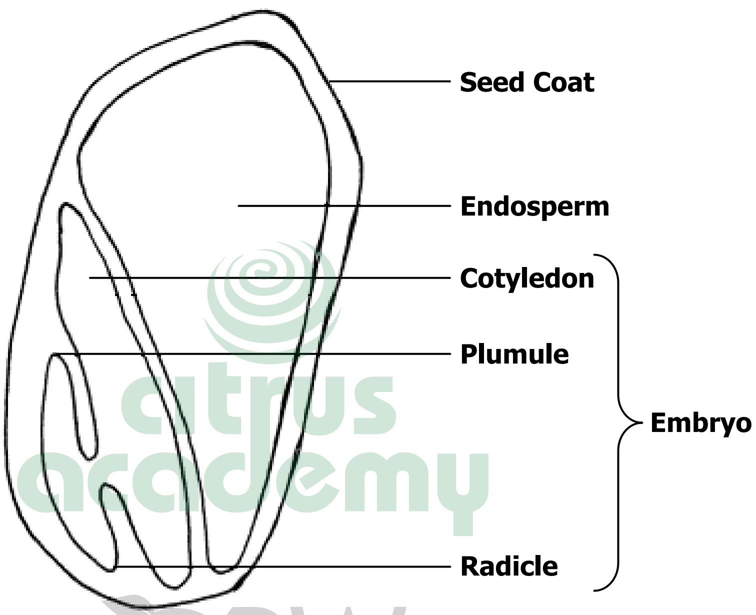
Contents of Module 2

Structures and Functions of Seeds

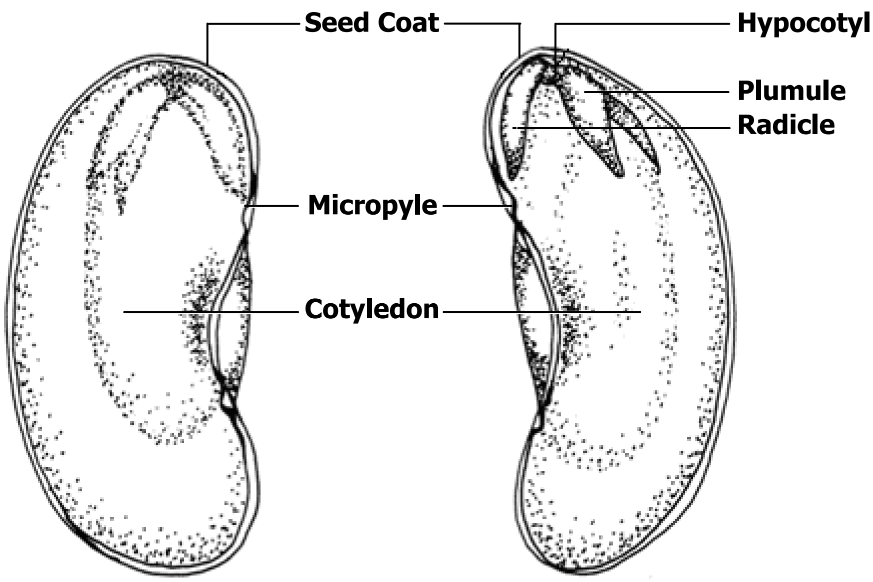
Seed Structures

In the first module of this learning program, we saw that there are two ways in which plants propagate, being through sexual and asexual propagation. Seeds are produced through sexual propagation and are made up of two parts, being:

- A seed coat
- An embryo



The Structure of a Monocot, Endospermous Seed



The Structure of a Dicot, Exendospermous Seed

Seed Coat

The seed coat is the protective outer layer of a seed. Seed coats protect the embryo from injury and from insects and diseases. Seed coats can be thin and soft, such as with avocadoes, leather-like, such as with beans, or thick and hard, such as with macadamia seeds.

There is a small opening in the seed coat, called the **micropyle**, through which the pollen tube passes before fertilisation, and through which the radicle emerges during germination.

The Embryo

The embryo consists of the following parts:

- The radicle
- The plumule
- The cotyledon

Radicle

The radicle is the part of a plant embryo that forms the root of the young plant after germination. The radicle can be compared to an egg with the root being a chicken. The radicle is the first part of the seed to emerge from the seed coat during germination.

Plumule

The plumule is the rudimentary primary shoot of a plant embryo.

Cotyledon

The cotyledons are the seed leaves. Plants are classified based upon the number of cotyledons in the seed. Plants such as grasses can be monocotyledons (monocots), containing one cotyledon. Dicotyledons (dicots), such as beans and citrus, have seeds with two cotyledons.

Endosperm

Endosperm is the nutritive tissue of a seed and may contain carbohydrates, proteins, and lipids. The endosperm is the temporary food source for the seed.

The seeds of all flowering plants start off with separate endosperm, but in some plants the endosperm is absorbed by the cotyledons of the developing embryo, leaving the mature seed without distinguishable endosperm, as is the case with the dicot seed shown in the figure above. Such seeds are called **exendospermous**.

In other seeds the cotyledons remain small or thin because the endosperm is not absorbed by the cotyledons and remain separate. Such seeds are known as **endospermous** seeds.

Seed Germination

definition

Seed Germination

Seed germination is defined as the emergence of the radicle through the seed coat. It is the resumption the growth of the seed after a period of dormancy.

The discussion below on seed germination relates to dicotyledonous plants, such as citrus. The process is similar for monocots, but there is no radicle emergence.

Once a seed has been formed it can remain resting (dormant) for a long period. The seed will only germinate when the conditions in which it finds itself are favourable for germination and growth. The most important environmental conditions for germination are:

- Adequate water
- Adequate oxygen
- Suitable temperature
- In some cases, suitable light

The specific conditions required for germination varies between different types of seeds, and is related with the conditions under which that specific plant is able to grow. Very few types of seeds will however germinate in extreme temperatures. Some seeds, such as citrus seeds, are coated with a gummy substance. This substance contains inhibitors to germination, and has to be removed before germination takes place.

Once seed germination has been triggered, the process is as follows:

- Imbibition
- Start of metabolism
- Radicle emergence
- Growth of plant parts

Imbibition

definition

Imbibition

Imbibition means the absorption of something, such as liquid or heat. In terms of seed germination, it means the absorption of water by the seed coat.

During germination water is absorbed, or imbibed, through the seed coat, which has been almost completely dry while the seed was dormant. The water causes the seed to soften and the micropyle to open up, enabling the seed to imbibe water faster. The seed coat swells as more water is absorbed, the respiration rate and other metabolic processes increase, and more oxygen is required.

Start of Metabolism

The first metabolic processes of the plant take place when the food reserves contained in the endosperm are converted to simpler substances that are then transported to the embryo. At this point, growth starts taking place.

Radicle Emergence

The radicle starts to grow at first through cell enlargement. It appears through the micropyle and forms the tap root. The tap root develops root hairs that absorb water and attach to soil particles. The tap root grows downwards in response to gravity.

Growth of Plant Parts

Some seeds, including endospermous seeds like those of castor bean and exendospermous seeds like those of beans, lettuce and pumpkin, undergo **epigeal** germination.

With epigeal germination, the **hypocotyl**, the part of the stem between the roots and where the cotyledons are attached, starts to lengthen. The hypocotyl grows upwards against gravity. As the hypocotyl lengthens, it pushes the plumule and cotyledon(s) above the soil. The **epicotyl** is part of the stem above the point where cotyledons are attached and below the growth point. The epicotyl starts to grow after the hypocotyl.

In other seed types, including exendospermous seeds such as peas, citrus, mango and avocado and endospermous grass seeds such as maize, the type of germination that takes place is called **hypogeal**. With hypogeal germination the hypocotyl does not develop and the cotyledons remain close to the roots. The epicotyl grows and pushes the plumule above the surface of the soil.

definition

Epigeal

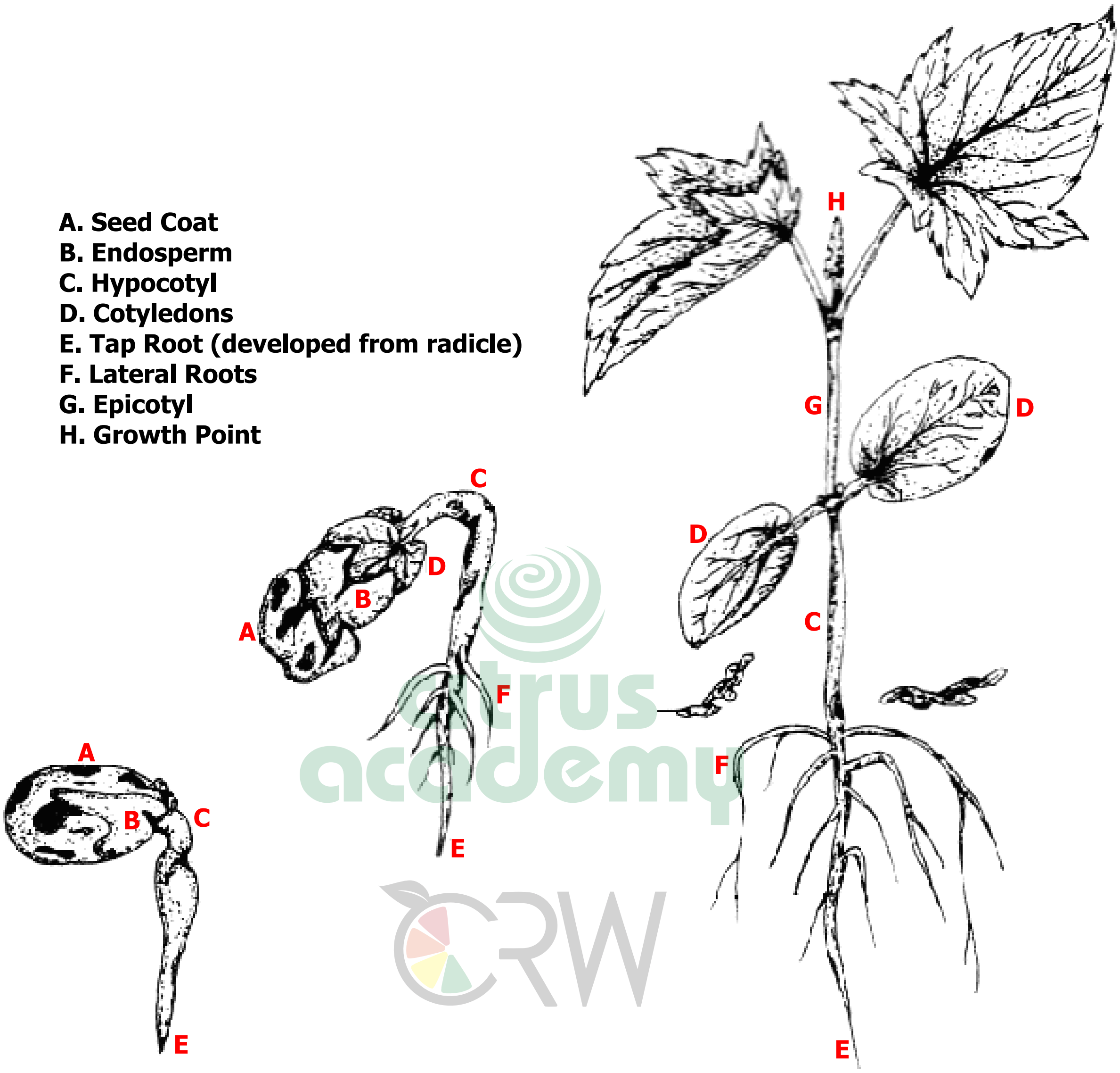
Epigeal means living or growing on or right above the surface of the soil. The term is used to describe seed germination in which the hypocotyl elongates so that the cotyledons are carried above the soil.

Hypogeal

Hypogeal means remaining below ground, and refers to when the cotyledons remain below the ground while the epicotyl of the seedling grows.

The plant survives on the reserves stored in the endosperm of the seed until it develops its first leaves, at which point photosynthesis is initiated and the plant is able to produce food. Up to this point, the plant is referred to as a seedling.

A. Seed Coat
B. Endosperm
C. Hypocotyl
D. Cotyledons
E. Tap Root (developed from radicle)
F. Lateral Roots
G. Epicotyl
H. Growth Point



practical

Activity 2.1 – Draw a Poster

Explain how seeds germinate in general. Draw pictures of each stage of seed germination and label the pictures.

summary

The Structures and Functions of Seeds

- Seeds are produced through sexual propagation and are made up of two parts, being a seed coat and an embryo
- The seed coat is the protective outer layer of a seed.
- The embryo consists of the radicle, the plumule, and the cotyledon.
- Some seeds also contain unabsorbed endosperm.
- Seeds with one cotyledon are referred to as monocot (monocotyledonous), and seeds with two cotyledons are called dicot (dicotyledonous).
- Once a seed has been formed it can remain dormant, or resting, for a long period until environmental conditions for germination are favourable.
- The most important environmental conditions for germination are adequate water, adequate oxygen, suitable temperature, and, in some cases, suitable light.
- Once seed germination has been triggered, the germination process is imbibition, start of metabolism, radicle emergence, and growth of plant parts.

Rootstock Growth Media

Types of Rootstock Growth Media

During rootstock propagation, three different types of growth media are used for the following:

- Seed germination
- Seedling trays
- Planting bags

Seed Germination

The recommended media for seed germination is medium grade vermiculite. Growth media such as perlite and vermiculite are sterile and classified as very low-risk for contamination, by virtue of the temperatures it is subjected to during processing.

Seedling Trays

The growth media used most often in commercial citrus nurseries in seedling trays and poly-tubes are sifted pine bark and peat moss.

This growth medium must allow for good water holding capacity. Because the cavities are small, it is more difficult to retain the water in the growth medium, and it therefore needs to be finer than the medium used in planting bags.

The extraction of root systems from seedling tray cavities can be difficult if sand is used as a constituent of the mix. This leads to the medium separating from the root system and may cause excessive transplant shock.

Planting Bags

Growth media used in planting bags vary greatly between nurseries – every nurseryman has his own recipe. The requirements for the growth media however remain the same, being:

- Air-filled porosity (AFP) of 14% to 20%
- Sterile
- pH of 6.5
- Electrical conductivity lower than 60mS/m (mili-Siemens per meter)

Commonly used growth media include pine bark, coarse sand, and mixes between the two. It is not recommended to add any other organic material, such as manure, because it is difficult to determine the nutrient content of such material and it may contain pathogens.

Growth Medium Treatments

Most commercial nurseries buy growth medium, such as pine bark, peat moss and sand, from suppliers.

Pine bark can be composted by the supplier or by the nursery, but it is essential that it must be composted very well before it is used. If composting is done properly the pine bark reaches a temperature of 60°C during the process, which means that the composted bark should be sterile. This should however not be assumed as one cannot be certain of how the composted bark was handled afterwards and during composting.

The best practice is to sterilise all growth media, including composted pine bark, peat moss, and sand, before it is used. The two main methods of sterilisation are steam sterilisation and fumigation.

Steam Sterilisation

The best and most economic way of sterilising growth media is through steam sterilisation. Steam sterilisation is harmless and effective, and although it requires an initial investment to install a steam sterilisation unit, in the long run it is more cost effective than chemical treatments.

The growth medium is placed in troughs or bins with pipes in the base of the structure through which steam is channelled. The growth media is covered with plastic. The temperature at the top of the heap of growth medium is measured and when it reaches 60°C, the medium has been sterilised throughout.

Fumigation

Fumigation is not the recommended sterilisation method, but it is still used in some places. The growth media is placed in heaps or troughs. The gas that is used for the fumigation treatment, most commonly methyl bromide, is heated by running it through a heated coiled pipe, after which it is applied to the growth medium.

practical

Activity 2.2 – Worksheet

Complete the following tasks:

- ✓ Place a sample of the growth media that is used in seedling trays in your nursery in a bank bag.
- ✓ Attach the sample to your workbook.
- ✓ Describe exactly how this medium is handled and treated in the nursery.

summary

Rootstock Growth Media

- Three different types of growth media are used during rootstock propagation, being for seed germination, seedling trays, and planting bags.
- The recommended media for seed germination is medium grade vermiculite.
- The growth media used most often in commercial citrus nurseries in seedling trays and poly-tubes are sifted pine bark and peat moss.
- Growth media used in planting bags vary greatly between nurseries, but the requirements for the growth media remain air-filled porosity (AFP) of 14% to 20%, sterility, pH of 6.5, and electrical conductivity lower than 60mS/m.
- Most commercial nurseries buy growth medium, such as pine bark, peat moss and sand, from suppliers.
- It is essential that pine bark must be composted very well before it is used.
- The best practice is to sterilise all growth media, including composted pine bark, peat moss, and sand, before it is used.
- The best and most economic way of sterilising growth media is through steam sterilisation.
- Fumigation is not the recommended sterilisation method, but it is still used in some places.

Rootstock Propagation Tools and Equipment

Introduction

The tools and equipment that is used during rootstock propagation are:

- Germination tray
- Seedling tray
- Planting tool
- Planting bags

Germination Trays

Seed germination trays are 5cm deep and made of a square wooden frame with a base made of gauze (shade cloth) for air root pruning and adequate drainage. Germination trays are placed on special metal racks.

definition

Air Root Pruning

Air root pruning happens when the roots of the seedlings grow through the base of the germination tray and is pruned by air exposure.

Air root pruning ensures that roots do not grow too long. It also means that seed germination trays must never be placed on a solid surface.

Germination trays must be sterilised after each used. All plant material and remaining growth media must be removed after the seedlings have been transplanted. Trays are then dipped in a suitable sterilisation medium.

Seedling Trays

Seedlings are transplanted from germination trays into individual cavities in seedling trays, with a recommended size of 5x5x10cm. There are two types of seedling trays, being solid foamalite trays and plastic trays with loose inserts. In some nurseries poly-tubes, which are small planting bags with a minimum volume of 200ml, are used instead of seedling trays.

The advantages of plastic trays are that the seedlings in the inserts can be moved around so that trays with uniform plants can be made up. Plastic trays are however considerably more expensive than foamalite trays. Both foamlite and plastic trays can be used more than once.

Before being used, foamalite trays must be dipped in a Styrodip (or similar) solution to coat the foam. This prevents the roots of the seedlings from growing into the foam.

Seedling trays must also be sterilised after each use. Make sure that all growth media and plant material is removed from the trays, and dip them in a suitable sterilisation medium.

Planting Tool

A tool is needed to make a hole in the growth medium in the seedling trays or poly-tube into which the seedlings are planted, and in the growth media in the planting bags when seedlings are transplanted from seedling trays. This can be any object that can make a hole of the right size, and is generically referred to as a dibber.

Planting tools must be sterilised before, during and after use. Do not place the tool on the ground while it is in use, as this will transfer pathogens from the soil to the growth medium. Sterilise it regularly to ensure that infection is prevented.

Planting Bags

Planting bags vary between nurseries, but the main guidelines are:

- A tall bag which is not too wide is better for drainage
- There must be drainage holes on the bottom fold of the bag. If the holes are too far up the side of the bag, water collect at the bottom of the bag, and if they are on the base of the bag, water will not be able to drain out if the bag is standing on a solid surface. Holes must be big enough to allow for adequate drainage.
- The plastic that the bag is made from must be of suitable quality so that the bag will last for as long as the tree is in it (up to 24 months). Carbon is added to the plastic to protect it against degrading from sunlight, which is why most planting bags are black.
- The size of planting bags varies, but the most commonly used bags have a volume of 4 to 5 litres.

practical

Activity 2.3 – Logbook

Hand in a logbook to prove that you have successfully worked with tools and equipment in the citrus nursery. Log you activities in the book for at least 10 working days, as follows:

- ✓ Make a list of all the tools and equipment that you work with during these 10 days.
- ✓ Next to each tool and equipment, write how you handle it before work commences, while you work with it, and after you have worked with it.
- ✓ Have your supervisor confirm that the procedures that you follow are accurate by placing his / her signature next to each day.

summary

Rootstock Propagation Tools and Equipment

- The tools and equipment that is used during rootstock propagation are germination trays, seedling tray, planting tools, and planting bags.
- Seed germination trays are 5cm deep and made of a square wooden frame with a base made of gauze for air root pruning and adequate drainage.
- There are two types of seedling trays, being solid foamalite trays and plastic trays with loose inserts.
- Seed germination trays and seedling trays must be sterilised after each use.
- A planting tool is used to make a hole in the growth medium in the seedling trays or poly-tubes into which the seedlings are planted, and in the growth media in the planting bags when seedlings are transplanted from seedling trays.
- Planting tools must be sterilised regularly to prevent infection.
- Planting bags need to be tall and not too wide for better drainage, with drainage holes on the bottom fold of the bag, and made from plastic of a suitable quality so that the bag will last for as long as the tree is in it.

Rootstock Propagation

The Role of Seeds in Citrus Rootstock Propagation

In commercial plant propagation it is very important that the nursery is able to produce plants that are true-to-type, meaning plants that are essentially the same as the mother plant.

We saw that with sexual (seed) propagation a **zygotic** embryo develops from which a seedling grows that has characteristics that are a combination of the characteristics of the mother and father plant. Because the characteristics of seedlings cannot be guaranteed, seed propagation is not generally used in the commercial propagation of other tree crops.

Citrus rootstock is however propagated from seed in commercial citrus nurseries, because of the special structure and development of citrus seeds, which allow the propagator to produce seedlings with essentially the same characteristics as the mother plant. Other fruit types do not have this characteristic, and true-to-type seedlings can therefore not be produced through seed propagation.

We already know that the embryo is surrounded inside the seed by the **nucellus**. In citrus, a somewhat unusual process occurs where some of the nucellar cells develop into nucellar embryos. The number can vary, with up to six nucellar embryos in some cultivars.

These cells do not undergo meiosis and contain the full set of maternal chromosomes, meaning that the nucellar embryos are deemed to be the same as the mother plant. Because the seed can give rise to more than one type of embryo, citrus is referred to as being **poly-embryonic**.

When the citrus seed germinates, more than one seedling grows from each seed. The zygotic embryo will always form one seedling, while the number of nucellar embryos that develop into seedlings differs. Mostly, between two and four seedlings grow from a single seed, one of them zygotic.

The zygotic seedlings differ from the nucellar seedlings in that they are either markedly more vigorous or markedly weaker and have off-type leaves. They are removed in the nursery when rootstock plants are propagated. Only true-to-type nucellar seedlings are eventually used as rootstock plants.

Rootstock Cultivars

Rootstock cultivars are identified or developed through breeding programs. These cultivars may not have edible fruit, but they are excellent rootstock plants.

A good rootstock cultivar is adaptable to the soil conditions and climate in a specific area, has a strong root system, is resistant to cold damage and pests and diseases, and can enhance the quality of the fruit. Some rootstocks, such as Swingle, can also delay the ripening of the fruit. Rootstocks are also used so that seedless fruit can be produced.

There are many hundreds of selections, but for commercial purposes only twenty to thirty are used worldwide. In Southern Africa the following rootstocks are commonly used:

- Rough lemon
- Volckameriana
- Swingle Citrumelo
- Carrizo Citrange
- Troyer Citrange
- X639 (Cleopatra X P. Trifoliata)
- C-35
- MXT
- Yuma citrange
- Other lesser used varieties such as Rangpur lime and Sunki Beneke

In the table below are the characteristics of the most commonly used rootstock cultivars.

	Rough-lemon	**Swingle Citrumelo**	**Carrizo Citrange**	**X639**	**C-35**	**MXT**
Disease susceptibility						
Exocortis	Tolerant	Tolerant	Sensitive	Susceptible	Susceptible	Susceptible
Tristeza	Tolerant	Tolerant	Tolerant	Tolerant	Tolerant	Tolerant
Phytophthora	Susceptible	Tolerant	Tolerant	Susceptible	Tolerant	Tolerant
Citrus nematodes	Susceptible	Tolerant	Susceptible	Not known	Tolerant	Tolerant
Soil factor						
Poor drainage	Sensitive	Tolerant	Sensitive	Sensitive	Sensitive	Sensitive
High clay content	Sensitive	Intermediate	Intermediate	Sensitive	Tolerant	Intermediate
High sand content	Tolerant	Intermediate	Sensitive	Intermediate	Intermediate	Intermediate
High chlorides	Tolerant	Intermediate	Sensitive	Intermediate	Sensitive	Sensitive
High pH	Tolerant	Sensitive	Sensitive	Tolerant	Sensitive	Sensitive
Drought	Tolerant	Tolerant	Intermediate	Sensitive	Sensitive	Sensitive
Replant	Sensitive	Tolerant	Intermediate	Sensitive	Tolerant	Intermediate
Tree performance						
Tree growth rate	Vigorous	Moderate	Moderate	Moderate	Slow	Moderate
Final tree size	Large	Medium	Medium	Medium	Small	Medium
Cold hardiness	Poor	Good	Good	Good	Good	Good
Longevity	Fair	Good	Good	Fair	Good	Good
Yield per tree	High	Good	Good	Good	Good	Good
Fruit quality	Low	Good	Good	Good	High	High
Rind colour development	Intermediate	Late	Early	Early	Intermediate	Intermediate

Adapted from Citrus Rootstocks: The Choice You Have – Louis A. Von Broembsen

Rootstock Seed

Seed propagation must be aimed at producing disease-free plants and represents a crucial stage in the production cycle. The process begins with seed germination, which is dependent on environmental factors and seed viability (the ability of the seed to germinate and grow into a seedling).

Seeds used for rootstock come from a tree with known and desired qualities. Seed from common, edible citrus fruits, such as sweet orange, grapefruit or mandarin, can be used for growing rootstock plants at home, but are generally not recommended for commercial purposes. Commercial citrus nurseries purchase seeds from certified sources, because these seeds are guaranteed to be true-to-type and free from diseases.

Rootstock seeds are extracted from mature and ripe fruits. The simplest means of extraction is making a horizontal cut into the fruit, just deep enough to avoid cutting the seeds. Twist the two halves apart and collect the seeds by using an electric juicer. The seeds are separated from the accompanying pulp by repeated washing.

Large-scale operations make use of a crusher, which separates the seeds from the pulp, rag and peel by using jets of water. The crushed fruit can also be treated with pectinase enzymes, which essentially digests the pulp, rag and peel, leaving the seeds intact.

Extracted seeds are surface-sterilised, as described in the next section, and air-dried. Properly treated and packaged seeds can be stored in a refrigerator at 10°C for four to six months with little loss in viability.

Seed sizes vary, and the table below gives an indication of the number of seeds contained in a litre volume. Larger numbers indicate smaller seed size.

Cultivar	Seeds per litre
Carrizo Citrange	2,600
Swingle Citrumelo	3,100
Roughlemon	5,600
Cleo x Trifoliate (x639)	4,800
Minneola x Trifoliate (MXT)	3,100
Yuma Citrange	4,000
Volckameriana	6,800

practical

Activity 2.4 – Workplace Interview

Conduct a workplace interview with the nursery manager or your workplace mentor and answer the following:

✓ Where do the seeds used in the nursery come from?

✓ Are there any special requirements for the seeds that are used in the nursery?

Seed Sterilisation

Seed treatment reduces the possibility of infections, but infected fruits should still be avoided when collecting seeds. Only healthy fruit still hanging on the tree are to be used, as rotten fruit and fruit lying on the ground might carry *Phytophthora* and contaminate the growth medium.

Seeds may be an entry point for diseases, and the propagator must ensure that they are treated with fungicides. The standard treatment as recommended by the Citrus Improvement Scheme (CIS) is described in the skills section of this learning module.

skills

Please see the instructions on **Sterilising Seed** in the Skills module.

Seed Germination

In commercial citrus nurseries in South Africa, seed germination happens in seed germination rooms, which is a sterile environment where high humidity and temperature can be maintained. Seeds are sown in germination trays, which are kept in the germination room until they have germinated and seedlings have developed at least two differentiated leaves.

During this time, the seedlings feed off the nutrients contained in the cotyledons, and are watered regularly. Seedlings are also regularly treated with fungicides because the warm and humid environment in the germination room is ideal for fungal growth.

skills

Please see the instructions on **Sowing Seed** in the Skills module.

Transplanting Seedlings from Germination Trays

Healthy seedlings with straight roots and more than two differentiated leaves are transplanted into poly-tubes or seedling trays with each seedling in an individual cavity.

As discussed before, seeds produce more than one, generally three, seedlings per seed. One of the seedlings is from the zygotic embryo, while the others are the nucellar seedlings, which are exact copies of the mother-plant. The zygotic seedlings are discarded during transplanting. Zygotic seedlings are either markedly weaker or markedly more vigorous than the other seedlings, and can be identified by the fact that their leaves are off-type.

Seedlings that are ready to be transplanted are selected from the germination trays, while the rest of the seedlings in the tray will remain there until they are ready. A germination tray is therefore emptied over a period of about a week.

Seedlings are selected as follows:

- Seedlings must have between two and four differentiated leaves.
- Seedlings must not have bench roots that grow upwards in a U-shape and downwards again (like a washbasin drainpipe). Slightly bent roots are acceptable, but U-bends must be avoided.
- Seedlings must be true-to-type, which can be observed in the leaves at this time. If the cultivar for instance has trifoliate leaves, zygotic embryos will at this stage have only one or two leaflets in stead of three, and these seedlings must be discarded.
- Seedlings that are transplanted at the same time must be of uniform size.

When seedlings are transplanted, care must be taken not to bend the roots. A seedling is therefore pushed in slightly deeper than what is required, after which it is carefully pulled out again to straighten the roots. The cotyledons of the seed are still attached to the stem of the seedling at this time, and should be just above the surface of the growth medium after the seedling is transplanted.

Seedlings are kept under controlled environmental conditions in greenhouses (tunnels) in the seedling trays. The seedling gets nutrients from the cotyledons for about the first two weeks, or until it has about six leaves.

After that time, fertiliser is applied with the irrigation (fertigation) to provide the seedlings with nutrients. The frequency of irrigation depends on the age of the seedlings, and on the environmental conditions. Overhead irrigation works well when seedlings are still small, but a hand-held hose with a water rose is used for older seedlings. Germination trays must be kept clean of weeds. Pests are monitored and spray applications are used to control pests if necessary.

skills

Please see the instructions on **Transplanting Seedlings – Germination Trays to Seedling Trays** in the Skills module.

Transplanting Seedlings from Seedling Trays

When seedlings reach a height of 10 to 15cm, they are transplanted to the planting bags where they will stay until they are planted in an orchard. Seedlings can be left in poly-tubes for a little longer, which is the main reason why poly-tubes are sometimes used.

When seedlings are transplanted to seedling trays, they are again selected for being true-to-type. Any remaining zygotic seedlings are discarded at this point, still identifiable by off-type leaf structures. Seedlings that are not vigorous or that are sub-standard are also discarded at this time.

The seedling is removed from the cavity in the seedling tray with the growth medium, either by pulling it from the top, or by pushing it from the bottom with a pencil. The growth medium must be moist when it is removed, otherwise it will not come out with the seedling.

When the seedling is planted in the planting bag, care must be taken not to plant it too deep. The seedling growth medium must still be visible on the surface of the growth medium in the bag after it has been planted.

Seedlings are kept in the shade house where environmental conditions are still controlled to a certain extent. It is important to keep seedlings that are of similar size together, so that the same management practices can be employed.

Seedlings are irrigated regularly, depending on the environmental conditions and on the size of the seedlings. The nursery manager determines the irrigation frequency and stand time for irrigation. Water is applied either through a permanent irrigation system, or manually with hoses.

Fertigation is used to provide nutrients to the seedlings. Planting bags must be kept weed free, and regular scouting is conducted to monitor pest levels. Spray applications of plant protection products are applied when necessary, while preventative programs for greening disease (aimed at controlling the insect citrus psylla) and citrus blackspot must be in place.

When the seedlings reach a diameter of about 8mm at a height of 20cm above the growth medium level, they are ready for budding.

skills

Please see the instructions on **Transplanting Seedlings – Seedling Trays to Planting Bags** in the Skills module.

Transplant Shock

Seedlings may suffer from transplant shock, which is when a seedling suffers a sudden loss in vitality after being transplanted.

Transplant shock is more likely to occur after a seedling is transplanted from a germination tray to a seedling tray, as its roots are bare during this operation. When it is transplanted to a planting bag, its roots remain covered in growth medium, and the risk of transplant shock is therefore reduced.

practical

Activity 2.5 – Flow Diagram

Draw a flow diagram of the steps required during seed tray preparation and seed germination.

summary

Rootstock Propagation

- With sexual (seed) propagation a zygotic embryo develops from which a seedling grows that has characteristics that are a combination of those of the mother and father plant.
- Because a zygotic embryo develops into a seedling that is not true-to-type, seed propagation is not generally used in the commercial propagation of tree crops.
- Citrus rootstock is however propagated from seed in commercial citrus nurseries, because of the special structure and development of citrus seeds.
- Rootstock cultivars are identified or developed through breeding programs.
- The rootstocks that are commonly used in Southern Africa are rough lemon, Volckameriana, Swingle Citrumelo, Carrizo Citrange, Troyer Citrange, X639 (Cleopatra X P. Trifoliata), C-35, MXT, and Yuma Citrange.
- Rootstock cultivars are variously resistant to specific diseases, adaptable to soil conditions, and induce tree performance.
- Seed propagation must produce disease-free plants.
- Seeds used for rootstock come from a tree with known and desired qualities.
- Commercial citrus nurseries purchase seeds from certified sources.
- Rootstock seeds are extracted from mature and ripe fruit, surface-sterilised and air-dried. It can be stored for up to six months under the right conditions.
- Seeds are sown in germination trays, which are kept in the germination room until the seeds have germinated and the seedlings have developed at least two differentiated leaves.
- Healthy seedlings with straight roots and more than two differentiated leaves are transplanted to seedling trays, which are kept in greenhouses or tunnels.
- When seedlings reach a height of 10cm to 15cm, they are transplanted to the planting bags where they are budded and where they then stay until they are planted in an orchard.
- At each transplanting point, zygotic seedlings are discarded, along with other seedlings that are not up to standard.
- Seedlings may suffer from transplant shock, which is when a seedling suffers a sudden loss in vitality after being transplanted.

Environmental Conditions for Rootstock Propagation

Introduction

In the previous module, the different environmental conditions that are monitored and controlled during the propagation process were discussed in detail. In this section we look at the environmental requirements for seed germination rooms, in the greenhouse, and in the shade house.

Germination Rooms

The most important environmental conditions for germination are adequate water, adequate oxygen, suitable temperature, and suitable light.

The ideal environmental conditions for seed germination are:

- Temperature – 28-29°C
- Humidity – above 80%

Adequate light is essential in the germination room. If the light is not adequate, seedlings will be etiolated, with long, thin, pale stems. Rooms are equipped with sources of artificial red light, which promote growth.

Depending on the type of light source used, it may also be able to increase the temperature in the room. If the light source is not able to increase the temperature, additional heating units are used. Incandescent lights are commonly used for this reason.

Humidity in the germination room can be maintained by using a humidifier, or by wetting the floor of the room.

Greenhouses (Tunnels)

The ideal environmental conditions for greenhouses are:

- Temperature – 28-29°C
- Humidity – below 50%

The environmental conditions in greenhouses (tunnels) are still controlled to some extent, but not as closely as in germination rooms. It is important to ensure that there is not a build up of CO_2 in the greenhouse.

Shade Houses

The conditions in shade houses are determined by ambient weather conditions. The temperature and humidity in the shade house cannot be controlled, while the light can be controlled only by the percentage of shade cloth used. The shade cloth also protects the seedlings from wind.

practical

Activity 2.6 – Presentation

Prepare a short presentation to educate your co-workers on the points below. Attach a copy of the presentation to your workbook.

- ✓ What are the exact environmental conditions that are required for citrus seeds to germinate successfully?
- ✓ How are these requirements met by the citrus nursery?
- ✓ How can the nursery worker assist with ensuring that these requirements are met?

summary

Environmental Conditions for Rootstock Propagation

- The most important environmental conditions for seed germination are adequate water, adequate oxygen, suitable temperature, and suitable light.
- Germination rooms are equipped with sources of artificial red light, which promote growth.
- The ideal environmental conditions for seed germination are temperature of 28-29°C, and humidity of above 80%.
- It is important to ensure that there is not a build up of CO_2 in the greenhouse, with an ideal temperature of 28-29°C and an ideal humidity of below 50%.
- The conditions in shade houses are determined by ambient weather conditions, with only the light being controlled by the percentage of shade cloth used.