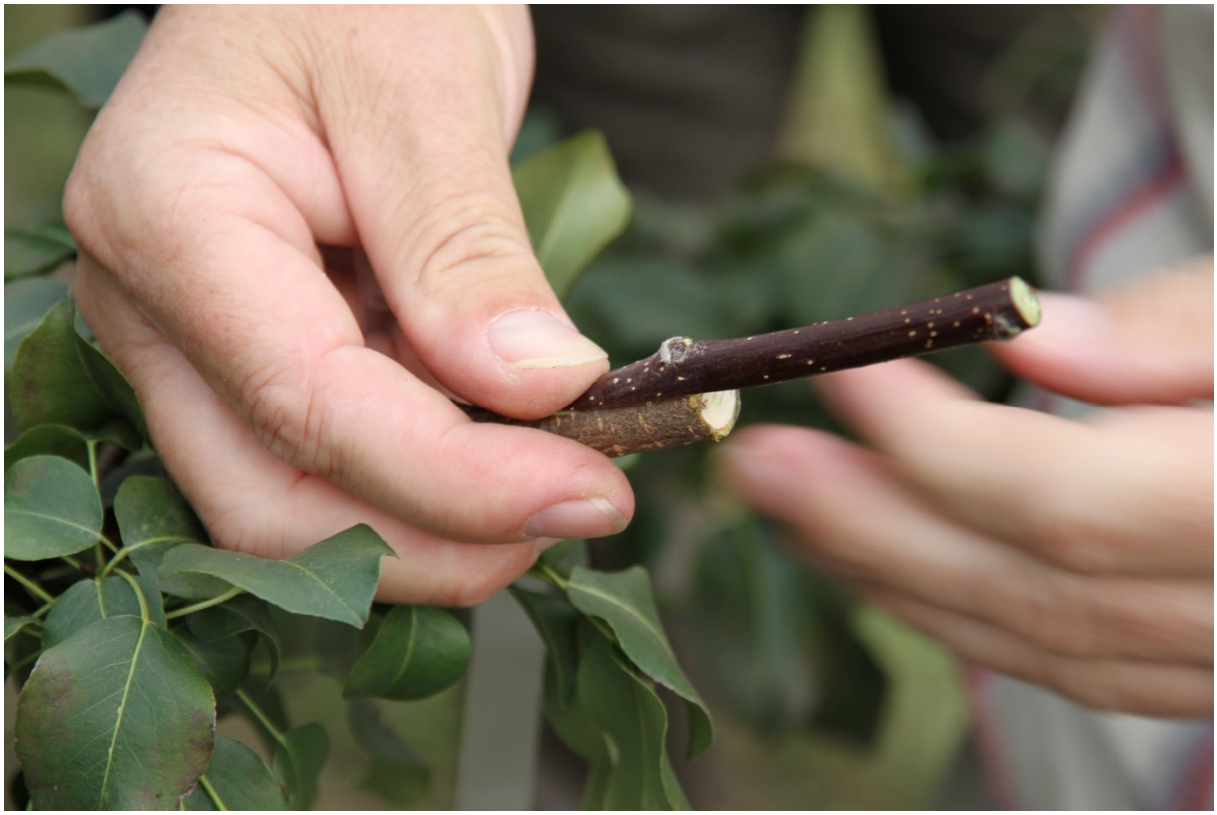
Teaching Materials

for Qualification of

Specialists in Traditional Orchards

MODULE: CARE AND MANAGEMENT



Lifelong Learning

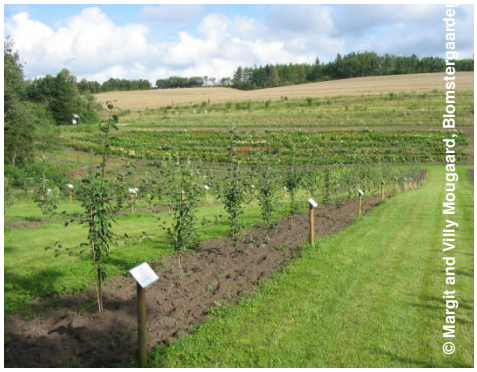
This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Teaching Unit 1: Introduction to propagation

Learning aims

He/she knows

- he definition and methods of propagation



Method

Brainstorming with picture cards

Content

- Basic techniques of propagation of fruit trees

Coordinator

Organisation

1 day before
Print and laminate the picture cards

Practice

Preparation

- Printing and laminating the picture cards
- Laying down the picture cards in the circle of chairs
- Preparing a pin board or magnetic board in the room
- Attaching the "term cards" to the pin board or magnetic board

Duration

45 Minutes

Location

Seminar room

Season

Feasible during the whole year

Tasks

Students should select one picture card that most suits their personal experiences or ideas about propagation and grafting. The selected card is presented with a short statement to the group.
Finally, the term "propagation" will be defined by the group and the individual picture cards assigned to the different propagation techniques. For this they will be attached to the pin board or magnetic board.

Materials

Magnets or pins

Equipment

Armchairs, pin board or magnetic board

Supportive documents

Info sheets:
Knowledge base

Enclosures:
Picture cards
Term descriptive cards

Results

One short presentation of the selected picture card by each student
One pin board or magnetic board with picture cards divided into topics.

Remarks

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.

Teaching unit 2: Seed balls

Learning aims

He/she knows

- The techniques of propagation:
  - Seedlings (generative propagation, origin of the seedlings, seed dormancy, seedling technology)

He/she is able

- to produce seed balls independently

Method

Practical exercise

Content

- Production of seed balls

Coordinator

Organisation

3 days before
Provide earth, clay and seeds

<table>
<tr><td rowspan="2">Practice
Preparation
• Preparation of working material</td><td>Duration
30 Minutes</td></tr>
<tr><td>Location
Seminar room

Season
Execution possible throughout the year</td></tr>
<tr><td colspan="2">Task
Each student gets a worksheet and make seed balls individually.</td></tr>
<tr><td>Materials
Mixture of flower seeds, earth, clay-earth, water</td><td rowspan="2">Supportive documents
Info sheet:
Production of seed balls

Knowledge base:</td></tr>
<tr><td>Equipment
Tables, chairs</td></tr>
<tr><td colspan="2">Results
2-3 seed balls per person</td></tr>
</table>

Worksheet Seed balls

With seed balls you can replant in places that are often impossible to embellish!

Simply wait until the rain has been predicted by the weather forecast and then scatter your flowers or herbs in the most unlikely places!

Instructions

- Mix the clay, soil and seeds together in the ratio 5: 1: 1.
- Mix the ingredients well.
- Add a little water afterwards, but just enough to create a dry dough.
- Knead the mass well and divide it into small portions.
- Form balls from the prepared portions and let them dry.
- Once they are dried, the seed balls can be used for planting!

Propagation

Definition (Reason / Objective)

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Methods

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(Copulation/Grafting/Shield budding)

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Cuttings

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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.

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Plant material

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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.*

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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.

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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

Old and regional local varieties are especially suitable for the cultivation of traditional orchards but are not so widely available to purchase. The original plant material must have good physical growth and be free of disease or infestation.

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.

Teaching unit 3: Methods of propagation

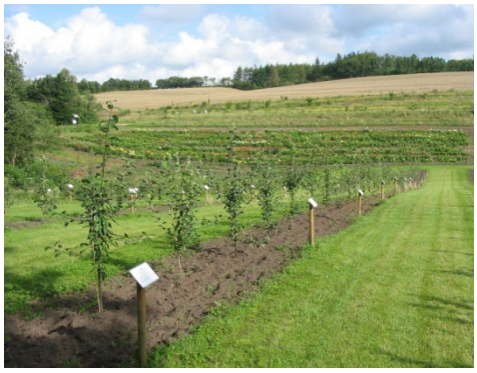
Learning aims

He/she knows

- the techniques of propagation:
  - Seedlings (generative propagation, origin of the seedlings, seed dormancy, seedlings technology)
  - grafting (copulation, budding, rootstock, scion)
  - cuttings
  - wildlings / root suckers

He/she is able

- to select and apply the right propagation method.



Method

Peer Education

Content

- seedling nursery
- grafting and budding
- cuttings
- wildlings and root suckers

Coordinator

Organisation

30 days before
Organisation of necessary plant material

14 days before
Organisation and if necessary copying of relevant literature

Practice

Preparation

- Providing working material
- Providing relevant literature

Duration

3 hours

Place

Seminar or workshop room

Season

depending on the propagation technique, which should be taught

Task

Students are divided into three groups of experts:

- seedling nursery
- grafting and budding
- cuttings, wildlings and root suckers

Each group analyses and prepares - using literature research or practical exercises - one of the topics in detail. Afterwards, the expert groups will be dissolved and experts will be mixed up, so that there is always at least one expert for each topic in new working groups. Then the experts teach their colleagues about their field of specialisation. Finally, the info sheets for different working techniques will be distributed.

Materials

Soil, plant pots, seeds, cuttings, root cuttings, buds, rootstocks, elastic bands, wax,

Equipment

Working tools: garden shears, grafting knife, tables, chairs

Supportive documents

Info sheets:
Outdoor seedling nursery

Seedling in the nursery

Grafting, budding, topworking, cuttings, wildlings

Knowledge base:
Expert text Propagation

Results

Each student as an expert shares his/her knowledge in his/her speciality field.

Remarks

Information Sheet: seedling nursery in the open

Seedling nursery in the open

1. Prepare field for seedling.
2. Sowing of the seed.
3. Gently cover with soil.
4. Water seedling, as soon as soil starts to become dry.
5. After first growing period, either replant in pots or leave on field.

Information Sheet: Seedling in nursery

Seedling in nursery

Works are undertaken early in spring, with the seedling already germinating.

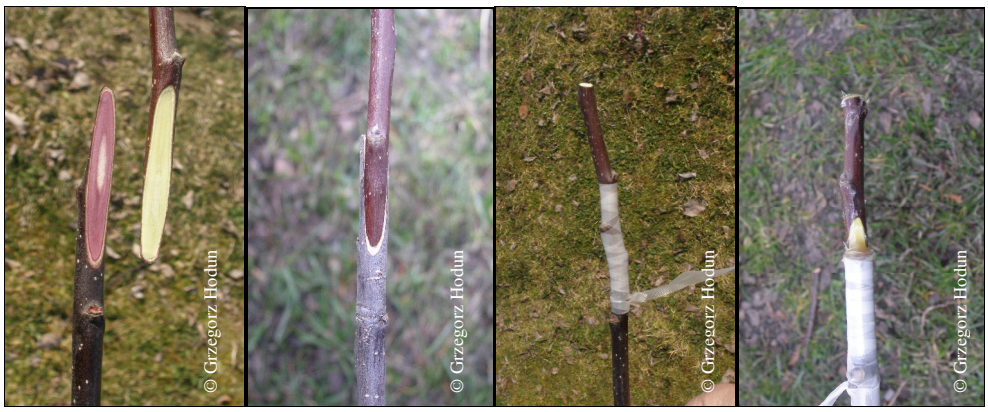
6. Prepare substrate for the seedling.
7. Place substrate in appropriately sized pot.
8. Put sprouting seedling into the pot.
9. cover seedling with a bit of soil.
10. Water and ensure frost-free location, until young plants present three to four leaves.
11. Replant young plants into pots.

Information Sheet: Grafting

Grafting

Grafting is undertaken in winter.

1. Cut away tip of surface und practice the copulation cut.
2. Cut top-graft to proper length (approximately 2-3 eyes).
3. Perform copulation cut at top-graft.
4. Perform copulation cut at base, preferably as angled or partly angled cut. This may become necessary when the base is significantly thicker than top-graft.
5. Put top-graft and base together at their cut edges and fix with elastic tape, e.g. plastic. The top layers have to match, at least in one spot. A straight cutter offers a better surface, than a serrated cut.
6. Wax open end of the top-graft, the joint of both plants and also the top of the base, should it be larger than the top-graft. All open surfaces have to be sealed with wax in order to avoid loss of water.



Information Sheet: Budding

Budding

Budding is carried out in the open on surfaces, in summer. The surface's tip though shall be removed in spring, exactly where the budding is to be carried out later.

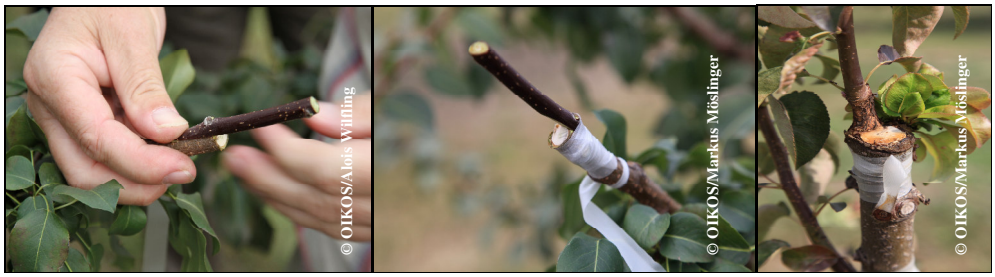
1. Plant surface into the open in spring.
2. Cut away eye from rootstock.
3. Place eye by means of T-cut or chip-cutting on the surface.
4. Fix budding with rope or elastic strips.
5. Remove surface's tip, just above budding early in spring.

Information Sheet: Multi-Grafting

Multi-Grafting

Multi-grafting is utilised in order to combine growth of different varieties on one single fruit tree. Multi-grafting is carried out in spring, shortly after the leafs began to sprout and the bark begins to become loose.

1. Cut back branches to a usable thickness, late in winter.
2. Once again cut away the branch tip in order to have a fresh wound.
3. As soon as bark starts to become loose, carry out a straight cut into the bark.
4. Carry out budding at the cut with at least one top-graft.
5. Attach top-graft to the branch with elastic tape or bast.
6. Seal all open surfaces with wax.



Information Sheet: Shoots

Shoots

This method only applies to elder and quince. Suitable shoots must present woodiness to some extent. In nurseries, they can be put into the soil early in spring, in the open only under frost free conditions.

1. Prepare open area for shoots or use appropriately sized plant trays.
2. Cut shoots to approximately 20 cm.
3. Put shoots into the open or in plant tray, only showing one eye above soil/substrate level.
4. Water shoots and keep wet subsequently; they shall not fall dry under any circumstances.
5. As soon as young plants show roots, they can be replanted.

Information Sheet: Wildlings

Wildlings

Root cuttings are separated sections of the root, which have already developed growth potential. Those cuttings should later form vigorous shoot growth. Wildlings are cut in winter, during the plant's dormant season.

Wildlings - layers

1. Put branches of the mother plant into the soil, early in spring.
2. After one or two growth periods, the branches should have built roots and thus be considered a new plant.
3. Separate the branch from mother plant with its roots.
4. Plant young plant into flower pot.

Earthing-up

1. Soil is piled ("earthed-up") around the mother plant from early spring throughout the growth period.
2. In the earthed-up soil, the shoots will develop new roots. Towards the end of the vegetation phase, the soil will be removed to uncover the mother plant. Those young plants, presenting roots, can be separated.
3. Separate shoot from mother plant.
4. Plant young plant into flower pot.

Root suckers

Root suckers follow the same principle as earthing-up and root layering with the exception, that the plant itself develops young plants without external influence.

1. Separate, cut, young plant of the mother plant's spur.

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

Lifelong Learning

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

Old and regional local varieties are especially suitable for the cultivation of traditional orchards but are not so widely available to purchase. The original plant material must have good physical growth and be free of disease or infestation.

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

Lifelong Learning

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.

Teaching unit 4: Selection of rootstocks

Learning aims

He/she knows

- he plant material (soil type, rootstock)
- the characteristics and requirements of plant material

He/she is able

- to select the appropriate rootstock for grafting

Method

Short presentation
Literature research

Content

- Types and varieties of fruit trees for the traditional orchard
- Characteristics and requirements of different rootstocks

Coordinator

Organisation

14 days before
Organisation and if necessary copying the literature

<table>
<tr><td>Practice

Preparation
• Providing literature
• Copying of worksheets</td><td>Duration
2 Hours

Location
Seminar room

Season
feasible throughout the year</td></tr>
<tr><td colspan="2">Short presentation
Students receive a brief introduction about the different types and varieties of apple trees for traditional orchards. Ultimately the meaning and function of the rootstock for grafting is clarified.

Task
Each student gets a work sheet. The work assignment is processed with support of the literature search on the internet. Finally, the results are presented in the group.</td></tr>
<tr><td>Materials</td><td rowspan="2">Supportive documents
Work sheets

Knowledge base:
Expert text</td></tr>
<tr><td>Equipment
Computer with internet connection, tables, chairs</td></tr>
<tr><td colspan="2">Result
One filled in work sheet per student</td></tr>
<tr><td colspan="2">Remarks
The solution of the assignment is in the enclosed information sheet.</td></tr>
</table>

Work sheet: Selection of rootstocks

Research and find different rootstocks for the apple tree grafting with regard to all described requirements. Prioritise primarily local plant materials!

Rootstocks with strong growth and good fruit quality:
1
2

Rootstocks with moderate growth, frost-hardy:
1
2

Rootstocks with very weak growth:
1
2

Rootstocks that are disease-tolerant and undemanding:

1
2

Info sheet: Rootstocks

Apple

Rootstock	Characteristics
A2	Very strong growing, very hardy, good quality fruit, ideal for large tree forms
M11	Very strong growing, good fruit quality
M25	Very strong growing, early bearing, good fruit quality
MM 111	Moderate growing, very hardy, high productivity, ideal for medium tree forms
M2	Moderate growing, little stable, for medium soils
M7	Moderate growing, tolerant to dry and wet soils, undemanding rootstock for small-sized tree forms
MM 106	Medium weak growth, ecologically adaptable, good fruit quality, regular
M 26	Weak growing, very hardy, also for worse soils
M9	Weak growing, oft for small-crown trees, good quality
M27	Very weak growing, not recommended for home gardens, demanding on soil, needs pale

Quelle: Arche Noah, Österreich; Kreisverband für Gartenbau und Landespflege Fürstenfeldbruck

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 Propogation

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

Spezies 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

Old and regional local varieties are especially suitable for the cultivation of traditional orchards but are not so widely available to purchase. The original plant material must have good physical growth and be free of disease or infestation.

Tools and materials

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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.

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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

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4. The date of grafting
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6. The weather
7. The cost of the scion and rootstock
8. The hours required and people involved
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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.

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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:

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Teaching unit 5 Grafting

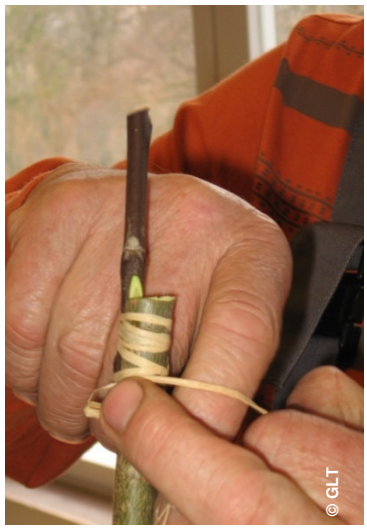
Learning aims

He/she knows

- grafting (copulation, budding, rootstock, scion)
- tools for propagation
- the care of the young trees in nurseries
- about documentation and labelling.

He/she is able

- to choose and apply the right tools and materials for propagation
- to care for young trees in the nursery
- to carry out the documentation and labelling of products



Method

Short lecture and demonstration
Practical exercise

Content

- Grafting techniques
- Selecting and cutting the scions
- Documentation and labelling
- Selection and care of the tool

Organisation

During the winter
Cutting the scions

Practice

Preparation

- Copying of info sheets
- Providing plant and working materials

Duration

2 Hours

Location

Outdoor

Season

depending on selected grafting techniques

Short lecture and demonstration

The correct cutting of scions on a fruit tree is briefly demonstrated. The tools required are shown and explained. Finally, the supply of scions is discussed.

Practical exercise

1. Task
The students practice grafting scions. Each truncates a scion and cares for it.

2. Task
Each student grafts one fruit tree independently by him/herself. The chosen grafting technique will be adjusted to the season and possibilities.

3. Task
Finally, each student labels his/her grafted tree. All working steps are recorded using the documentation sheet.

Final presentation

All necessary measures (watering, fertilisation) of aftercare of young plants in nurseries are discussed.

Materials

Grafting knife, pruning shears, bands, grafting wax, labels

Equipment

A fruit tree to demonstrate the budwoods is required

Supportive documentation

Info sheets:
Info sheet Documentation

Knowledge base:

Results

One scion per student. One grafted small tree per student.

Remarks

If no fruit tree is available, the cutting of scions can be demonstrated using the image cards.

Info sheet: Documentation

1. Record the name, number, and the origin of the rootstock.
2. Document the day of grafting and set the grafting method to be used.
3. Note the number and variety of seedlings.
4. It is recommended to write down weather conditions.
5. Note down the price of the scion and the rootstock.
6. Finally, make a note of how many hours and how many persons were required for propagation.

Rootstock			**Grafting**		**Seedlings**	
Name	Number	Origin	Day	Method	Number	Variety

Weather	**Price**		**Requirements**	
	Scion	Rootstock	Stuents	Persons

Lebenslanges Lernen

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained

Image cards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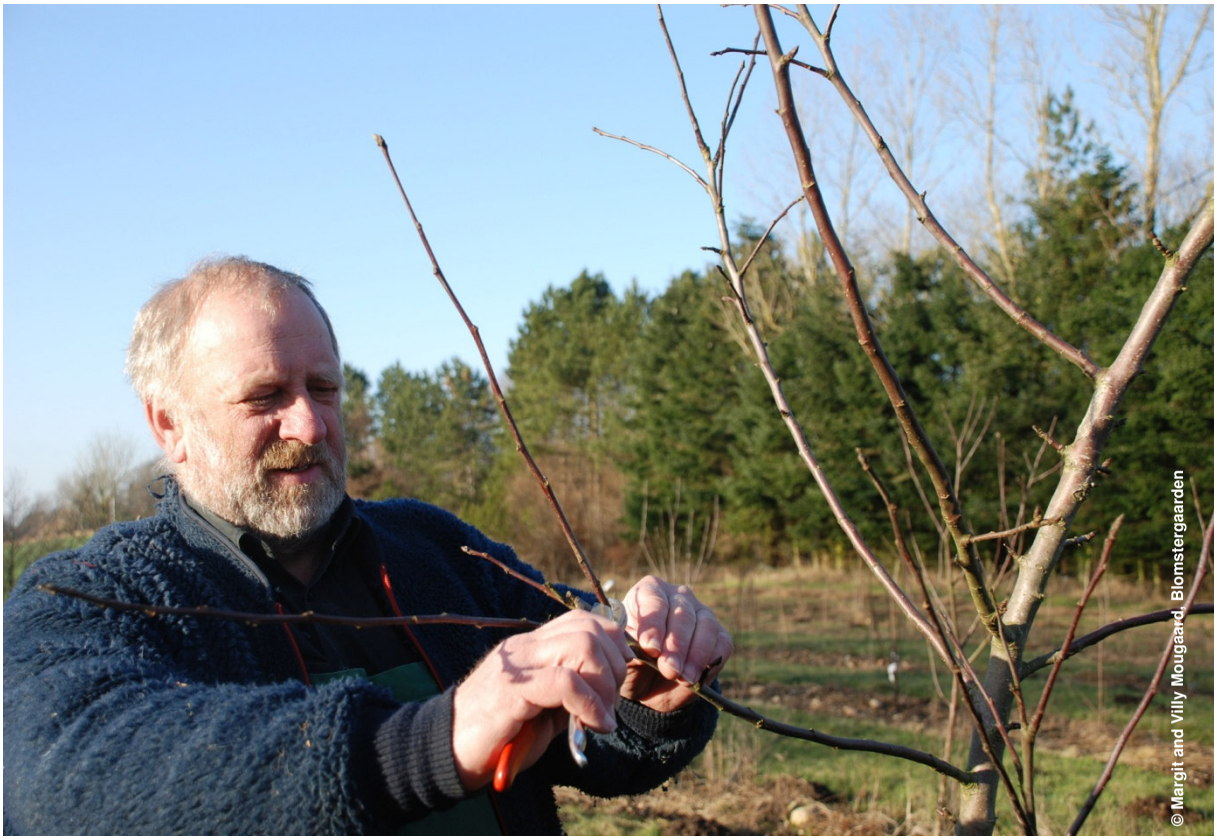
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Propagation

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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.

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

Old and regional local varieties are especially suitable for the cultivation of traditional orchards but are not so widely available to purchase. The original plant material must have good physical growth and be free of disease or infestation.

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.

ESTO – European Specialist in Traditional Orchards	
CARE & MANAGEMENT	Unit 4
Propagating fruit trees for traditional orchards	L 4

KNOWLEDGE

He/she is able to

1. understand and provide the definition and methods of propagation
2. explain techniques of propagation from:
    a) seeds (sexual reproduction, origin of the seeds, seed dormancy, seeding technology)
    b) grafts (copulation, budding, rootstock, grafting scion)
    c) cuttings
    d) wildlings / root suckers
3. describe features of plant material
4. analyse the tools for propagation
5. explain the care for young trees in nurseries
6. explain the documentation and labelling
7. analyse the costs of staff, material, machines and external services

SKILLS

He/she is able to

1. choose and use appropriate methods to ensure successful propagation
2. choose and to use appropriate tools and materials to ensure successful propagation
3. take care for young trees in nurseries
4. do documentation and labelling according to legal requirements
5. do calculation of costs

COMPETENCES

1. He/she propagates fruit trees according to traditional methods on his/her own.
2. He/she calculates and documents propagation of traditional fruit trees on his/her own.