LEARNER GUIDE

Plant Manipulation

Level 2

P.O. Box 461, Hillcrest, 3650
(031) 313-3364

Title:		**Apply Plant Manipulation Methods**					
Applied Title:		**Apply Citrus Plant Manipulation Methods**					
Field:		Agriculture and Nature Conservation					
Sub-Field:		Primary Agriculture					
SETA (SGB):		AgriSETA					
Skills Area:		Plant Manipulation					
Context:		Citrus Production					
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Author:		C. Alexander					

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Unit standard alignment and assessment tool development:
Cabeton Training and Development

Project coordinator:
Jacomien de Klerk

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Directions

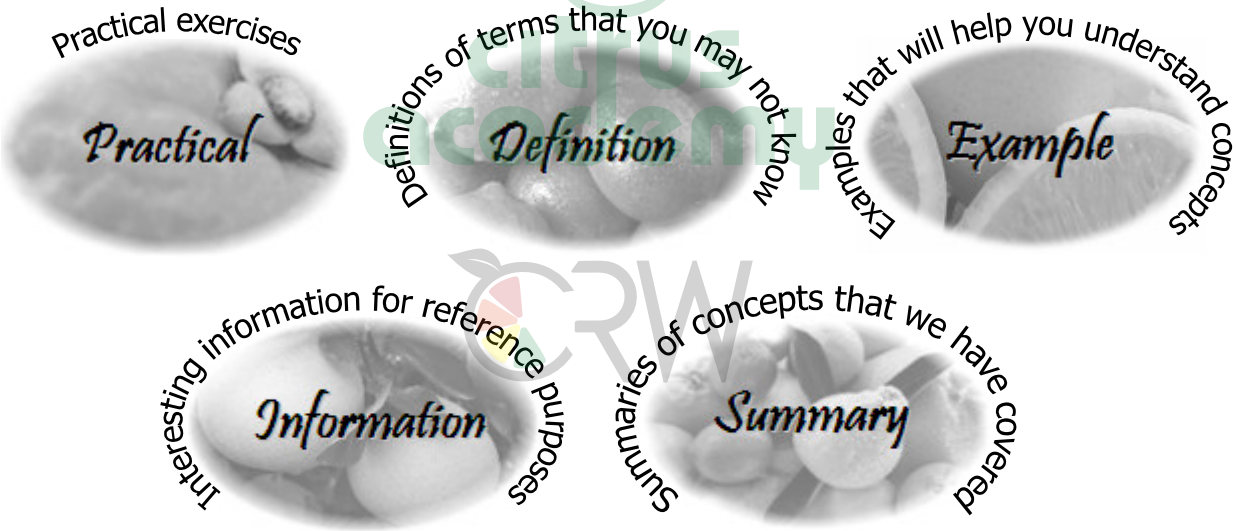
This learning material has been developed to assist the learner wishing to complete this unit standard. The guide contains all necessary learning to ensure that the learner will attain the competencies required by the unit standard.

The learner guide is accompanied by a Learner Assessment Guide. Please ensure that you have access to this guide as well.

The learner guide was designed to be used by a learner during the presentation of a skills program based on the unit standard, and to be kept afterwards by the learner for reference purposes. The learner assessment guide was designed to be completed during and after the presentation of the skills program, and forms part of the assessment process.

Although this learner guide contains all the information required for attaining competency in this unit standard, references to additional resources, both printed and electronic, are provided for further study by the learner.

Information in boxes is indicated by tags that show:



Introduction

1. Purpose

A learner achieving this unit standard will be able to train (manipulate) plants by applying a narrow range of techniques, as well as providing limited guidance to others. This unit standard builds on the learner's skills and capacity to apply plant manipulation in a production environment and use this to contribute towards to overall productivity of a production enterprise by maximising growth and yield.

Learners will gain specific knowledge and skills in plant manipulation techniques and will be able to operate in a plant production environment implementing sustainable and economically viable production principles.

They will be capacitated to gain access to the mainstream agricultural sector, in plant production, impacting directly on the sustainability of the sub-sector. The improvement in production technology will also have a direct impact on the improvement of agricultural productivity of the sector.

2. Learning Assumed to Be in Place

It is assumed that the learner has successfully completed the unit standards listed below:

NQF Level	*Unit Standard Number*	*Unit Standard Description*
1 (ABET 4)	Literacy and Numeracy	
1	116203	Manipulate plants
1	116167	Select, use and care for hand tools and basic equipment and infrastructure
2	116057	Understand the structure and functions of a plant

Introduction to Citrus Production

1. Introduction

This learning material has been developed in the context of citrus production, which means that the skills area is dealt with in terms of and as applied to citrus production. To help the learner place the material in the right context, it is necessary for the learner to understand the background to citrus production, and the manner in which a citrus plant produces fruit.

2. Background

Citrus originates from the subtropical regions of south-east Asia. In the wild, citrus trees in these regions produce fruit all year round, and the fruit are small, poorly coloured and blemished. In the absence of effective production practices, citrus trees do not produce fruit suitable for the market.

Citrus production is largely concerned with management of the practices and processes that manipulate the tree to produce high yields of marketable fruit. Production management, together with the selection of superior varieties and plant improvement, can be seen as an on-going effort to influence the natural tendencies of the tree.

Consumers want the fruit of their choice to be available at all times. Fruit should look good, be unblemished, well-coloured (superior exterior quality), taste good (high interior quality) and be of the right size. At the same time, the citrus producer wants orchards that will provide high yields over an orchard lifespan of 18 to 30 years. On top of all this, the citrus orchard must be managed in such a way that production practices have the least possible impact on the natural environment. Commercial citrus production management is about achieving these objectives efficiently and cost effectively.

3. Citrus Planting

Citrus trees are planted in rows in orchards. The planting distance, also called tree spacing or espacement, between rows and between trees within rows, is determined by numerous factors including climate, variety, and soil type. A typical tree spacing is 6m between rows by 3m between trees, meaning that 555 trees per hectare (ha) are planted (1ha = 10,000 m^2).

Once planted, trees take three or more years before bearing fruit that can be marketed. Thereafter, per tree and per hectare yields steadily increase to 40 to 70 t/ha – depending on cultivar and variety – after a further 4 to 7 years. If the trees are well looked after, this level of production will remain fairly constant until trees start to decline naturally.

Yield

Yield refers to the amount of fruit produced, and can be expressed in terms of:

Tree yield	kg per tree	kg/tree
Orchard yield	tons per hectare	t/ha
Export yield	15kg carton equivalents per hectare (10kg carton equivalents for soft citrus)	cartons/ha

4. Lifespan

The average economic lifespan of a commercial citrus orchard varies between 18 and 30 years, and can be as high as 30 to 60 years in hot, dry areas. Citrus is therefore viewed as a long-term crop. For citrus production to be profitable, the orchard must produce high yields of quality fruit every year, and do this consistently over a long period of time.

In citrus production the challenge is therefore to make production decisions and take actions to ensure high annual production of marketable fruit, while ensuring that these decisions and actions contribute to the long-term sustainability of the orchard.

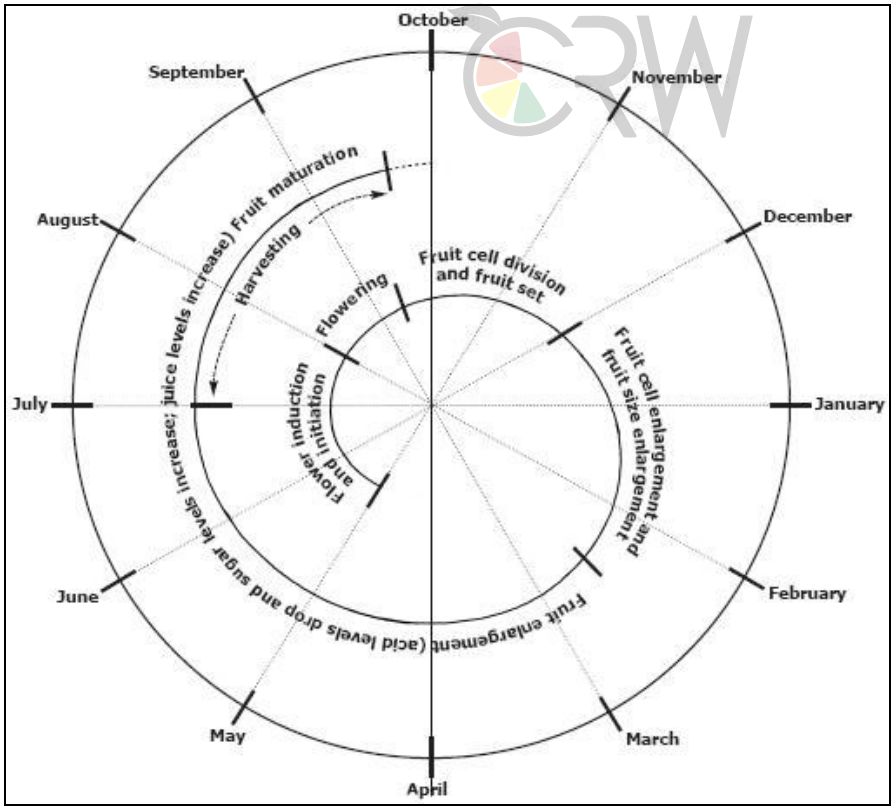
5. Citrus Plant Phenology

Phenology

Phenology refers to regularly recurring biological phenomena and the environmental and climatic factors that influence them. In citrus, phenology specifically refers to the annual cycle of the citrus tree.

Understanding the phenology of the citrus tree is essential to understanding the reasoning behind many of the practices and actions employed in citrus production. For example, the timing of fertiliser applications is linked to the phenology of the tree, with most fertilisers being applied at appropriate times to optimise flowering, fruiting, fruit development and fruit maturation.

The figure and table below set out the annual cycle of the citrus tree with regard to fruit production. Please note that this figure and table reflect the approximate flower and fruit development cycle of a valencia orange tree, and that the phenology of various cultivars differ.



Stage	***Description***	***Time Period***
Flower Induction and Initiation	Flower initiation is the induction and differentiation of vegetative buds into flower buds at a cellular level, and cannot be seen with the naked eye.	May to July
Flowering	Flowering or "bloom" is when blossoms appear on the tree.	August to Mid-September
Cell Division and Fruit Set	Cell division is the period when cells making up the fruit increase in number. Fruit set is the period from flowering or "bloom" until the end of fruitlet drop, after which the final fruit load is determined.	Mid-September to November
Cell Enlargement and Fruit Growth	Cell enlargement is the period during which cells making up the fruit increase in size. Fruit growth is the period during which the fruit grows and develops.	December to Mid-February
Fruit Maturation and further Fruit Growth	During this period fruit enlarges further and matures internally, meaning that the flavour, sugars and acids reach their optimum levels.	Mid-February to September
Harvest		July to September

It is important to note the term **citrus season** refers to the period from when flower initiation begins to the harvest. The season is generally from the beginning of August of one year to the end of July of the next year, although harvesting may extend to September and October for late cultivars.

6. Citrus Learning Material

The following citrus specific learning material is available from the Citrus Academy:

Skills Area	***Description***
Enterprise Selection, Planning and Establishment	Concerns itself with identifying the various components of an agricultural enterprise, and with the selection and planning processes for a new enterprise, and looks at the physical layout of a farm, with specific reference to infrastructure, orchard layout, etc.
Propagation	Concerns the various methods and requirements for the multiplication of plant material of specific varieties that possess desired qualities.
Crop Establishment	Concerns the establishment of a new citrus orchard, in terms of the physical planting of trees and the care for young trees.
Plant Structures and Functions	Considers the structure and function of various plant parts and the manner in which nutrients, water, air and sunlight is taken up and processed.
Plant Nutrition and Soil Management	Concerns itself with plant nutrients, in terms of the requirements of the citrus plant and the supplementation of nutrient elements through fertilisation, with specific reference to the timing and manner of application.
Water Quality	Considers the various factors that influence water quality and manners in which water quality can be measured and controlled. Considers furthermore the effect of water quality on tree and fruit growth and development, in combination with effective irrigation, fertilisation and pest control.

Skills Area	***Description***
Plant Manipulation	**Concerns various types of physical and chemical plant manipulation, with specific reference to pruning, girdling and the application of plant growth hormones, and tools and equipment used for this purpose.**
Irrigation	Looks at the technical aspects of orchard irrigation, with reference to the types of irrigation systems, the installation of new irrigation systems, and the repair and maintenance of an irrigation system. Also concerns irrigation scheduling, and measures to ensure effective irrigation.
Pests, Diseases and Weeds	Concerns the identification of pests, diseases and weeds that threaten citrus production. Also considers various methods of effective control, and the planning required for this purpose.
Crop Protection	Looks at the practical application of crop protection agents through various methods, with specific reference to tools and equipment used, and health and safety requirements.
Food Safety	Concerns the requirements in terms of health and safety, and environmental control for ensuring food safety and hygiene.
Harvesting	Looks at the process of determining fruit maturity through maturity indexing, the harvesting of fruit, and the tools and equipment used for this purpose.
Conservation	Considers the impact of farming practices on the environment, with reference to the measures required to minimise this impact and protect the environment.
Marketing	Concerns the factors influencing citrus marketing, and the development of an effective marketing plan.
Production Management	Concerns the actions and processes involved in effective production management, with specific reference to the coordination of the various production tasks and processes and the creation of a strategic plan for the enterprise.
Industry Overview	An overview of the citrus industry and the various institutions involved.
Packhouse Practices	Concerns the specific principles and practices that are employed in the packhouse environment, and specifically: • Citrus Product Characteristics • Understanding Citrus Fruit Markets • Health and Safety in the Packhouse • Personal Hygiene Requirements for Packhouse Personnel • Understanding and Maintaining the Cold Chain • The Role of Quality Checks in the Packing Process • The Application of Fruit Treatments • The Application of Pre-Sorting Prior to Packing • Receiving Fruit into the Packhouse • Grading Fruit in the Packhouse • Packing and Packaging Materials • Palletisation of Packed Fruit • Storage of Fruit • Dispatch and Transportation of Packed Fruit • Understanding Automated Packing Solutions

Chapter 1

After completing this chapter, the learner will be able to:

Demonstrate an understanding of the selection and use of appropriate tools and equipment for a pre-determined manipulation method

1. Introduction

Plant manipulation is the skilful management or treatment of plants to derive a specific outcome. Trees are manipulated in various deciduous crops such as apples, pears and grapes, to enhance the fruit size and quality. Do we need to manipulate, citrus and why?

Citrus is sold to overseas consumers through fresh fruit exports, local supermarkets, hawkers, juice manufacturers, and processors. Each of these markets has their own requirements in terms of the external and internal quality of the fruit. The highest income is from fresh fruit exports.

What fruit would a discerning overseas buyer like? It has been found that overseas consumers prefer fruit that is large and orange-red in colour, has no blemishes, tastes sweet, and is easy to peel. If you want to sell your product at a good price, you have to provide the consumer with what they want.

A fruit tree will not necessarily naturally produce fruit that complies with these requirements. Plant manipulation methods contribute to producing a marketable product at an acceptable price.

Plant manipulation cannot mend diseased or neglected trees, or solve cultivar selection or other problems. All other production practices should be under control, including plant nutrition, irrigation, soil related factors, fungal diseases, and protection from pests. It is also assumed that the right cultivar has been planted on the right rootstock in the right area. If any of these factors are neglected or done incorrectly, the problems that will occur as a result cannot be resolved through plant manipulation alone. The cause of the problem must be identified and rectified, and only then the correct plant manipulation technique can be selected to improve the situation.

When dealing with the various manipulation techniques, keep in mind that a citrus tree is a living organism. Circumstances change and are dependant on many internal and external factors, and plant manipulation therefore does not always have the same predictable outcomes. Knowledge of the tree and local conditions, and experience in using these techniques play a big role in being able to predict the outcome. Certain techniques, concentrations and timing also vary between cultivars, different climatic zones, and different microclimates.

2. Plant Manipulation Methods

Plant manipulation methods are divided into two categories, being physical and chemical manipulation. Some methods, such as fruit thinning, can be done manually or chemically, and therefore falls under both categories.

2.1. Physical Plant Manipulation Methods

The methods in this category all make use of a physical form of intervention or manipulation. These methods include:

- ***Pruning*** means the physical cutting back of certain parts of the tree. Pruning is used mainly to control the size of citrus trees, to improve their shape, and to improve light interception

inside the tree. Pruning can be done by hand or by using machines. Hedging and topping is a mechanical method that uses tractor-mounted machinery.

- ***Skirting*** means to cut back or remove low hanging branches to a specified height above the soil surface. Skirting is done to prevent fruit and branches from touching the ground and to enhance various cultural practices.

- ***Girdling*** means making a thin cut through the bark of the tree. Girdling is done to increase fruit set and raise the sugar levels in the fruit.

- ***Manual fruit thinning*** means manually removing selected fruit from a tree to improve the quality of the remainder of the fruit.

2.2. Chemical Plant Manipulation

Chemical plant manipulation is done through the application of chemicals or hormones to achieve the desired results. Chemical plant manipulation is done to achieve:

- ***Fruit set improvement*** to increase the number of fruit on the tree that will reach marketable size and quality.

- ***Chemical fruit thinning*** to reduce the number of fruit on the tree to improve the quality of the remainder of the fruit.

- ***Fruit size enlargement*** to make the harvestable fruit larger in size.

- ***Harvest delaying*** to hang the fruit on the tree for a longer period – while retaining its quality – until after its normal picking time.

- ***Creasing control*** to control the conditions under which the tree grows or fruit is produced in order to prevent or delay the onset of creasing, which is caused by tearing of the fruit rind.

It is important to always operate within the parameters prescribed on the product label. Read the label carefully before using any chemical and only spray according to the recommendations. Take special note of any warnings, precautions and directions for use.

3. Plant Manipulation Tools and Equipment

There are a number of tools that are used during manipulation of citrus. Care should always be taken to use them correctly and safely.

3.1. Pruning Shears

Pruning shears are used to cut off smaller branches of up to 20mm thick when pruning and skirting. There are two types of pruning shears, namely by-pass and anvil shears. By-pass shears are used for soft tree wood and stems, while an anvil shear gives a clean cut in hard and dead wood.

Figure 1.1: By-Pass Pruning Shears

Figure 1.2: Anvil Pruning Shears

3.2. Lopping Shears

Lopping shears are used to cut branches up to 30mm thick when pruning and skirting. Lopping shears have long handles for better leverage. Lopping shears are available in by-pass and anvil shears. Pneumatic pruning and lopping shears are also available, with or without telescopic handles.

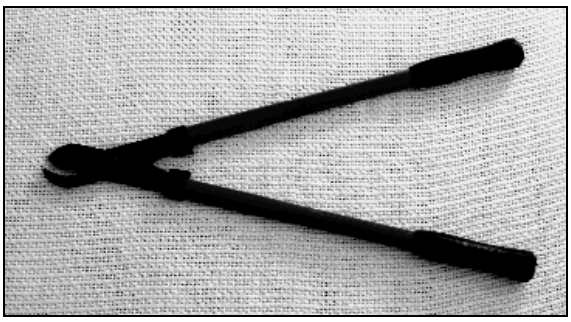


Figure 1.3: Lopping Shears

Definition

Pneumatic Equipment
When equipment is **pneumatic** it means that the equipment is driven by compressed air. A flexible hose runs from an air compressor to the equipment. Less physical pressure needs to be exerted when using pneumatic equipment and work can be done faster and with less effort, because the compressed air does most of the work.
Telescopic Handles
Telescopic handles are used to extend the handle of a piece of equipment, enabling one to reach high branches. These handles are normally tubular and can slide in and out of each other, extending or shortening the handle.

3.3. Bow Saw

Bow saws are available in various sizes and have replaceable blades. Bow saws are used for cutting thicker branches than the lopping shear is capable of. The blade must be under tension otherwise it tends to twist, resulting in a skew cut.

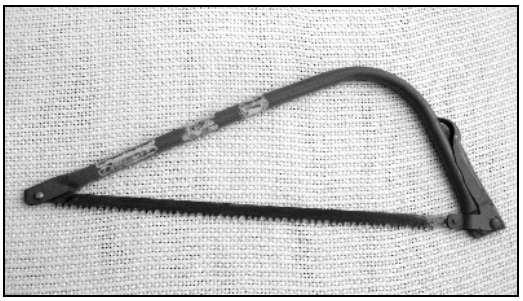


Figure 1.4: Bow Saw

3.4. Pruning Saw

A pruning saw gives a quick, neat, clean cut through thicker wood when a saw is needed. It uses a pulling action for cutting. Pruning saws are available with straight, curved or folding blades.

They are more expensive than bow saws, but give a better cut. Pneumatic saws are also available, with or without telescopic handles.

Figure 1.5: Pruning Saw

It is important to remember that citrus trees **must never be over-pruned** – this posts a much bigger danger than under-pruning. Some of these tools, such as the pruning saw, would not normally be appropriate when pruning a citrus tree. It poses the danger of cutting too deeply into "old wood", which could cause damage to the tree resulting in the tree becoming diseased, bearing a poor quality crop and / or dying.

It is always better to ensure under-prune with traditional pruning shears only, unless a citrus expert is present and you want to make some specific form changes to the citrus tree.

3.5. Wound Sealant

A wound sealant is used to seal large pruning wounds in order to prevent the wood from drying out and to prevent the possible entry of pathogens. Various makes of sealant are available, but it is important to ensure that they are not phytotoxic to citrus. The sealant is applied to the wound by means of a brush.

Phytotoxic

Phytotoxic means poisonous to plants. Some chemicals are poisonous to certain plants while others can be poisonous under certain conditions, for example when plants are under stress.

Figure 1.6: Wood Sealant

3.6. Carpet /Utility Knife

A utility knife is used during girdling for making a thin cut through the bark of the tree. This is not the ideal tool to use for this purpose, but it is easily obtainable and cheaper than custom-made tools.

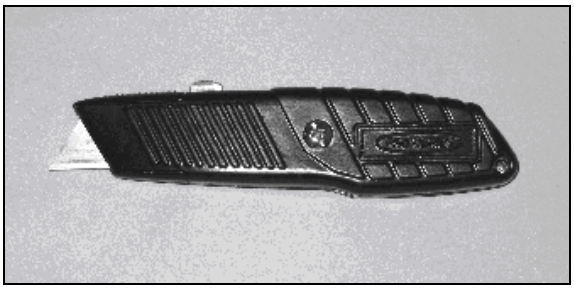


Figure 1.7: Carpet / Utility Knife

3.7. Girdling Saw / Knife

Custom-made girdling knives and saws are used during girdling and work better than a carpet or utility knife for making a thin cut through the bark of the tree.

3.8. Girdling Pliers

Custom-made girdling pliers are large pliers-like tools with three sharp cutting wheels that cut through bark when the tool is drawn one-third of the way around a tree trunk or limb.

Figure 1.8: Girdling Pliers

3.9. Skirting Stick

A skirting stick is cut to a desired length, usually 600–800mm, and used during the skirting process to measure the distance from the ground to obtain a uniform skirting height.

3.10. Ladders

Various types of ladders are used to reach the high parts of the tree during pruning or other plant manipulation processes. Metal ladders are more hardy and stable, but are heavy to carry around. Wooden ladders may also be used, but they must not be painted. A person must never climb a tree without using a ladder, as Phytophthora can be spread in this way.

Phytophthora

Phytophthora is a disease that causes root rot and collar rot in citrus trees, as well as brown rot of fruit. It is a fungal disease which can be carried in both soil and water.

3.11. Mechanical Hedgers and Toppers

Mechanical hedgers and toppers are large, expensive, specialised pieces of equipment, designed and built for being mounted on a tractor and pruning many trees in a short time. They remove parts of the outside canopy and cut trees uniformly and some can also be used to skirt trees. A hedger can cut vertically or at an adjustable angle, with the cutting angle normally 15° off vertical. A topper cuts off the tops of the trees horizontally or up to a 45° off the horizontal angle.

Due to the high purchase cost, they are used mainly on large farms.

Figure 1.9: Mechanical Topper

3.12. Mulching Equipment

A mulcher is a tractor drawn machine that chops up the foliage left in the rows after pruning. After processing, the chippings and shredded foliage is left in the rows as mulch.

3.13. Fruit Count Frame

A fruit count frame is used to count the number of fruitlets on a tree to determine whether hand thinning is required. It is made from electrical conduit tubing, metal rods or wooden dowels that can be dismantled for easy transport. Different sizes are used for mandarins and oranges.

3.14. Fruit Measuring Callipers

There are various kinds of fruit measuring callipers. They are used to measure fruit size to assist in the decision of when to use a chemical plant manipulation method. The two types illustrated below measure smaller fruit. Other callipers are available to measure larger fruit.

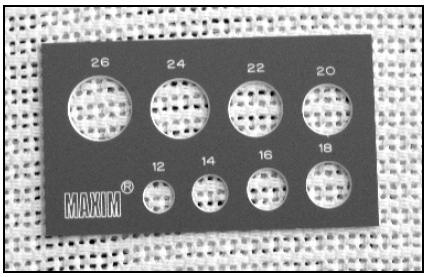


Figure 1.10: Card Calliper

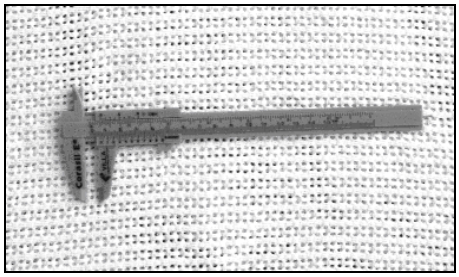


Figure 1.11: Vernier Calliper

3.15. Protective Clothing and Safety Equipment

Suitable gloves, such as welding gloves, must be worn at all times during plant manipulation processes to protect the hands. Safety goggles must be worn during all sawing, hedging and topping operations, and while sterilising equipment.

It is preferable to wear suitable clothing such as overalls and strong footwear as other clothing can easily be torn. Wear long sleeves to protect the arms from scratches.

4. Equipment Use and Maintenance

Plant manipulation tools and equipment must be used and adjusted according to the specifications of the manufacturer, and must be used only for the purpose for which it was designed. Instructions on chemical labels must be studied carefully and the safety instructions printed on the label must be strictly adhered to.

The tools and equipment must be kept in good working order and checked carefully before being used. Blades must be kept sharp and rust-free, and nuts and bolts must be tightened. Tools and equipment should be stored in a secure storeroom that is dry and free from dust. At the end of the season, tools and equipment must be serviced and oiled to prevent rust.

When applying physical plant manipulation methods, such as pruning, workers must be aware of people working on the same tree. It is better to have only one person at a time working on a tree. All workers must be aware of safety and emergency procedures, and must know where the first aid box is kept should it be needed.

4.1. Shears

The cutting diameter for the specific type of shear must not be exceeded, being branches up to a diameter of 20mm for pruning shears and 30mm for lopping shears. Thicker branches must be cut with a saw. The correct type of shear must also be used for the type of wood that is being cut. Bypass shears are to be used for softer wood, and anvil shears for hard and dead wood.

The blades of shears must always be sharp and sterile, and ensure that nuts and bolts are tight. Sterilise the blades before and after use, and keep shears lightly oiled when they are not in use. Particular care must be taken when using pneumatic shears and the manufacturer's instructions must be followed carefully.

4.2. Saws

The bow saw has a replaceable blade and it must be replaced whenever the blade becomes blunt. The blade must be under tension when cutting.

The pruning saw works with a pulling action, as opposed to a forward (pushing) action like other saws. When using a pruning saw, care should be taken not to accidentally cut or damage nearby branches.

Keep blades lightly oiled when not in use and check that blades are tightly attached before being used. Ensure that the blade is sharp, and sterilise blades before and after use. Particular care must be taken when using pneumatic saws.

4.3. Wound Sealant

Various types of wound sealant are commercially available. The sealant is applied over the wound with a brush. Care must be taken to ensure that the sealant is not phytotoxic to citrus. Large sealed areas exposed to the sun can be painted with non-toxic white paint to prevent sunburn. It is not necessary to seal small wounds. Wear a mask while stirring the sealant, and gloves and goggles when applying it.

4.4. Carpet / Utility Knife

During girdling, the knife is drawn around the branch or stem, not cutting deeper than the bark thickness. Do not loosen or remove any bark during cutting. These knives have either fixed or retractable replaceable blades. The blades must be replaced when they become blunt. The blades are very sharp and must be used with care. Sterilise blades before and after use.

4.5. Girdling Saw / Knife

These saws or knives are made specifically for girdling and can be used to girdle a limb (branch or stem) of any diameter. Blades can be plain or serrated (toothed). Some tools have an adjustable guide to control cutting depth, which must never be deeper than the bark thickness. The tool is pushed into the bark, moved forwards then cut backwards. The cut meets up on the other side of the limb. No bark must be lifted or removed during the process. Sterilise blades before and after use.

4.6. Girdling Pliers

Girdling pliers have three sharp cutting wheels mounted on adjustable handles in a triangular configuration. Handles can be adjusted to girdle limbs, branches or stems, from 35mm to 100mm in diameter.

The pliers' jaws are placed around the limb, only light pressure is applied to the handles, and the tool is turned. To complete the girdling action, the tool handle need only be turned one third of the circumference of the limb. The result is a fast, neat cut right around the limb without the operator having to move around the tree. Where there is excessive fluting of the limb, meaning grooves in the wood, the missed grooves can be cut with a girdling or utility knife.

Ensure that the blades on the cutting wheels are kept sharp. Sterilise the wheels before and after use.

4.7. Skirting Stick

The skirting stick is used to get uniform skirting in an orchard. It can be made from any stick or tubing and is cut to the desired height, usually around 600-800mm. The stick is placed on the ground and any branch hanging lower than the desired height is removed. The unwanted branches are preferably cut off at the juncture with the scaffold branch. Be careful not to cut off too much foliage, especially on young trees.

4.8. Ladder

Ladders are used to reach high parts of the tree when pruning. They are available in aluminium, fibreglass or wood with different designs and lengths. The most common type has a third leg that is placed on the ground under the tree canopy for stability. Ensure the ladder is stable before climbing and do not stand on the top rung. The ladder must be long enough for the purpose, so that the worker does not have to reach too far, which may result in a fall. Always face the ladder when ascending and descending.

Ensure that the ladder is kept in good working order, that nuts and bolts are kept tight, and that the rungs are kept clean. Do not place hands on the rungs and do not climb in the tree as this can spread Phytophthora. Ladders must not be painted.

4.9. Mechanical Hedgers and Toppers

Most models of mechanical hedgers and toppers consist of four to eight large circular, rotating saw blades, mounted on an adjustable arm and driven by the tractor's PTO. Some models can hedge and top simultaneously, but normally these operations are done separately, starting with hedging. The operator drives at the correct speed, being vigilant of any obstructions or holes in the pathway that may cause the tractor to tilt and cut off too much foliage.

The operator must ensure that all bolts are tight, that blades are sharp and balanced, and the machine is properly mounted on a tractor of the right capacity. Blades must be sterilised before entering a new block of trees or a new orchard and after being used. Sick trees must not be pruned in this way, as certain diseases can be spread via mechanical contact.

Strict safety precautions and safety gear are needed to protect the operator, including a safety cage, earmuffs, gloves, goggles, overalls, and boots. The operation must be carried out when no other production practices are in progress in the block. Suitable warning signs are to be placed at the entrance to the orchard.

4.10. Mulching Equipment

A mulcher is a tractor drawn piece of equipment used after pruning. The pruned foliage is raked into the row between the trees and the mulcher then chips or shreds the cuttings into small pieces. This material then acts as mulch in the orchard. Prior to using, ensure that no parts are loose and that the blade is balanced. Nobody must be allowed to walk behind or near the mulcher when in operation.

4.11. Fruit Measuring Callipers

The **average fruit size** is determined by selecting 200 fruit at random and measuring the diameter of each using fruit measuring callipers or a measuring card. Select twenty trees at random in a uniform block that has to be sprayed and measure ten fruit per tree. Calculate the average fruit size based on these results. It is important that only fruit is measured that will not fall off naturally and that all sizes of fruit on the tree, large and small, is measured. Do not measure the small yellow fruit that will fall off.

There are different types of callipers available to measure fruit diameter, and they are used in different ways.

- The ***vernier calliper*** has two jaws that are pressed over the fruit and the diameter is read off a sliding scale. It can be used for measuring fruit up to 150mm in diameter, but is more suited to measuring small fruit.
- A ***card calliper*** has holes of specific sizes. The fruit is passed through the matching holes. The range is 12 to 26mm, with increments of 2mm diameters.
- ***Grading rings*** are plastic rings with specific diameters. The fruit is passed through a ring of the suitable size. The range is from 13 to 92mm diameter.
- A ***fruit strap calliper*** is used to measure large fruit nearing or at maturity. It is accurate from about 50mm diameter and larger.

When using a calliper, do not squeeze the fruit too tight or force it through a particular hole. This will damage the fruit skin.

4.12. Tractors and Large Equipment

Using tractors and large equipment is a specialised task. Only workers that are trained in the use, maintenance and safety aspects of such machinery should be allowed to operate them. Always operate the equipment according to the manufacturer's specifications, such as maintaining correct gear and tractor speed during spraying. The operator must take full responsibility for the equipment. Calibrate and use the right nozzles on spraying equipment.

5. Equipment Sterilisation

All blades on plant manipulation equipment must be sterilised prior to use. This is to prevent the spread of citrus viroids, such as exocortis which is highly mechanically transmissible. The virus is especially prevalent in older trees of certain cultivars on tolerant rootstocks, which was used before inspections by the S.A. Citrus Improvement Programme started.

It is impractical to sterilise equipment after each tree when pruning a large number of trees. It is more practical to sterilise the tools between each homogenous block or orchard. Equipment must however be sterilised continuously if sick trees are being pruned.

A good disinfectant for sterilising tool and equipment is a 20% solution of household bleach (20ml bleach added to 80ml water) with the active ingredient 3.5% sodium hypochlorite, such as Jik®. Beware of cheaper brands that may not have the desired active ingredient. This sterilising mixture is corrosive and causes blades to rust. The following solution has given good results for sterilising and preventing rust of blades: 30 parts Jik®, 25 parts vinegar, 2 parts light spray oil and 75 parts water.

It is preferable to spray blades with the sterilising solution, but it can also be dipped in the solution or wiped with a cloth that has been dipped in the solution. Make up a fresh solution daily and keep it in a dark container, out of direct sunlight.

Do not let the solution get into contact with open wounds, eyes or clothing. Keep all equipment and sterilising solutions out of reach of children and animals.

6. Plant Growth Stages

In the Introduction to Citrus Production at the start of this learner guide, we identified the plant growth stages. Refer to the annual phenology cycle in the introduction and make sure that you understand the concepts defined below.

Full Bloom Full bloom is when the petals of a flower on an inflorescence, which is a shoot with flowers on, are fully opened or the time when 70% to 80% of the flowers on the tree have opened.
Physiological Drops Physiological drops refer to a process during which the tree drops fruit and flowers as a result of physiological processes, and not as a result of nutrient deficiency, drought, neglect, etc. There are two physiological drops. A drop of flowers and small fruit occurs during and just after flowering. The remaining fruit on the tree are termed the *initial fruit set*. A second drop, the so-called *November drop*, occurs approximately two months after full bloom. After this drop, the *final fruit set* remains on the tree, with a much smaller number of fruit remaining from then until the time of harvest.
Petal Drop Petal drop refers to when the petals of the flower naturally fall off, or abscise.
Colour Break Colour break occurs when there are signs that the colour of the fruit-rind is changing from blue-green. It indicates the beginning stages of fruit (rind) maturity. On the colour scale this is referred to as transparency 7 in a range from 8 (blue-green) to 1 (full orange).
Normal Picking Date The normal picking date is the date when the fruit is ready for harvest under normal conditions, meaning that the fruit conforms to certain internal and external quality standards.

7. Citrus Tree Manipulation Methods and Relevant Plant Growth Stages

In table 1.1 below, we will look at when during the growth cycle the various plant manipulation methods are applied.

Manipulation Method	*Plant Growth Stages or Timing*
Physical Plant Manipulation Methods	
Pruning	• **Nursery Trees** – Pruning is used for the removal of suckers and is done regularly throughout the year. • **Young Trees (<3 years)** – Pruning can be done at any time during the year, as the trees are not yet bearing. • **Mature, Bearing Trees** – Trees are pruned annually if necessary, preferably in winter just after harvest. Trees can also be pruned up to 4 to 6 weeks after full bloom, but this is less desirable. Return in November/December to check re-growth. • **Old Trees in Decline** – Pruning are preferably done in winter just after harvest. Return in November / December to check re-growth. • **Mechanical Hedging and Topping** – This method is used preferably in winter just after harvest. Directly thereafter, windows are pruned by hand. Water shoots and suckers are removed by hand in December or January.
Skirting	Skirting can be done at any time, but should not be done too late (after final fruit set) as one would not want to remove growing fruit. The most practical time is after harvest or at the time of pruning.
Girdling	• **Fruit Set** – Girdling is done two weeks before to two weeks after petal drop to improve fruit set. • **Fruit Quality** – Girdling is done two to four weeks after the final physiological fruit drop, in late December to early January, to improve fruit quality.
Manual Fruit Thinning	• **Valencias and Tomangos** – Hand thinning is done on these cultivars when the frame count exceeds seven fruit per 500x500x500mm frame, around four to six weeks after full bloom, November to December. • **Clementines** – Hand thinning is done on this cultivar when the frame count exceeds fifteen fruit per 300x300x300mm frame, in mid-January in cooler areas after the fruit has reached 20mm.
Chemical Plant Manipulation Methods (Sprays)	
Fruit Set Improvement (Gibberellic acid)	In clementines, this spray can be applied from 65 to 75% petal drop to four weeks after 100% petal drop. The timing of the spray affects the response.
Chemical Fruit Thinning	• **Oranges, Clementines, Satsumas and Grapefruit** (Corasil.E®) – The spray is applied at the end of the physiological fruit drop period at the smallest fruit diameter on the product label. • **Oranges, Clementines, Satsumas and Grapefruit** (Maxim®) – The spray is applied after the end of the physiological fruit drop period at the smallest fruit diameter on the product label.
Fruit Size Enlargement	• **Oranges, Clementines, Satsumas and Grapefruit** (Corasil.E®) – The spray is applied at the end of the physiological fruit drop period at the largest fruit diameter on the product label. • **Oranges, Clementines, Satsumas and Grapefruit** (Maxim®) – The spray is applied after the end of the physiological fruit drop period at the largest fruit diameter on the product label.
Delaying harvesting (Gibberellic acid)	• **Grapefruit** – The spray is applied at colour break to T5 or up to three weeks thereafter. Average fruit size must not to be larger than 89mm. • **Lemons** – The spray is applied five to eight weeks before the normal picking date.
Creasing control (Gibberellic acid)	• **Navels and Valencias** – The spray is applied during January to February, or for navels in May when colour is at least T3, or after mid-June for valencias. Concentrations depend on timing.

Table 1.1: Application of Plant Manipulation Methods in Relation to Growth Stages

8. Applying Plant Manipulation Methods

In this section, we discuss both physical and chemical manipulation methods. Refer to the table above and ensure that you understand the growth stages during which each of the methods is used. Only a limited number of commercial manipulation products are mentioned.

Scaffold Branches Scaffold branches are the main, supporting branches in a tree. Scaffold branches grow from the trunk of the tree, and are the most important branches. All other branches grow out from them. It is ideal to have four to five well-spaced scaffold branches on the tree.
Complex Branches Complex branches are smaller limbs on the tree with a multitude of other, even smaller limbs branching off, also referred to as a "highly-branched" branch. These branches grow out in many directions, looking like a complicated railway network, as opposed to one main line.
Suckers and Water Shoots The term sucker or water shoot is often used to mean the same thing. A sucker normally refers to an unwanted shoot growing out from the rootstock. A water shoot on the other hand normally refers to an unwanted, vigorous shoot growing out from a tree trunk. It tends to grow straight up in search of light.

8.1. Physical Plant Manipulation Methods

8.1.1. Pruning

Over-pruning is much more damaging to a tree than under-pruning. Remember that one can always remove more branches if necessary, but it is not possible to put branches back that have been removed if a tree has been over-pruned.

Trees of different ages are pruned in different ways. On newly planted trees:

- Remove shoots removed that is not required to form branches. The unnecessary shoots are broken off when they are still very small and soft, usually up to 500-600mm from ground level.
- Break or cut off suckers growing from the rootstock. This is done for trees of all ages.
- Cut off the water shoots or tall, upright, strong shoots growing straight up next to the stem, or trunk.

With older trees, a little more light is required inside the tree. Do the following:

- Remove dead twigs and branches. These are mainly inside the tree.
- Cut out branches that cross over each other.
- Remove broken branches.
- Remove water shoots.

- Remove complex branches.
- Where two branches grow out of the same place, remove the weaker one.
- Remove long, thin branches with yellow leaves.
- Do not cut off too much foliage.
- After doing the above, get a fellow worker to stand on the other side of the tree. If you can make out the shape of your fellow worker, you have pruned enough.
- It should not be necessary to remove branches that are too thick for the pruning shear, meaning branches that have a diameter of more than 20mm.
- Do not prune trees that are sick or under any form of stress, except for breaking out dead wood.
- Sterilise pruning shears between trees.

It is important to remember that citrus trees should not be over-pruned. A number of tools, such as bow saws, loppers, etc. would not be appropriate for use during regular citrus pruning, as it would mean that we would cut too deep into old wood, which could cause damage to the tree. It could cause the tree to become diseased, bear a poor quality crop and / or die. It is always better to use traditional pruning shears only, unless a citrus expert has been consulted and specific form changes to the citrus tree are required.

8.1.2. Skirting

- Use the skirting stick to measure the height to which the tree must be skirted.
- Cut off branches hanging below this height.
- Branches must preferably be cut off where they join the scaffolds, unless too much material will be removed.

8.1.3. Girdling

Girdling is done either on the trunk of the three, or on scaffold branches. For fruit set, it is safer to girdle two thirds of the scaffold branches than the trunk.

- Girdle 100-150mm above the bud union for trunk girdling.
- Make a cut of 1mm wide only through the bark of the limb or trunk down to the wood.
- Do not damage the wood.
- Run the cut right around the limb or trunk, so that it meets again on the other side.
- Do not remove any bark.
- Only girdle healthy trees that are not subject to any stress.

8.1.4. Manual Fruit Thinning

When a decision has been taken to manually thin a heavy fruit set, the prescribed number of fruit is removed as follows:

- Remove fruit that are blemished and / or malformed;
- Remove fruit that are smaller than a specified diameter, e.g. smaller than 30mm in diameter for oranges and smaller than 20mm for clementines, at a specific time;
- Thin fruit clusters to one or two fruit.

8.2. Chemical Plant Manipulation Methods

PLEASE NOTE

It is important to always consult the chemical distributor or technical advisor before purchasing and applying any chemical product. Always read the product label and work within the prescribed parameters and in accordance with the safety instructions.

A residue of the chemical on fruit may also not be allowed in the specific export market. Determine what the withholding period is for the specific chemical before it is applied. This is especially important for those chemicals used to delay harvesting and for creasing control, as they are applied close to the harvest time.

Chemical fruit manipulation methods all make use of the application of chemicals through spraying to trees to achieve the desired outcome. Chemicals are applied in various quantities, as follows:

Full Cover Spray

A full cover spray thoroughly wets the tree canopy and penetrates the inside of the canopy, drenching the branches and framework of the tree.

Medium Cover Spray

A medium cover spray wet the foliage of the tree to the point of run-off, meaning that all leaves of the tree are wet but very little spray material drops off the leaves. The tree canopy is not necessarily penetrated, but some of the branches may be slightly wet.

Light (Outside) Cover Spray

A light or outside cover spray wets only the outer canopy of the tree. These sprays are applied at low volume and with a light covering of the tree canopy. Droplet size is small, and the tree is sprayed with a fine mist of spray material.

8.2.1. Fruit Set Improvement

Gibberellic acid, in the form of a commercial product such as the ProGibb®40%, is applied in a full cover spray in the prescribed concentration.

8.2.2. Chemical Fruit Thinning

Two products are used for chemical fruit thinning, depending on the variety of citrus. These products are Corasil.E® and Maxim®. Both are applied in a medium cover spray according to the prescribed concentration.

8.2.3. Fruit Size Enlargement

The same products are used than for chemical fruit thinning. Medium cover sprays are applied in the prescribed concentrations.

8.2.4. Delaying Harvesting

Gibberellic acid, in the form of a commercial product such as the ProGibb®40%, is applied to grapefruit and lemons in a full cover spray in the prescribed concentration and at the prescribed time.

8.2.5. Creasing Control

Gibberellic acid, in the form of a commercial product such as the ProGibb®40%, is applied in a full cover spray in the prescribed concentration and at the prescribed time. The concentration and timing depends on the variety.

Chapter 1

- Plant manipulation is the skilful management or treatment of plants to derive a specific outcome, and contributes to producing fruit that is acceptable to the market.
- There are physical and chemical plant manipulation methods.
- The methods of physical plant manipulation are pruning, skirting, girdling and manual fruit thinning.
- Chemical plant manipulation makes use of the application of chemicals and hormones to achieve fruit set improvement, fruit thinning, fruit size enlargement, harvest delaying, and creasing control.
- The tools and equipment that are used in plant manipulation are spraying equipment, pruning shears, lopping shears, bow saws, pruning saws, wound sealant, carpet or utility knives, girdling saws or knives, girdling pliers, skirting sticks, ladders, mechanical hedgers and toppers, mulching equipment, fruit count frames, fruit measuring callipers, and protective clothing and safety equipment.
- When applying plant manipulation methods all workers should take all necessary safety precautions.
- Tools and equipment must only be used for the purpose it is meant for, and must be maintained and stored carefully.
- All tools and equipment must be sterilised regularly to ensure that diseases are not spread between trees.
- Various plant manipulation methods are used at the various plant growth stages, being full bloom, physiological drops, petal drop, and colour break.
- Trees are pruned differently at different growth stages. It is always better to rather under-prune than over-prune.
- Applications for chemical plant manipulation methods are made through light, medium or full cover sprays.

Complete activities 1 and 2 in the **Learner Workbook**.

Chapter 2

After completing this chapter, the learner will be able to:

Illustrate a basic knowledge of framework development principles as part of plant manipulation methods

1. Introduction

Trellising is used in certain agricultural crops to assist with framework development, meaning that the direction and manner in which the plant grows is manipulated by using an external framework to which it is either tied to, or to which it can attach itself.

Trellising is used to optimise yield and fruit quality. In the case of granadillas, for instance, trellising allows the plant to grow off the ground, where it is able to produce more fruit and fruit of a higher quality. Another common example is certain varieties of green beans. If green beans were not provided with trellising support in vegetable gardens, they would grow along the ground, resulting in a low yield and poor quality.

Trellising is not only used for climbing plants that requires a structure to grow on. It is also widely used in deciduous fruit farming to assist the trees with framework development.

2. Trellising in Citrus

Trellising is not commonly used in citrus production. It has been tried on an experimental basis, but is not common to use as a commercial practice. Citrus trees are a lot sturdier than deciduous fruit trees, and therefore are not given to manipulation through trellising. The only manner in which the framework of citrus trees is developed and managed, is through pruning.

The only practice in citrus production that is related to trellising is where young trees are tied to stakes to ensure that they grow upright. They are planted in an orchard only when they are strong enough and no longer require support, and this practice is therefore restricted to the nursery. It is discussed in greater detail in the Propagation learning material.

Figure 2.1: Young Citrus Trees Tied to Stakes

Chapter 2

- Trellising is used in certain crops to assist with framework development.
- In citrus, trellising is not commonly used, except for where stakes are used to support nursery trees.

Complete activities 3, 4 and 5 in the **Learner Workbook**.

Chapter 3

After completing this chapter, the learner will be able to:

Demonstrate an intermediate understanding of flower and fruit manipulation principles

1. Flower Manipulation

Flower manipulation is not widely practiced in citrus in South Africa, but correct pruning can improve flower quality. The better quality flowers are identified as follows: A green blossom, being a flower having leaves in very close proximity to it, is of better quality than a white blossom. White blossoms are poor quality flowers, most of which fall off. White blossoms can thus be cut off during the blossom season, which is done by pruning. Fruit size can be improved in this manner. Blossom quality can be improved by means of urea sprays at bud-break and two to three weeks later.

In some areas, although not in Southern Africa, chemical flower manipulation is used. Ralex®, a gibberellin-based product, is applied to the trees to suppress flowering, which encourages better fruit size. This method is however not commonly used.

Flower manipulation aims to achieve healthy inflorescences, with the benefits of:

- Sufficient, but not excessive blossom
- Green blossom
- Consistent blossom (not "on-and-off" flowering)
- Larger fruit
- The right vegetative and floral growth ensures a healthy blossom the next season

2. Fruit Manipulation

Fruit are manipulated in citrus production by both physical and chemical means. Manual fruit thinning is the only physical fruit manipulation method that is used. All the chemical plant manipulation methods that were discussed in chapter 1 are in essence fruit manipulation methods. They are:

- Fruit set improvement
- Chemical fruit thinning
- Fruit size enlargement
- Delaying harvesting
- Creasing control

3. Advantages of Fruit Manipulation

The advantages of fruit manipulation are:

- Improved fruit size, with fruit falling into better paying counts.
- Improved production, achieving a better and more consistent yield.
- Improved fruit quality, meaning improved internal quality and improved consistency in quality between fruit borne on the inside and outside of the tree.
- Improved fruit colour with colour developing earlier, achieving a deeper, more consistent colour.

- Improve pack-out, whereby fruit are produced with less blemishes, that are less sensitive to storage problems and has better rind integrity. Fruit can also be packed later.

4. Physical Fruit Manipulation Methods

Manual fruit thinning is the only physical fruit manipulation method that is employed in citrus production.

In chapter 1, we discussed the physiological fruit drops that occur naturally as part of the physiological processes of the tree. If the tree is still bearing a heavy crop after the final drop, a decision may be taken to thin the remaining fruit by either manual or chemical means.

For optimum fruit size, a citrus tree needs a minimum leaf to fruit ratio, meaning that the tree should not bear too many fruit in relation to the number of leaves. If this ratio is too low, meaning if there are too many fruit on the tree, there are not enough nutrients to maintain all the fruit, and a crop of small fruit will result.

Fruit thinning is also used to get a more uniform fruit size and improve the overall quality by removing small and blemished fruit while they are still small, before it consumes the energy and resources of the tree.

For trees below the age of three years, all fruit is removed to allow the tree to use all its energy for vegetative growth. If fruit on small trees are allowed to mature, it may also pull the tree over. Fruit on such young trees are also not of a very good quality. The fruit is stripped by hand after November drop, meaning the final physiological fruit drop.

Manual fruit thinning is a more old-fashioned technique than chemical fruit thinning, which is a relatively new technique in South Africa. Hand thinning can be done fractionally later than chemical thinning. Hand thinning also gives the opportunity to remove blemished and malformed fruit more selectively before harvest, which improves the pack-out percentage. Manual thinning has however never become popular due to its labour intensity.

5. Chemical Fruit Manipulation Methods

In citrus production, most chemical plant manipulation methods are concerned with fruit manipulation. The timing of the application of chemicals greatly determines the effect that it will have.

5.1. Fruit Set Improvement

Fruit set is a complex process that is influenced by many factors, and is dependent on flowering. The best flowering, and therefore fruit-set, occurs where low temperatures and mild water-stress precedes flowering. These conditions allow the tree to enjoy a period of rest. A warm, wet winter will result in a poor, protracted flowering.

If the tree carried a heavy crop the preceding season, the flowering and fruit-set are also affected negatively. The reserves of the tree are depleted. The vegetative flush is also affected.

Nutrients are added to the soil to replenish the reserves of the tree before the flowering and fruit-set. The quantities of the applications are determined by taking into account the yield in the previous season. This process is discussed in more detail in the Fertilisation and Soil Management learning material.

An application of gibberellic acid around the time of petal-fall increases the sink strength of the fruitlets. The sink strength is the mobilisation of nutrients that promotes fruit set.

In warmer areas, a higher concentration of gibberellic acid is required to ensure a good fruit set, while little or no fruit-set chemicals are used in cooler areas.

5.2. Chemical Fruit Thinning

Chemical fruit thinning is done for the same reasons as physical fruit thinning. An application of fruit thinning chemicals just after the final physiological fruit drop causes small fruit to abscise, or drop off. This allows the tree to retain only the number of fruit that it can successfully grow to the required size.

The shorter the period between the physiological fruit drop (November drop) and the application of the chemicals, the greater the thinning effect.

5.3. Fruit Size Enlargement

Fruit size at harvest is directly related to temperature, with the largest fruit in warmer regions. A sunny and warm spring gives rise to larger fruit at harvest. Crop load, moisture stress, and nutrition also play a role in fruit size.

Maximum fruit size potential is determined in the cell division stage, where as many cells as possible must be formed, which can then enlarge later. Maximum fruit growth is realised in the cell expansion stage, when cells get bigger.

Fruit enlargement chemicals are used where a high yield and small fruit are expected, and are applied after the physiological fruit drop, and work by increasing juice sac development, with an improvement in the transport of energy and other resources towards the fruit. A secondary effect is an improvement in fruit size uniformity.

5.4. Delaying Harvesting

Pack-out percentages of certain cultivars deteriorate rapidly due to decay towards the end of the harvest season, when more creasing, puffiness and granulation occur, and when fruit become too large for export. Blemishes are also more noticeable, and the rind starts to soften. This problem can be partly alleviated by the spraying of gibberellic acid, which retains the quality of the fruit.

Gibberellic acid sprays can be used on navels, grapefruit and lemons.

Besides preventing over-maturity, delaying the harvesting time can have other benefits, not necessarily applicable to all cultivars, such as:

- Lengthening the picking period
- Moving the picking period into a drier time
- Moving the picking period to a time when better prices can be realised
- Retaining the overall fruit quality of the fruit normally picked last

Harvesting of grapefruit and lemons can be delayed by up to three to four weeks with the use of gibberellic acid together with the growth regulator 2.4-D.

5.5. Creasing Control

Creasing is a peel disorder. It happens when the albedo, the white pithy part, tears. It is related to tree and fruit stress early in the season, and mineral nutrition plays an important role. Sudden temperature changes can also promote the onset of creasing.

Gibberellic acid is applied to fruit to delay the onset of creasing, and must be applied before the appearance of creasing on the fruit.

Chapter 3

- Flower manipulation is not widely practiced in citrus production in Southern Africa.
- Manual fruit thinning is the only physical fruit manipulation method that is used.
- All the chemical plant manipulation methods are in essence fruit manipulation methods.
- Fruit manipulation has the advantages of improving fruit size, production, fruit quality, fruit colour, and pack-out.
- Manual fruit thinning is used to reduce a heavy crop after the final physiological fruit drop.
- Chemical fruit set improvement increases the sink strength of the fruitlets, which is the mobilisation of nutrients that promote fruit set.
- The application of fruit thinning chemicals causes small fruit to abscise.
- The application of fruit size enlargement chemicals improves the transport of energy and other resources to the fruit.
- Applying chemicals to delay the harvest helps to prevent over-maturity.
- Creasing control chemicals must be applied before the onset of creasing.

Complete activity 6 in the **Learner Workbook**.

Chapter 4

After completing this chapter, the learner will be able to:

Illustrate a basic knowledge of pruning principles as vegetative plant manipulation methods appropriate to the crop

1. Introduction

Three vegetative plant manipulation methods are applied in citrus production, being pruning, skirting, and girdling, with pruning divided into manual pruning and mechanical hedging and topping.

2. Manual Pruning

Pruning

Pruning is a process involving the cutting off or cutting back of plant parts for better canopy shape and more fruitful growth, through the use of more efficient light interception.

Citrus trees grow naturally into a certain shape and in a specific manner, which varies depending on cultivar and rootstock. Branches grow upright from the stem and then bend under its own weight as it becomes bigger to form lateral branches, which then turn down further to form skirts. New branches sprout on the upper side of the lateral branches and become dominant. The new branches again bend under their own weight as they grow, and the whole process is repeated.

Branches at the top of the tree are more vigorous. Because new branches sprout from the upper part of existing branches, cutting braches from the top of a branch encourages re-growth, while cutting branches from the underside of the branch will not result in re-growth.

If left to its own devices, the tree will end up with a dense outside bearing shell and a dark inside. Fruit is mainly borne on the outside shell, especially toward the top of the tree, with little fruit growing on the inside. Pruning can change the situation and create more light in and through the canopy, allowing for more vigorous growth on the inside of the tree.

One of the biggest mistakes with pruning is to wait too long before you prune. This result in heavy, drastic pruning when the tree is older, which can cause a drastic drop in the crop. One must however also be careful of pruning for the sake of pruning. Pruning must be done with a specific purpose in mind, if and when necessary. Remember trees must never be pruned to upset the balance between fruiting and vegetative growth production. Steady fruiting itself is a useful tree size controlling factor.

Pruning is done for various reasons at various stages in the growth of the tree. The four main stages are:

- Nursery trees
- Young trees (less than three years old)
- Mature, bearing trees
- Old trees in decline

2.1. Nursery Trees

The pruning of nursery trees is done by experienced nurserymen. The grower specifies what kind of trees is required at delivery, with a choice between trees with formed scaffold branches, whip trees that have had no pruning, or mini trees, being trees that are still very small. Note that a tree that has formed scaffold branches must have a stem thick enough to support them.

The nursery tree must be clean of suckers from ground level past the bud union and up to a specified height (usually 500-600mm) or to the level of the lowest of the potential scaffold branches. Removal of undesirable suckers is an ongoing process and is done frequently. Suckers are removed when their shoots are small and tender, to ensure that all the growth energy goes into the wanted parts of the small tree.

It is important not to remove too much growth, excluding suckers on the stems, from a nursery tree.

2.2. Young Trees

During this phase, the growth of the tree is trained slowly. Shaping is a slow, important process, and the ideal shape will not be achieved in the first year.

Suckers become less of a problem once trees have been planted in an orchard because stem protectors limit sucker growth, but it is important to remove such growth if and where it is found from ground level to the desired scaffold branch height. As the size of the tree canopy increases, suckers will also appear less because the stem, or trunk, will be exposed to less light. Light interception is normally not a problem with such young trees. What is important is profuse vegetative growth.

Firstly, four to five well-orientated scaffold branches must be developed. Scaffold branches must preferably have a wide crotch angle in relation to the stem, as these branch attachments are stronger. Figure 4.1 shows the difference between a narrow and wide crotch angle.

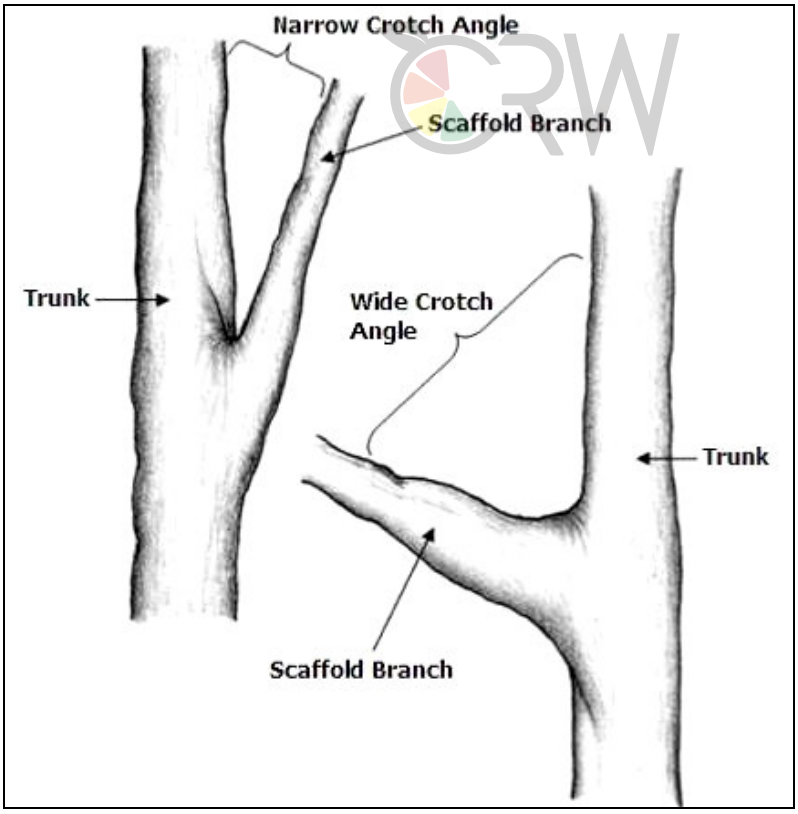


Figure 4.1: Crotch Angles on Scaffold Branches

Scaffold branches must also be well-orientated, meaning that they should be evenly spread around the trunk of the tree, and they should be at various heights. Figures 4.2 illustrate these concepts.

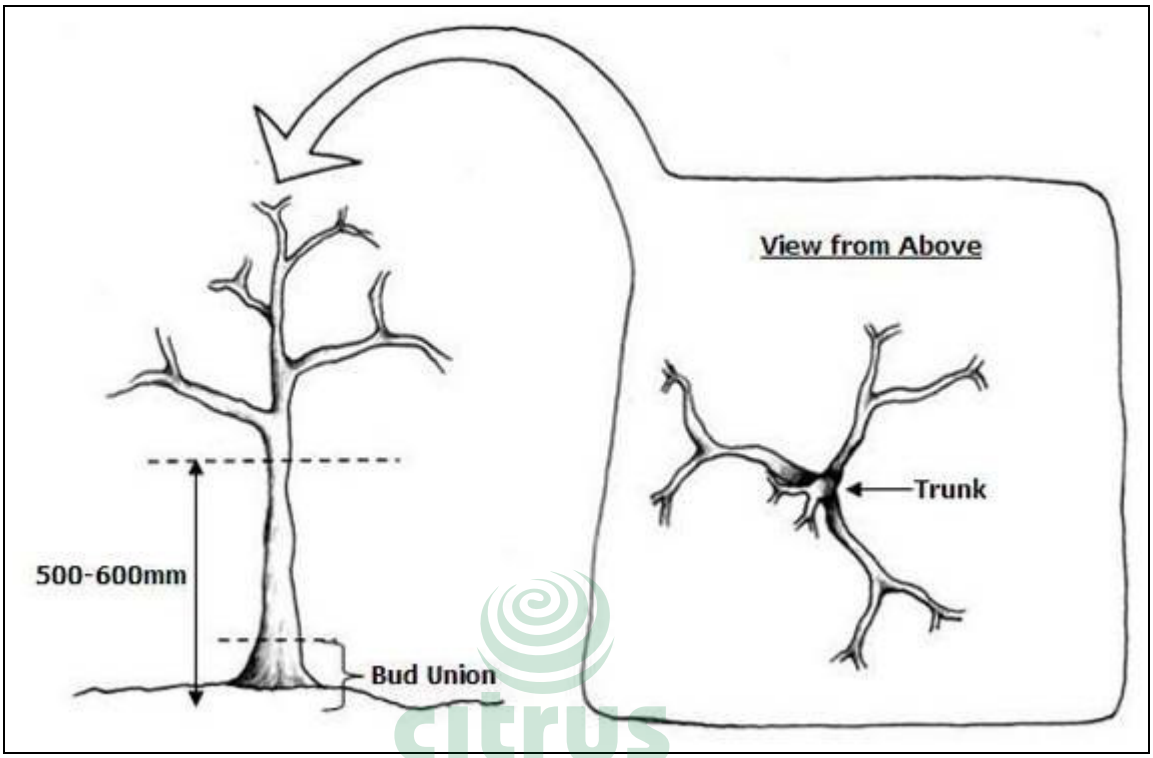


Figure 4.2: Scaffold Branches Spaced at Various Heights and Evenly Around the Tree Trunk

Scaffold branches must be spread horizontally and vertically around the trunk in the manner described above for the sake of tree shape, but more importantly for light interception.

A tree requires light for photosynthesis, which is the process through which it produces food, in this case citrus fruit. Through ensuring an optimum spread of scaffold branches while the tree is still young, and through shaping the tree and cutting light windows in the canopy once it is mature, the tree is able to intercept as much light as possible.

2.3. Mature Trees

After the first two years of the tree's lifespan, the tree shape, determined by the development of suitable scaffold limbs, should be well-developed. The tree shape must now be maintained through judicious pruning. At the same time it is also desirable, within limits, to contain the tree size.

The focus at this growth stage is on:

- Light interception
- Encouraging the growth of fruiting wood
- Simplify the plumbing

Judicious pruning will let in more light, without being detrimental to plant growth. We want as much light throughout the tree as possible. Light is necessary for fruit bud formation. Production of fruiting wood is encouraged by maintaining healthy growing shoots which will bear fruit in the following season.

What does "simplify the plumbing" mean? The pipe to your kitchen tap is 100m long and 1cm thick. The neighbour's pipe is 10m long and 2cm in diameter. Whose kitchen sink will fill up the

fastest when you open the tap? The neighbours will, because the water has a shorter way to travel, and can travel faster because of the thicker pipe.

Food, or nutrients, and water travel to leaves and fruit through the branches in the same way that water travels through a pipe. Thick, short branches are able to deliver the maximum amount of food and water to the leaves and fruit. "Simplifying the plumbing" means keeping the branches as short and thick as possible.

2.4. Old Trees

Old trees tend to lack vigour and produce low yields of small fruit size. This can be due to other underlying factors which can cause decline, and these factors must be rectified first.

On old, declining trees there invariably are long, old, thin branches. If these are removed or cut short, the growth of strong, healthy branches will be promoted. Light interception is important, as a lack of light within the canopy invariably is a problem in older trees. Tree size can also be reduced. Vigorous new growth must be encouraged.

3. Mechanical Hedging and Topping

Mechanical hedging and topping is a pruning technique used to cut trees back on both sides of a row at the same time. The advantage of using mechanical hedging and topping is that trees are pruned fast and uniformly.

Hedging is done by cutting just off the vertical, which allows more light penetration over the surface of the tree. It unfortunately does remove some of the fruiting wood, but produces more fruiting wood in the next season. For this reason, trees are hedged on one side one year and on the other side the following year.

Topping, which is the cutting off of the top of the tree horizontally or at an angle, is done immediately after hedging. Both operations have to be done at the same time in combination to be effective. With this technique effective light penetration through the top of the tree is ensured, resulting in fruit size improvement. With vigorous trees, this operation is followed up with selective hand pruning at a later stage to control re-growth.

Trees are hedged and topped during winter, straight after the harvest. It can be done annually.

4. Skirting

Skirting is done to prevent branches and fruit from touching the ground. Branches hanging below the desired skirting height are cut off, preferably where they join the scaffolds, unless too much material will be removed. The skirting height is normally 600-800mm from the ground.

Figure 4.3 is an illustration of skirting. The skirting height is indicated by the thick dotted line. The places where branches should be cut are indicated by thin dotted lines. If the skirting height is close to the juncture with the scaffold branch, the branch can be cut off at the juncture.

If the branch on the left in figure 4.3 were to be cut off at the juncture with the scaffold branch, too much vegetation will be lost in the process and it must therefore be cut at the skirting height.

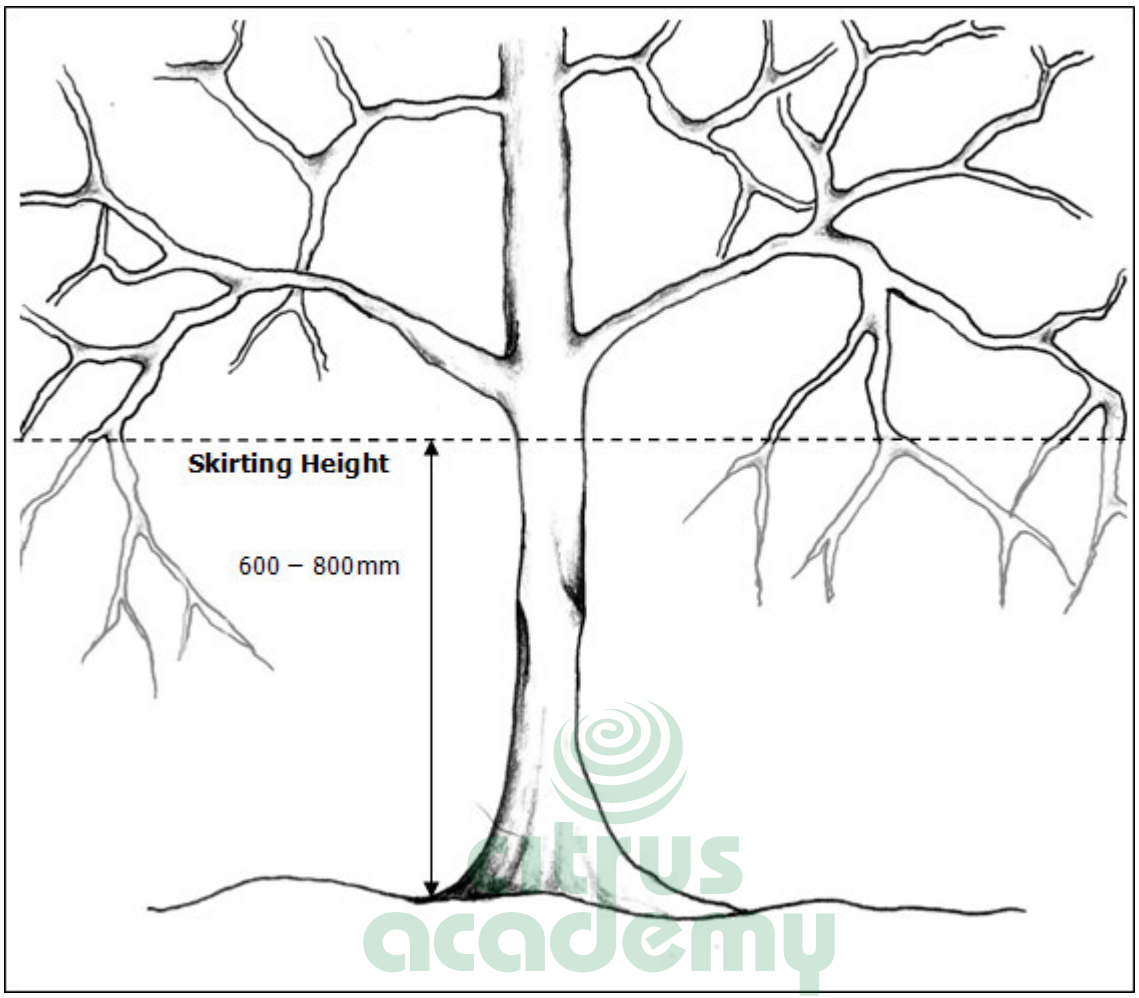


Figure 4.3: Branches to Be Removed During Skirting

5. Girdling

Girdling is a thin cut made through the bark of the tree trunk or of a branch. The cut heals again after two or more weeks.

Girdling is done to improve fruit set and to improve sugar levels in the fruit, and girdling for these to purposes is done at different times during the season. Timing is critical in determining the effect girdling will have on the tree or fruit.

The principles of girdling for fruit set are not quite clear. The girdling cut causes a break in the phloem, which is the food-conducting tissue of a plant. It is thought to cause an increase in the carbohydrates and / or hormone levels that are necessary for fruit set. This has the effect of setting more fruit on the tree. It is unclear what the long-term effects of annual girdling are.

Girdling to improve internal fruit quality is done in summer. The girdling cut temporarily slows down or stops the flow of sugars to the roots and some sugars are redirected to the fruit. This can increase fruit sugar levels. It is unclear what the long-term effects of annual girdling are.

Whether girdling for fruit set or fruit quality, it is important not to girdle trees under any form of stress.

Chapter 4

- Pruning is a process involving the cutting off or cutting back of plant parts for better canopy shape and more fruitful growth, through the use of more efficient light interception.
- On nursery trees, suckers are continually removed through pruning.
- The shape and growth of young trees are trained slowly through pruning. A number of scaffold branches that have wide crotch angles and that are evenly spaced around the tree trunk are selected at this stage.
- When pruning mature trees, the focus is on light interception, encouraging the growth of fruiting wood, and simplifying the plumbing of the tree.
- On old trees, long, old and thin branches are removed from the tree to encourage more vigorous growth.
- Mechanical hedging and topping is used to cut trees on both sides of rows at the same time and to cut the tops of trees to a uniform height.

Complete activities 7 and 8 in the **Learner Workbook**.

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