

Propagation

Definition (Reason / Objective)

Plant propagation is a term from the field of horticulture and agriculture and describes the different methods for creating new plants from other plants. It is used, for example, to reproduce fruit-bearing plants (usually standard trees and shrubs) in mixed grassland orchards (traditional orchards). There are two primary mechanisms: sexual (generative) propagation and asexual (vegetative) propagation. Generative propagation is achieved by sowing seeds. Through the combination of the genetic material from two parent plants, the next generation is a new genetically unique plant. In vegetative propagation, on the other hand, reproduction is the product of the plant material itself. Parts of the parent plant are encouraged to take root, and the resulting young plants are therefore genetically identical to the parent.

Methods

Generative Propagation

Seedlings

Generative propagation is achieved using the seeds of a plant. The origin of the seed, the seed provenance, is usually a seed plantation or a specific location. Between its harvesting and sowing, the seed must be kept in a state of dormancy to prevent it from germinating at the wrong time of the year. This is best achieved by placing the entire apple, or the core, on a sandy surface. After the body of the fruit has rotted, the pips overcome their physiological dormancy in winter. The cold period stimulates their germination. The seeds of apples and pears need a cold spell of 8 to 12 weeks and can be sown from September to October in open land. The genus *Prunus* with the species plum, cherry, zwetschge (continental plum

variant similar to the damson), sloe and subspecies such as bullace (*Prunus domestica* subsp. *insititia*) initially need a warm spell followed by cold period.

The necessary intensity of the respective temperature period depends on what is required for the seed to penetrate the seed coat (testa). The seeds require water, warmth, light and oxygen to germinate. The resulting seedlings have a single root that grows downwards and several seed leaves that grow upwards. The structure of the soil influences root development and sufficient protection against the weather can be favourable for the development of the seedling and the form of the new plant. Once the soil temperature is warm enough, the seedlings should be planted in open ground, ideally as soon as possible to make maximum use of the vegetation period. Apple, pear, hawthorn and the *Prunus* species germinate between 7 and 15°C. *Prunus* does not germinate well at higher temperatures. The following seed stocks are used for traditional orchards: *Malus domestica* “Antonowka” and a few regional varieties with particular genetic variations such as *Pyrus nivalis* “Pöllauer Hirschbirne” and “Batul”, an old Hungarian apple variety.

Vegetative Propagation

Grafting methods

(Copulation/Grafting/Shield budding)

Standard fruit trees can exhibit two grafting points. That means that the tree consists of a fruit rootstock, a tree trunk, and a top variety for the crown of the fruit tree. In most cases, the grafting point of fruit trees is just above ground. The grafting point is the place at which two plants (or parts of plants) are joined together in a permanent living connection (“union”). Substances vital for the plant’s survival – water, nutrients, assimilation products and so on – must be able to be

transported through the grafting points in both directions. To prevent disharmonies or incompatibilities between the grafting partners, the cambium tissue of both parts of the plant must be placed in contact with each over as large a surface area as possible. The most common methods for grafting fruit trees in summer are bud grafting and scion grafting. If the top variety and the trunk belong to the same species, grafting usually presents no problems. Likewise, the grafting of different species within the same genus is usually successful. Plum and cherry trees cannot be grafted onto a rootstock of the same kind although they both belong to the genus *Prunus*. Grafting can, however, be a successful method for propagating related species. Pear (*Pyrus*) can be scion grafted onto quince (*Cydonia*). The slow growing rootstock for pear trees are Quince A and Quince C which belong to the variety *Cydonia oblonga*. If a scion rejects the rootstock, then there is either an inconsistency or an incompatibility. Some pear varieties cannot be grafted. The rejection of the rootstock may, however, only become apparent after several years. Some pear varieties do not truly harmonise with quince as the stock and in such cases an additional stem-forming grafted section is required.

Copulation (splice-grafting) is a propagation method that is undertaken during winter using a dormant grafting budwood (called a scion) with one or more buds. The scion must be stored in moist and cool conditions until needed. The copulation is prepared by cutting the end of the scion and the end of the rootstock (or at least part of it) at the same diagonal angle. The living tissue of both plants, the callus, grows together when at least a part of the wound has maximum surface contact. A clean, sharp slice provides better surface contact than a jagged or frayed surface. The scion is bound to the rootstock with rubber band or strips of plastic grafting tape. All exposed plant tissue – the grafting point as well as tip of the scion – must be sealed with grafting wax.

Topworking is a special form of propagation for grafting a new fruit variety onto a mature fruit tree stem. Different varieties can also be grafted onto the same fruit tree. This propagation method, also known as bark grafting, is usually undertaken in spring when the tree has begun to bud and the bark is easily plied from the wood (May/June). Graft wood (scions) should be cut to the desired size in late winter and as soon as the bark of the rootstock can be loosened one or more scions are inserted beneath a flap of the bark. All exposed plant tissue – the grafting points as well as tips of the scions – must be sealed with grafting wax.

The *bud grafting* method (also called shield budding) is a propagation method used in summer. This method uses a bud rather than a twig, either via a T-shaped incision in the bark of the stem (T-budding) or via the transplantation of a chip bud from one plant to another (chip budding). For the bud grafting, the freshly-formed bud (often just a bark shield with a bud attached) is removed immediately before use from the mother plant. If the bud cannot be used immediately, it must be stored in a cool and moist place (for example a refrigerator) to prevent it from drying out. It should be used within 3 days. The buds are held in place on the rootstock with elastic bands or strips of plastic grafting tape.

Cuttings

Propagation using cuttings is a vegetative propagation method. The cutting method is used to propagate many different kinds of plants, but the root-forming properties of plants vary considerably from species to species. Different cuttings are taken depending on the type of plant. Stems and roots can both serve as cuttings. Stem cuttings are commonly used for fruit bushes (elderberry, blackcurrant, redcurrant and gooseberry) and can be taken and propagated in summer and in winter, both in open ground as well as in a greenhouse. Some rootstocks are used as cuttings in winter. These woody cuttings are usually at least one-year-old stems (without roots), and are placed in open ground when there is no longer the danger of frost. They will begin to take root during the following vegetation period. Root cuttings are taken from the roots of an existing plant and already have root growth. The cuttings later become the new shoot growth points. They are cut out of the dormant parent plant in winter and are commonly used to multiply raspberries and blackberries.

Cuttings are rarely used as a means of propagating standard fruit trees such as apple and pear trees.

Wildlings and basal shoots (suckers)

Using the 'layering method', branches are bent down and partially covered with soil so that the submerged part can develop roots mid-branch that will serve as the basis for a new plant. This layer can also be divided into sections to create several new plants. It is important to ensure that the branch develops its own roots for the next new plant. The rooted branch (called a layer) can then be separated from the parent plant, once the new young plant has started to develop. It may take up to two vegetation periods before the new plant forms enough roots. Another variant of layering is to heap topsoil around the base of the parent plant (mound layering), thereby encouraging it to form shoots at its base. Within this mound, new roots form for the parent plant. At the end of the vegetation period in the dormant season, the earth can be carefully removed from around the parent plant, and if new roots are visible a new plant can be separated off from the parent plant.

Root bundles follow the same basic principle as mound layering. Here, though, it is the parent plant that forms new plants. Soil mounds are used for hazel and selected rootstocks. Many local varieties such as Zwetschge and sour cherry are propagated using wildlings. For example, a local variant of the sour cherry with the botanical name *Prunus cerasus* 'Løvskal'.

Plant material

For the propagation of fruit trees and their planting in traditional orchards, the top variety is the most important part of the plant material. In Europe, for example, there are more than 2000 named apple varieties and many other unknown but nevertheless existing varieties.

Rootstock

The rootstock (base) is often a seedling or a special variety of plant base. The geographic origin of the base determines the kinds of soil and climate conditions that the fruit tree is suited to. The choice of rootstock can determine the overall growth and therefore the size of the mature fruit tree. Standard trees are usually the product of a fast growing rootstock. By using fast or very fast growing rootstock, it is possible to maintain standard trees in traditional orchards. Slow growing rootstocks are generally not suitable for planting traditional orchards. Certified rootstocks guarantee the origin of the plant base and that it doesn't contain any disease. The use of locally available rootstocks ensures that the plant material is better adapted to the local conditions (e.g. climate and soil), but it can also lead to more uneven growth of the resulting fruit trees. For apple trees, regularly certified rootstock is suitable for propagation. *Malus domestica* 'Bittenfelder' (seedling) is resistant to frost as well as dry conditions. Some selected clones from the East Malling Research Station exhibit very fast growth. Rootstocks with the designation M11 ('Doucin vert') are frost-resistant; M2 ('Doucin') is suitable for low-nutrient soils

but is more prone to greenfly, although not to storage diseases; while A2 is well suited for wet or loamy soils and can cope with strong temperature fluctuations (continental climate). In Poland, apple seedlings of the variety 'Antonowka' are used, pear seedlings of the variety *Pyrus caucasica*, plum seedlings of the variety *Prunus cerasifera*, and sweet cherry seedlings of the varieties *Prunus avium* and *Prunus mahaleb*. In Denmark the corresponding varieties are *Malus domestica* 'Bittenfelder', *Pyrus communis* and *Prunus avium*. Pear trees in the form of seedlings are a very fast growing rootstock and are well suited for grafting. This rootstock can cope with dry and stony soils, as well as wetter, clayey soils. The "Kirchensaller cider pear" is one of a group of 'Kirchensaller' varieties (from the York Research Station). This particular homogenous seedling is very resistant to frost and is well suited for copulation and bud grafting.

Scions

The scion (budwood) used for the top variety is part (a one-year-old long shoot from the previous year) of a genetically identical parent plant and retains this genetic information for that part of the plant after grafting. This is important in order to ensure the identity of the variety of the fruit trees. The shoot has the same susceptibilities and resistances to disease as the parent plant with which it shares its genetic information. The shoots used for the top variety should be healthy, free of infestation, physically intact (undamaged) and sufficiently woody. The scion should exhibit well-developed buds. For this reason, it can be advisable to cut them from the periphery of the tree crown. Long annual branches from the centre of the crown are so-called water shoots (or suckers). These are usually healthy but

have poorly developed buds. To obtain useful scions, regeneration cutting of the parent plant may be necessary in the year before to encourage the plant to produce vigorous propagation material. Scions are cut in winter when the trees are dormant. The shoots of sweet cherry, sour cherry, peach, apricot and pear trees should be cut immediately after the first cold period in December. The shoots of apple and plum trees can be cut in January and February. The seasonal shoots of these fruit varieties may even be cut at the beginning of March if they are still dormant and have not yet started to sprout buds. Once the dormancy period of the shoots ends, the shoots are no longer suitable for use as scions for later propagation. Scions are cut and bundled according to fruit species and variety and labelled accordingly. If the scions are not used immediately, they need to be stored under special conditions: usually they are wrapped in a moist material or in cling film. Alternatively they may be placed with the cut surface 10 cm deep in moist sand. Scions must be kept cool from the time of their cutting to their usage. An air temperature of 1 – 2°C is ideal, for example in a chilled room or a cellar. For bud grafting, the top variety is cut in summer as a bud (or shield) during the peak growth period of the plant. To reduce moisture evaporation after cutting, the leaves should be removed immediately with only a small part of the base of the leaf left intact. Buds or shields prepared in this way need to be used for bud grafting within a period of 2 – 4 days if they are kept cool during this period.

Species and varieties

The criteria for the selection of the original plant material are always the same regardless of whether propagation will be conducted by seed (generative propagation) or by grafting, budding or cuttings and root bundles (vegetative propagation). The selection of particular species and varieties depends on the following criteria:

- Geographic origin (continental prevalence)
- Soil conditions
- Natural protection

Alte und regionale Landsorten sind speziell für den Streuobstanbau geeignet, aber nicht immer so leicht im Handel verfügbar. Das Ausgangsmaterial muss ein gutes physisches Wachstum aufweisen und frei von Krankheiten sein.

Tools and materials

Grafting knife

Special kinds of grafting knives are available for the different grafting methods. These are either specially formed for a particular purpose or sharpened on one side only. One way or the other: the knife should be chosen to fit the hand of the user. There are different basic blade forms and also knives for lefthanders. To create a clean slice with a smooth contact surface the blade has to be kept very sharp. If the blade is blunt, the cut will not be smooth, resulting in an unsuccessful or inconsistent graft between the scion and rootstock. It is worth investing the money in a high-quality grafting, budding or universal gardening knife. In addition, the knife must be sharpened regularly to ensure that it remains usable over many years. For certain purposes, e.g. bark grafting where the bark needs to be peeled back, a curved blade is necessary.

Whetstone

A special whetstone is recommended for sharpening the grafting knife. The whetstone should be made of two different materials, one on each side. The first is to pre-sharpen the knife, the other made of a very fine-grain material for finishing the knife blade. The necessary degree of sharpness can only be achieved using such two-material whetstones. The whetstone should be wetted prior to use.

Garden shears

These should likewise be chosen to fit the hands of the user. There are different types and sizes of shears, and shears for lefthanders are also available. Garden shears should always be kept sharp and clean. They can last for many years when properly used and looked after.

Saw

A sharp tree hand-operated saw with a non-corrosive saw blade is a standard part of an orchard expert's equipment. The saw should be able to cut through branches with a maximum thickness of 7 cm.

Elastic bands, grafting tape and strips of plastic

These ensure that the separate parts of the plants are well bonded with one another. They are typically elastic to ensure that the one-year-old branches are held pressed against the rootstock or the grafted branch. A natural alternative to plastic is raffia.

Grafting wax

Wax is needed to seal any open surfaces of cuts and to prevent the plant or graft from drying out. Directly after the graft has been fabricated, wax is brush-applied both to the graft point as well as to the tip of the scion.

Cold fluid wax can be used directly from the bottle, while hard wax first needs warming to make it fluid before it can be used.

After care

The kind and intensity of after care measures for new fruit trees depends on the grafting method used. After copulation in winter, saplings can either be kept in pots or planted into open ground. Bud grafting takes place in summer and therefore happens on the rootstock in the orchard. The tip of the rootstock is removed in spring just above the bud or chip grafting point. Saplings and cuttings are replanted from special propagation beds into pots or cultivated outdoors for later use. The saplings require water and fertiliser during the growth period. To cultivate a standard fruit tree with a continuous trunk, the tip should not be cut off. To begin with, while the tree is growing, the trunk must be held upright with a rod. For example, the young, still supple branch is fixed to a bamboo cane to ensure it grows with a straight stem. Any shoots and branches that grow out of the rootstock beneath the grafting point should be removed as soon as possible. The new fruit tree can finally be planted out as a yearling or two-year-old plant. Any covering materials such as rubber bands, tape or raffia should then be removed to prevent the grafting point from becoming constricted.

Documentation and labelling

Documentation

Documentation is a very important aspect in order to record the process of propagation and to manage the production of fruit trees in a sensible way. Documentation is also the basis for registration. It provides information for the gardener, for the regulatory authorities and also for other partners. Good records provide the necessary information for monitoring the efficiency of propagation and the day-to-day operations of the company. Likewise, the records provide a basis for judging the success of the measures. They represent a point of reference for the process of propagation and allow one to judge productivity, and where necessary to make corrections when problems arise. It is a form of quality management. The following information on the materials and techniques used must be recorded:

1. The type, number and origin of the rootstock
2. The variety, number and origin of the scion
3. The variety, number and origin of the cuttings
4. The date of grafting
5. The grafting method
6. The weather
7. The cost of the scion and rootstock
8. The hours required and people involved
9. The varieties that appear in the plant beds and plant rows

It is advisable to draw up a planting scheme. This can contain information on the number of beds, their respective sizes and the rows of plants within them. The planting scheme includes a record of all

parts of the trees together with the species and other relevant information (for example, date planted, treatment, etc.). It can be useful to regularly undertake an inventory recording the number of grafted, planted and sold trees and plants over the year.

Labelling

When working with large quantities of trees of different varieties, it is useful to label each young tree. Labelling is important, as not all young tree varieties are easily distinguishable. There is no international standard and the colours suggested below are just an example of how a labelling system could be organised. The label can record the kind of fruit, the variety, the rootstock, the genetic origin of the variety and the name of the company that provided it. Labels are typically made of plastic, metal or wood, but the most commonly used label is a plastic strip. Fairly small labels usually survive better in tree nurseries, for example up to 20 cm long and 1–2 cm wide. The colour of the label depends on the source of the plant material:

- The label is white if the plant material has come from a primary source (pre-basic material).
- The label is blue if the plant material has come from a plantation (basic material).
- The label is orange if the plant material is certified

The writing on the label may be written in pencil or with a water-resistant pen, or even laser-printed. Printed information may fade and become illegible over time. This must therefore be checked at regular intervals for as long as the trees are in the tree nursery.