graft and the rootstock are prepared by making corresponding grooves at the grafting position and joining them tightly together. This type of graft is more durable than the cleft graft, especially if the stock's surface is rough. After grafting, tie and cover the graft area, then prune the stock branches short to encourage scion growth.

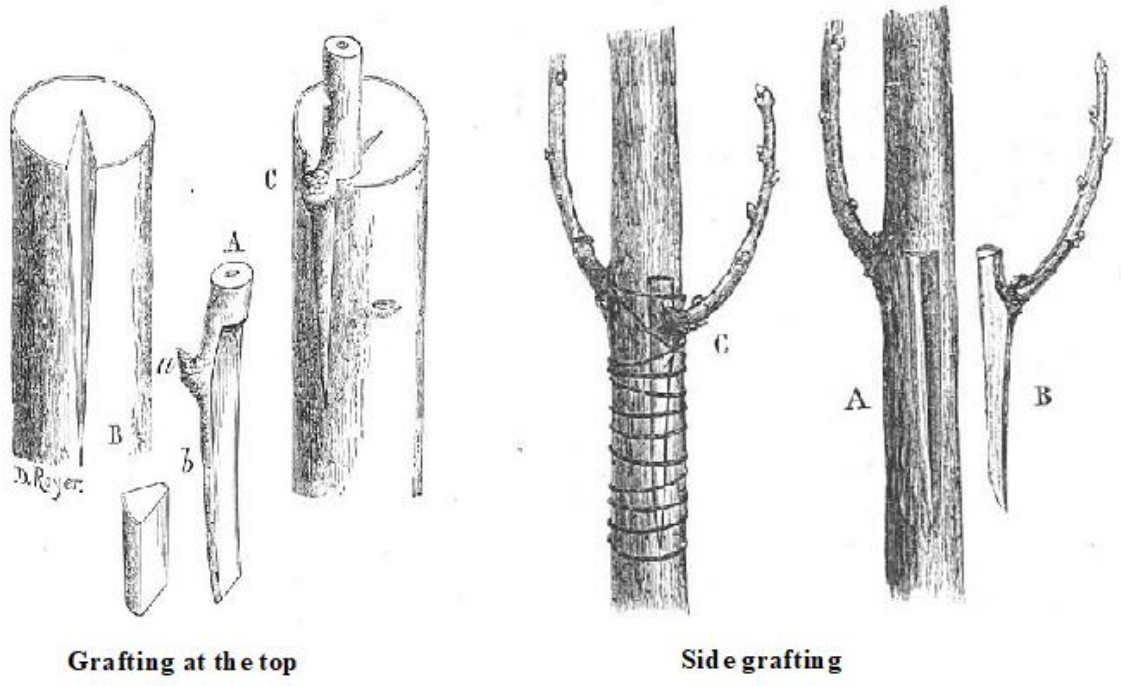

Fig.12. inlay grafting. Baltet 1869

E. Grafting into living wood (Ober)

This category encompasses several traditional grafting techniques, such as spiral grafting at the top of the trunk. This method involves inserting a piercing tool vertically between the bark and living wood to prepare the graft site. Another technique is side grafting, where the stem is carved at an angle without reaching the heart, facilitating the insertion of the graft. These methods were employed by Crimean farmers. However, these primitive methods have largely been abandoned and are no longer common. There are two types:

- Apical grafting in living wood
- Side grafting in living wood

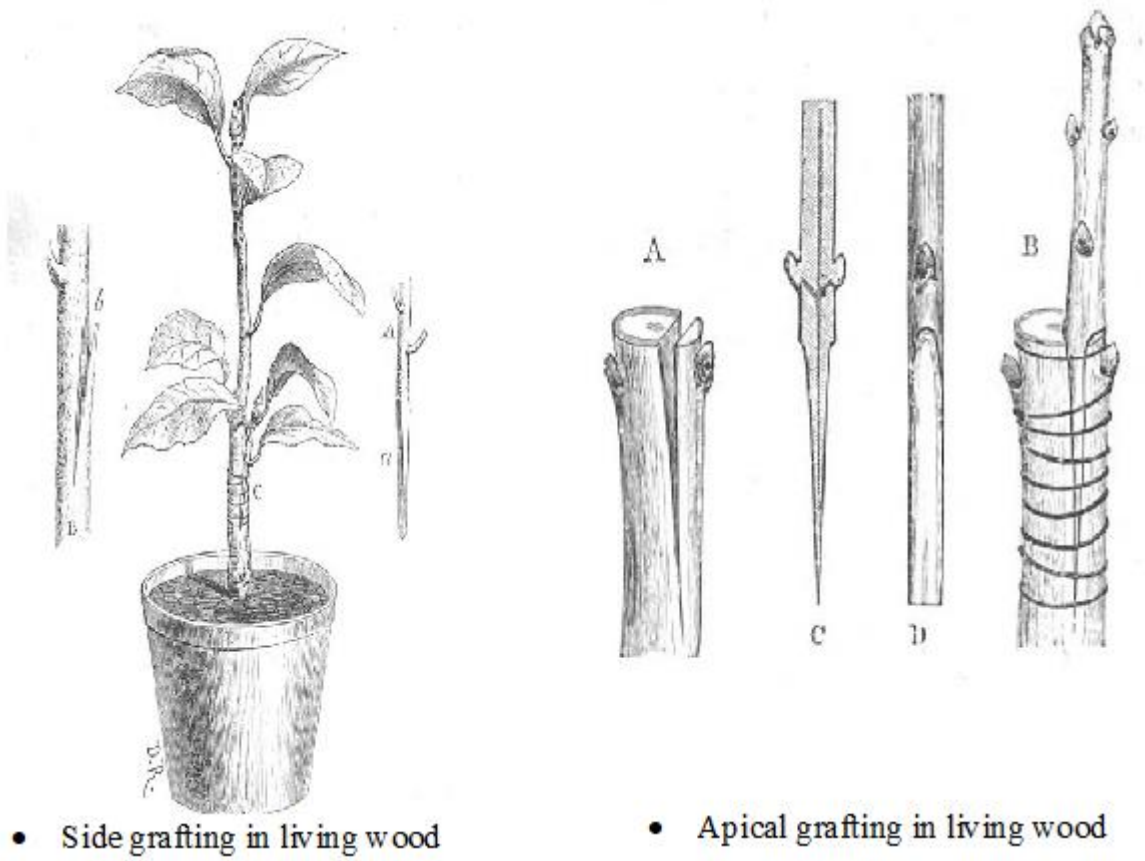

Fig.13. Grafting into living wood (Ober). Baltet 1869

3. Eye or bud grafting:

In woody plants, the terms 'eye' and 'bud' have the same meaning. This type of grafting relies on the use of a single bud attached only to the bark, excluding the wood. This bud is known as the scion. The scion must include the entire layer of bark down to the living wood because a lack of bark will reduce the success of the graft. There are two main types of this grafting: shield grafting (also known as eye propagation) and tube or flute grafting.

The rootstock must be in a state of sap activity so that the bark can be easily separated from the wood. Any obstructing branches must be removed beforehand. It is also preferable for the rootstock and scion to be at a similar stage of growth.

3.1. Grafting (propagation by budding)

This is the most common method used in nurseries. When grafting in summer, the bud is taken from the current year's branches, and when grafting in spring, it is taken from the previous year's branches. Healthy buds of medium strength should be chosen.

3.1.1. Propagation by budding under the bark (grafting):

The bark of the rootstock is cut into a T shape and the bud is quickly inserted underneath to prevent drying out. It is then tied tightly in place, taking care not to cover the bud itself. Flexible ties, such as raffia or wool, are used and care is taken to protect the grafting site from drying out or extreme heat.

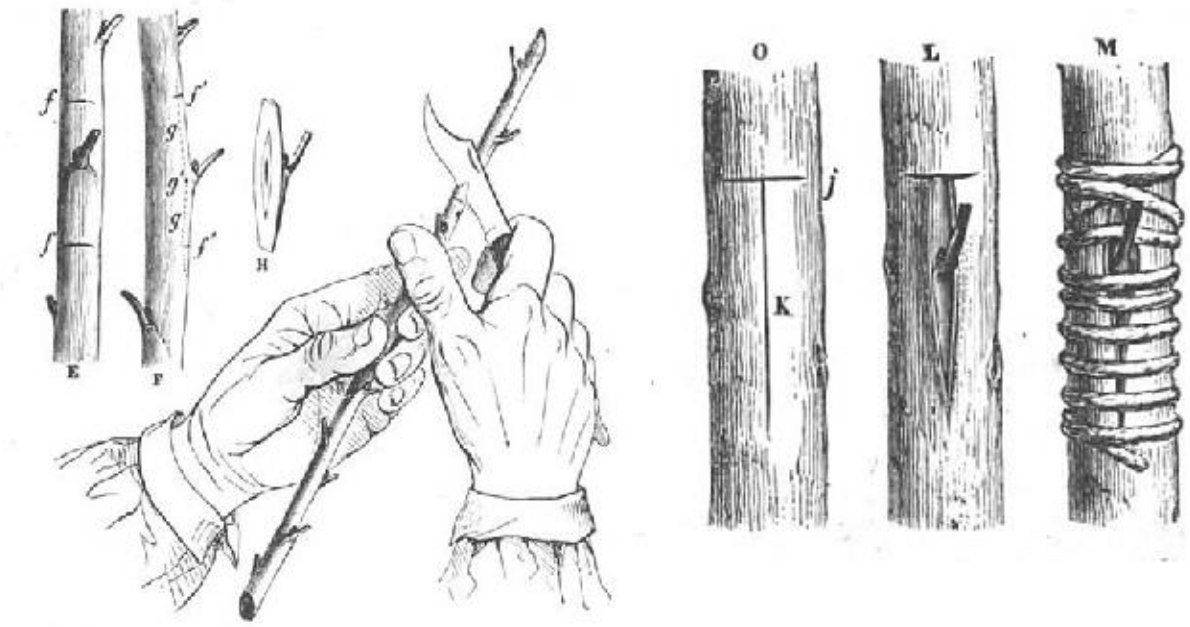

Fig.14. Propagation by budding under the bark (grafting) Baltet 1869

3.1.2. Grafting with a shield (assembly):

This method is used when it is difficult to separate the bark. Part of the rootstock bark is removed and replaced with a shield carrying the bud, which is then carefully tied in place. This method is used for some trees, such as figs and mulberries.

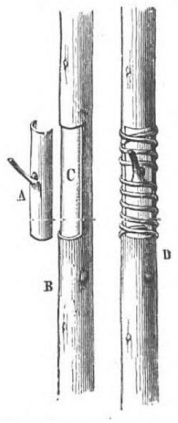

Fig. 15. Grafting with a shield (assembly) Baltet 1869

3.1.3. Compound or double grafting

This involves placing two or more buds on the same rootstock to increase the chances of success or to create fan- or palm-shaped trees. Bud grafting may be used as a precursor to subsequent branch grafting.

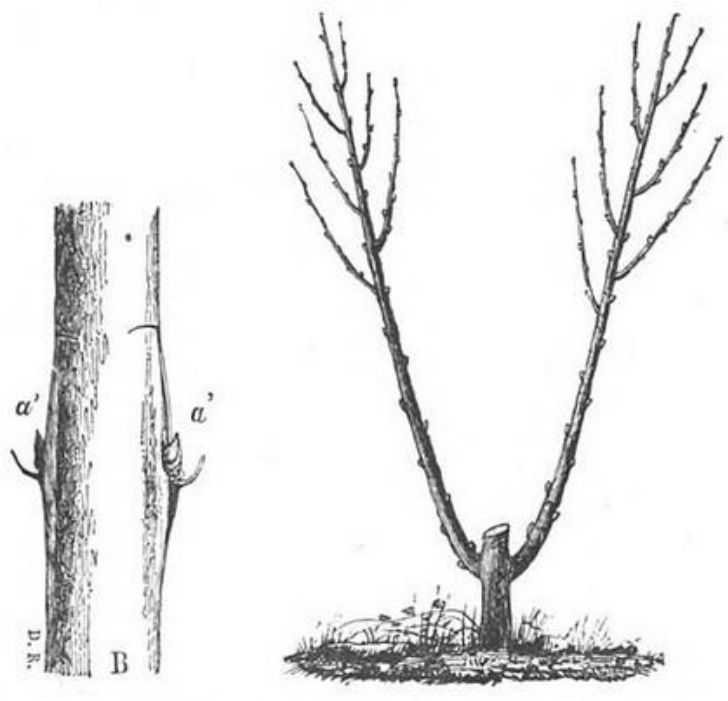

Fig.16. Compound or double grafting Baltet 1869

⇔ **Care after bud grafting** this involves checking the ties, loosening or removing them if necessary, and removing any unwanted shoots. It also involves gradually pruning the rootstock in order to direct the sap flow towards the grafted shoot. For dormant bud grafting, cut the rootstock above the grafting site in the spring.

3.2. Flute (or whistle) grafting

This type of grafting is called 'flute grafting' or 'whistle grafting' because the method of removing the scion resembles the removal of a tube from the bark, as in the making of a rural flute. Although modern nurseries have replaced it with faster methods, it is still successfully used in some areas to propagate trees such as chestnut, walnut, mulberry, fig, cherry, almond and willow, particularly by those accustomed to it.

It is mainly carried out in spring, when the sap begins to flow; however, it can also be done in late summer, before the generative layer (the cambium) weakens. The graft is a tube of bark

with at least one bud. This tube is removed from the graft branch and then attached to a similar tube of bark that has been removed from the rootstock at the same time.

Preparing the scion

- Two circular cuts are made above and below the bud to determine the length of the scion.
- The two cuts are joined by a longitudinal cut.
- The bark is then carefully removed, ensuring that the scion bud remains intact.
- It is best to work quickly in a calm environment to prevent the exposed tissue from drying out.
- The rootstock should preferably be young and strong. If it is thick, graft onto the branches instead of the trunk. You can delay cutting the top of the rootstock until after successful union.

Types of grafting using a grafting tool:

a. Regular grafting:

The graft is attached to the same area of the rootstock from which the bark tube was removed, with the eye of the graft positioned below a bud to encourage sap flow. The grafting area is tied up and paste or ointment is applied if necessary, particularly if any parts remain exposed.

b. Grafting with bark strips

After removing the bark from the rootstock, leave long strips attached at the bottom. Place the scion and return these strips over it to cover the exposed parts, securing them with a tie. This method is especially useful when the scion's diameter is smaller than that of the rootstock.

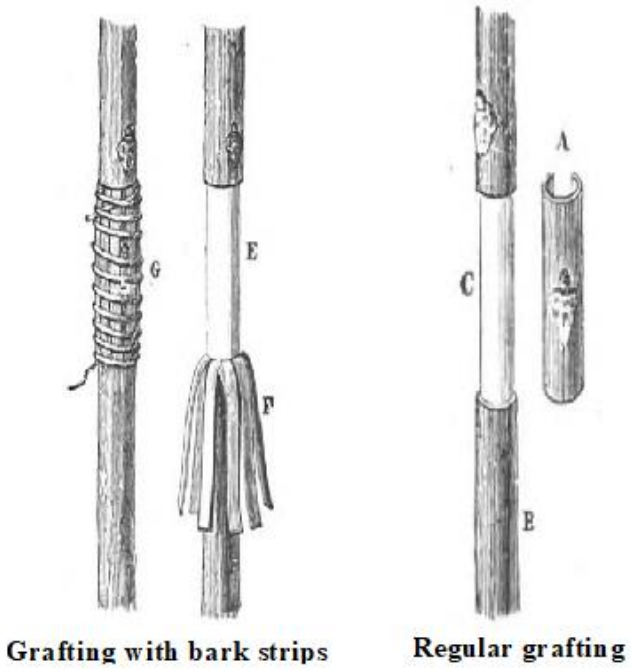

Fig.17. Flute (or whistle) grafting. Baltet 1869

⇔ **Care after grafting**

- Keep an eye on the graft to ensure that it does not choke the grafted area.
- Provide support (a stake) to protect the graft.
- If they're too dense, cut back the top branches of the rootstock.
- Gradually cut back the top of the rootstock, depending on the type of graft.
- If the graft has a growing bud, gradually cut the rootstock after the union has taken place successfully.
- If it has a dormant bud (summer grafting), postpone the final cut until the following spring.
- When grafting, shorten the upper part of the branch or stem above the grafting site to direct the sap towards the graft.

4. Care should be taken with the grafts after they have been grafted.

A. Monitoring the Graft (Bonding)

About eight days after grafting, check that the graft is not strangling the plant. If the graft begins to enter the bark due to root growth, cut it with a grafting knife on the side opposite the grafted bud and it will fall off without needing to be pulled. Not every slight pressure is a reason to remove the tie immediately. If the grafting time is approaching, it is sufficient to cut the tie partially or replace it with a new one. However, if the tie is actually strangling the plant, cut it from the top and bottom, then carefully remove it, as small remnants can cause serious damage.

Ideally, remove the tie in autumn before winter so that the bark and grafting points can adapt gradually. Cold-sensitive grafts should be left tied until spring, unless they are in an area exposed to frost. Ties on fruit bud grafts should be left on for longer and only removed once the fruit has set. During the first few days, you should also:

- Re-tighten any ties that have loosened.
- Renew the paste (mastic) if it cracks or falls off.
- Replace failed grafts.
- Remove any paper or protective covers that were placed there to shield the graft from the sun and drought.

B. Rootstock cutting (grafting)

This method of grafting is similar to side grafting. The grafted plant is gradually separated from the parent plant by cutting off the top of the rootstock. The aim is to concentrate the sap in the graft and rootstock. For lateral grafting, such as layering, bud grafting or under-the-bark grafting, the rootstock is cut immediately or after winter, depending on whether the bud is growing or dormant.

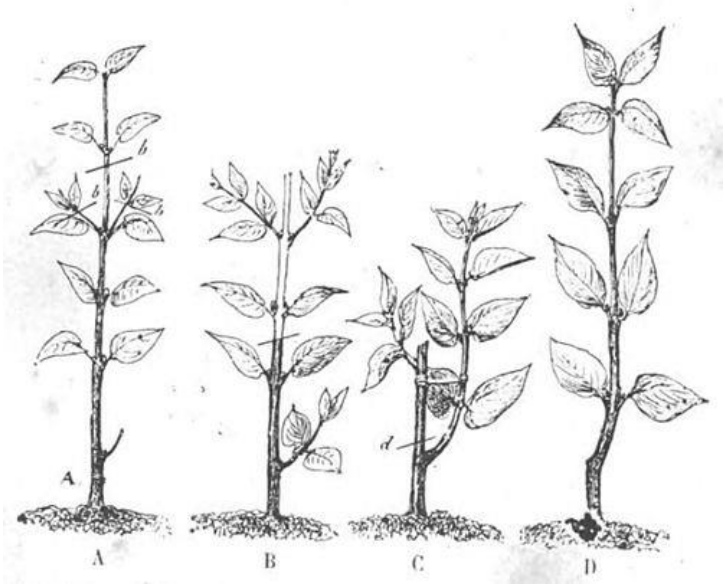

Fig.18. Successive topping of the graft with a growing bud (lilac). Baltet 1869

C. Remove excess shoots (partial pruning).

When growth begins, the shoots should be removed vigorously. Later on, only the shoots growing between the ground and the grafting site should be removed. This leaves a few selected shoots to help draw sap towards the scion.

D. Pest control

Pests such as caterpillars, aphids, slugs and snails must be continuously monitored and eliminated. This should be done throughout the year, regardless of the weather conditions.

E. Securing the graft (staking).

When the grafted branches reach a length of about 10 cm, secure them to a stake or support to protect them from wind and storms, and to ensure they grow straight and healthy.

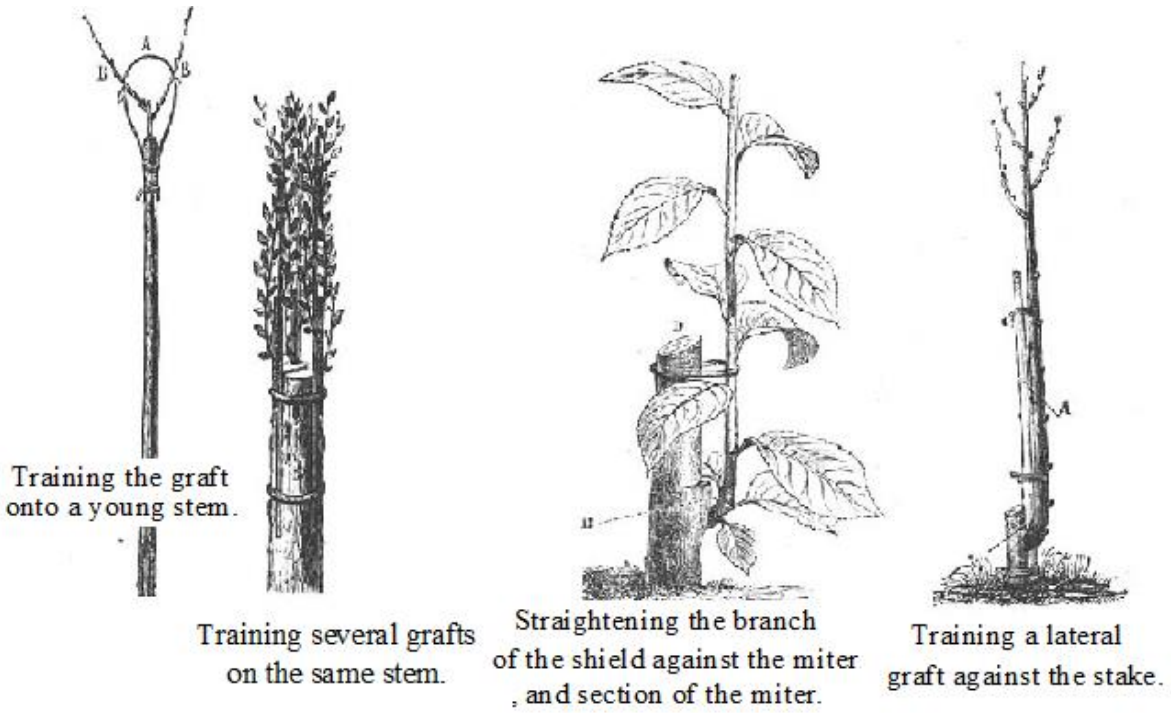

Fig.19. Securing the graft. Baltet 1869

F. Removing the tongue (the excess part of the rootstock)

After a year of growth, the excess part of the rootstock above the graft is removed. Leaving it for too long can lead to its death and the rotting of the wood. This part is cut at an angle and the wound is covered with clay or a special ointment to facilitate healing.

G. Reducing swelling at the graft site

If significant swelling forms and hinders sap flow, light incisions are made in spring to encourage tissue growth and improve the plant's nutrition.

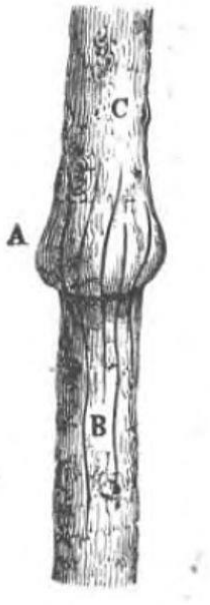

Fig.20. Reduction of graft beading. Baltet 1869