# LEARNER GUIDE

# Harvesting

## Level 2



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|---|---|---|---|---|---|---|---|
| **Title:** | | **Harvest Agricultural Crops: Procedures** | | | | | |
| **Applied Title:** | | **Harvest Citrus: Procedures** | | | | | |
| **Field:** | | Agriculture and Nature Conservation | | | | | |
| **Sub-Field:** | | Primary Agriculture | | | | | |
| **SETA (SGB):** | | AgriSETA | | | | | |
| **Skills Area:** | | Harvesting | | | | | |
| **Context:** | | Citrus Production | | | | | |
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# Directions

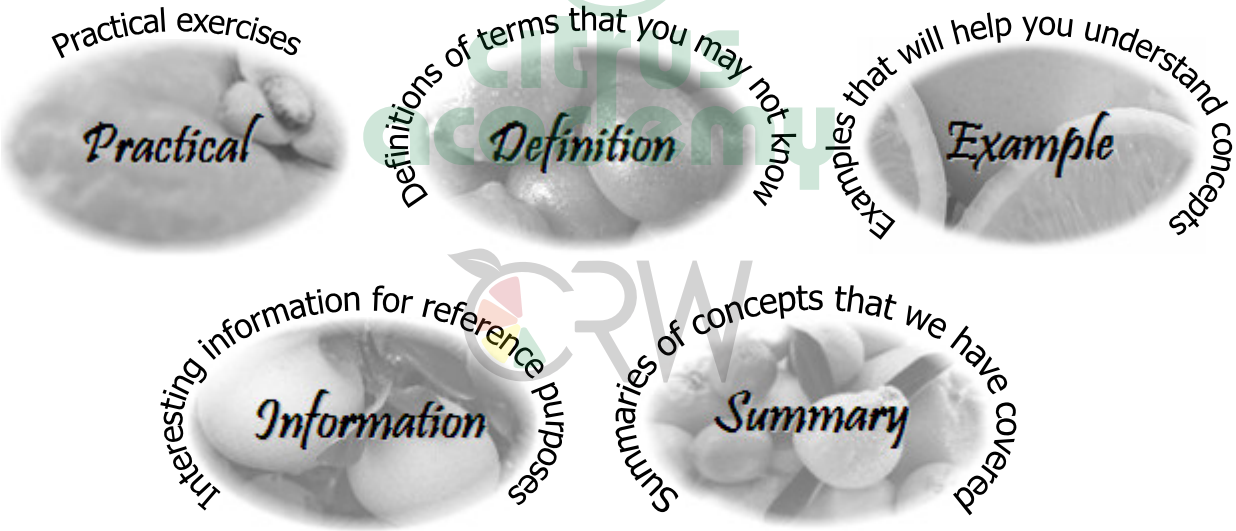
This learning material has been developed to assist the learner wishing to complete this unit standard. The guide contains all necessary learning to ensure that the learner will attain the competencies required by the unit standard.

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 harvest crops according to basic procedures making use of basic harvesting tools.

Learners will gain specific knowledge and skills in harvesting 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 | 116201 | Harvest agricultural crops |
| 1 | 116156 | Collect agricultural data |
| 2 | 116060 | Utilise and perform minor repair and maintenance tasks on implements, equipment and infrastructure |

# 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<br>(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.

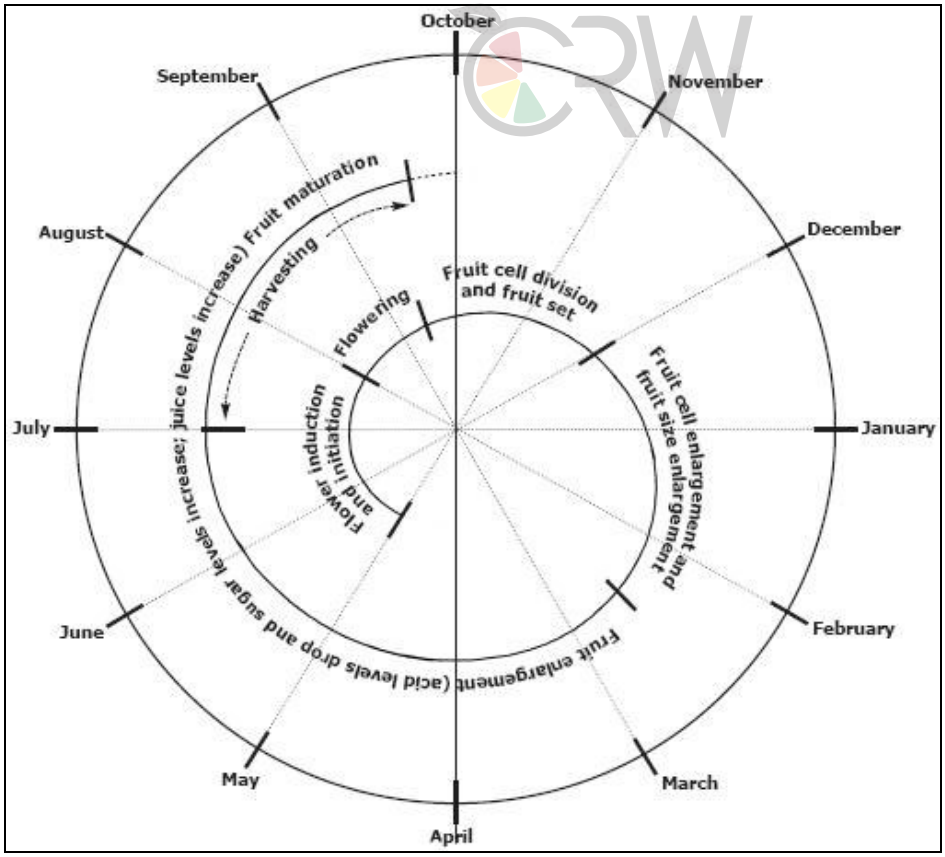
## 5. Citrus Plant Phenology


**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 |

| ***Skills Area*** | ***Description*** |
|---|---|
| | pest control. |
| 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:<br><br>• Citrus Product Characteristics<br>• Understanding Citrus Fruit Markets<br>• Health and Safety in the Packhouse<br>• Personal Hygiene Requirements for Packhouse Personnel<br>• Understanding and Maintaining the Cold Chain<br>• The Role of Quality Checks in the Packing Process<br>• The Application of Fruit Treatments<br>• The Application of Pre-Sorting Prior to Packing<br>• Receiving Fruit into the Packhouse<br>• Grading Fruit in the Packhouse<br>• Packing and Packaging Materials<br>• Palletisation of Packed Fruit<br>• Storage of Fruit<br>• Dispatch and Transportation of Packed Fruit<br>• Understanding Automated Packing Solutions |

# Introduction to Harvesting

The logical end to all crop production efforts is the harvesting of the crop and the movement of the crop into marketing channels to the ultimate consumer.

The volume and quality of the crop have been determined by production practices and the impact of climate. However, proper harvesting and postharvest handling and storage practices are necessary to minimise losses during distribution and to assure that only good quality produce reaches the consumer.

Harvesting methods vary considerably between different types of crops. Some crops, such as maize, are harvested mechanically with the help of combine harvesters, while other crops, such as berries, are carefully handpicked.

In orchard farming, including citrus, fruit are picked from the tree mostly by hand, from where it is taken to the packhouse in bins or trailers.

The citrus farmer must make many decisions about the harvesting process that will influence the quality of the fruit that reach the consumer and that will determine the cost of the picking and the packing process. When the farmer for instance sees that there is a lot of fruit that will obviously not be suitable for export, he may choose to pick the poor fruit in a separate process either before or after the export fruit is picked. Stripping substandard fruit is referred to as culling.

Other very important decisions that the farmer must take is when to start picking, and in what order to harvest the various orchards. In this, the farmer takes into account the historical harvesting records and is assisted by methods of determining the maturity of the fruit, which is referred to as maturity indexing.

It is also important to have a thorough understanding of the harvesting requirements for various types of citrus. Some citrus cultivars are more susceptible to for instance oleocellosis, which is damage caused to rind cells by peel oil release as a result of abrasion, rough handling or other injuries, and must therefore be treated with more care.

# Chapter 1

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

**Select and use appropriate tools / equipment for pre-determined harvesting method**

## 1. Introduction

The equipment used for harvesting citrus ranges from tools such as clippers that are used to cut the fruit off the trees, to tractors that are used to transport the harvested crop from the orchard.

In preparation for harvesting, an assessment is done of the tools and equipment that will be required. This is done by taking into account the:

- Size of the farm
- Cultivar spread
- Period during which the picking must be completed
- Size and capacity of the packhouse to which the fruit is delivered

From this information, the number of picking teams and the size of the teams are determined, which guides one in determining equipment requirements.

## 2. Harvesting Tools and Equipment

The tools and equipment that are used most often while harvesting citrus are:

- Clippers
- Picking bags
- Ladders
- Bulk bins and picking trailers
- Tractors

## 3. Using Harvesting Tools and Equipment

### 3.1. Clippers

The most common tool used for removing fruit from trees is steel clippers. They are used to cut the stem of the fruit as close to the button, or calyx, as possible without injuring the shoulder of the fruit.

**Figure 1.1: Harvesting Clippers**

Other types of pruning shears and similar equipment that are not designed for harvesting can be used, but are not recommended.

Clippers fit comfortably into the palm of the hand, have a rounded point and curved blade to avoid damaging the fruit. A spring keeps the blade in an open position and ensures fast recovery for efficient picking.

## 3.2. Picking Bags

A number of receptacles are used to collect picked fruit, but the most common is a picking bag. Picking bags are generally made from canvas or polyvinyl. They have a single strap and are slung over the shoulder of the picker. As the picker picks the fruit, it is placed inside the bag until it is full. It is then taken to a general collection point in the orchard where the bags are emptied into bulk bins or picking trailers.

Some picking bags have closed bottoms, in which case the bags have to be upended when being emptied into the picking trailer or bulk bin. Other types are open at the bottom with a flap that seals while fruit is being picked. There are also various designs of bags, including some that have a frame around the top to keep the bag open for the picker.

Picking buckets, lugs and other receptacles were also used in the past, but are not common unless being needed for a specific reason. These receptacles are less user-friendly and generally harsher on fruit.

## 3.3. Ladders

Ladders are used during harvesting depending on the height of trees. Ladders are placed alongside trees, or rested against the canopy in the case of larger trees.

Ladders vary from home-made, single-sided, two-legged ladders made from locally grown wood to factory-manufactured, two- or three-legged ladders generally made from aluminium or wood.

## 3.4. Bulk Bins and Picking Trailers

Fruit are taken from the orchard generally in bulk picking trailers with a capacity of 2t to 3t or in wooden or plastic bulk bins with a capacity of 350kg. In small operations, crates with a capacity of 15kg to 20kg capacity are used.

Picking bags are emptied into the bulk bins or trailers at a central collection point in the orchard. Trailers are pulled by tractors, while bulk bins are transported on specially designed bin trailers.

**Figure 1.2: Picking Trailers and Bulk Bins in the Orchard**

Picking trailers are usually made of steel and have hinged sides that can be opened up to release fruit at specifically designed off-loading ramps at the packhouse. In some cases, as a space-saving practice, the main fruit holding section of the picking trailer can be detached from its wheeled undercarriage by a gantry hoist and stacked on top of other trailers outside the packhouse.

Bulk bins are generally made from wood, or plastic in more recent times, and are moved in and out of the orchard in different ways. The most commonly used method is to place the bulk bins on light, simply-structured steel trailers. Bin trailers are designed to carry between two and four bins. Bulk bins are mostly placed on the trailer and removed from the trailer by a forklift, but to improve productivity and turn-around, adaptations are sometimes made to allow bins to roll off on the trailer on roller channels.

The most sophisticated method presently used to move bins around is by using specifically designed pneumatic lift trailers which move down orchard rows and pneumatically clamp and transport bins out.

### 3.5. Tractors

Tractors are an integral part of any harvesting operation as they are required to haul fruit out of the orchard to the loading bay and sometimes pickers to the point of harvest. Either converted tractors or forklifts are required for stacking bins if bulk bins are being used for transporting harvested fruit.

## 4. Maintaining and Cleaning Harvesting Tools and Equipment

Management practices that control postharvest waste losses start in the orchard with the fruit on the tree, and continue through the picking process into the packhouse. The maintenance and cleaning of harvesting tools and equipment is an important part of this chain. In addition to this, poorly maintained tools and equipment can slow the harvesting process and endanger workers.

In terms of postharvest losses, the most obvious and direct result of poorly maintained equipment is injuries to fruit. These injuries can occur for a number of reasons, from poorly aligned and ineffective clipper blades, to wire holding together ladder parts scratching fruit. Poorly maintained bins with protruding screws and splintered wood are particularly the cause of many injuries and resultant waste.

There are numerous pathogens present in any orchard, particularly during the harvest period, and lack of attention to hygiene and sanitation, particularly of equipment that comes into direct contact with and can contaminate fruit, increases the possibility of fruit contamination and postharvest waste.

Every person is responsible for maintaining and sanitising the equipment that they use during the harvesting process. The guidelines for maintenance and sanitation are laid down by management and every worker must be aware of the requirements.

Faulty tools and equipment must not be used under any circumstances, as this can compromise food safety and worker health. Faulty equipment must be reported to the supervisor or manager immediately, and repaired or replaced.

### 4.1. Clippers

All clippers must be checked before harvesting starts to ensure that the spring action is working well, and that the blades are sharp and closely aligned. This should also be checked on a regular basis during picking. Clippers must also be cleaned and sterilised prior to harvesting and regularly during picking.

### 4.2. Picking Bags

In preparation for harvesting, all picking bags must be cleaned and checked for holes and tears. Bags must be checked during picking to ensure that minor problems are sorted out before fruit is injured or picking efficiency decreases.

### 4.3. Ladders

Ladders must be checked for sharp edges, splinters, loose components and dirt to ensure fruit is not damaged when the ladders are placed alongside the trees or against the canopy, and to ensure that pickers are not injured while carrying or using the ladders.

### 4.4. Bulk Bins

Bulk bins are normally supplied by the packhouse, or rented from an equipment supplier. In preparation for harvesting, bulk bins are checked for sharp edges and splinters to avoid damage to fruit. They are also cleaned and sterilised to prevent contamination and decay. This is normally done by the supplier of the bulk bins.

### 4.5. Picking Trailers

Picking trailers must be serviced before harvesting starts, and all moving parts of picking trailers must be checked. The fruit carrying area of the bin must be checked for dirt, sharp edges, and latch functioning.

### 4.6. Tractors

In preparation for harvesting, tractors must be serviced to ensure that breakdowns do not cause unnecessary delays during the picking process.

## 5. Storing Tools and Equipment

When not being used, tools and equipment must always be stored in a secure, dry and clean room, separate from agrochemicals. The tools and equipment should be issued to the workers every morning and locked up again after the day's work.

The storage facility must be secure to ensure that unauthorised persons cannot gain access. It must be dry and clean to prevent contamination and rust. Tools and equipment must be stored separately from agrochemicals to prevent chemical contamination, and to ensure that the equipment is safe should a spillage occur.

## 6. Reporting Procedures

Tools and equipment must be managed with the assistance of a recordkeeping system that will enable management to determine at any time how much of each item there is, and where the item is being used or stored.

Faults in tools and equipment must be reported immediately to the supervisor or manager, and the situation must be rectified.


**Chapter 1**

- The tools and equipment requirement for harvesting is determined by the number of picking teams and pickers that is required for the picking operation.
- The number of picking teams and pickers that is required is determined by the size of the farm, the cultivar spread, the picking period and the capacity of the packhouse.
- Tools and equipment used commonly during citrus harvesting are clippers, picking bags, ladders, bulk bins or picking trailers, and tractors.
- Clippers are used to cut the stem of the fruit to remove it from the tree.
- Fruit is placed into picking bags, which are emptied into bulk bins or picking trailers.

- Tractors are used to transport the picking trailers, or bulk bins on trailers to the packhouse.
- Tools and equipment must be maintained to limit downtime during the harvesting operation, to prevent injury to fruit, and to minimised risks to worker health and safety.
- Every worker is responsible for maintaining and cleaning the tools and equipment he or she is using.
- The blade alignment and spring action of clippers must be checked before harvesting and regularly during picking.
- Clippers must be sterilised before and during picking.
- Picking bags must be checked before and during harvesting for holes and tears.
- Ladders must be checked for sharp edges, splinters and loose components.
- Bulk bins are cleaned and maintained by the supplier from which the bins are rented.
- Picking trailers and tractors must be serviced before harvesting.
- Tools and equipment must be stored in a secure, clean and dry room.
- Faulty tools and equipment must be reported to the supervisor or manager immediately and repaired or replaced.


Complete activities 1, 2, 3 and 4 in the **Learner Workbook**.

# Chapter 2

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

**Carry out sampling for maturity indexing according to established and familiar procedures**

## 1. Introduction

The general internal and external quality status of all fruit at the time of harvest and ultimately at consumption, is dependent on a large number of factors. Production practices and climate from fruit set in early summer through to harvest in autumn or winter all play a role. Fruit maturity can be defined as the point at which the fruit needs to be harvested from the tree, whether for storage or for movement to the consumer. Information on fruit maturity and the prediction of changes in fruit maturity is important for a number of reasons, including:

- Guiding orchard practices particularly in the lead up to harvest
- Indicating expected harvesting dates
- During harvesting, it gives an indication of the pace of fruit maturation and the probable picking window
- Predicting postharvest fruit behaviour, which is in turn critical for decisions on handling, storage conditions, shelf-life and potential market destinations

The monitoring of crop maturity is assisted by a technique known as maturity indexing.

## 2. Maturity Indexing


**Maturity Indexing**

Maturity indexing is, simply put, the process of monitoring the **physiological development** of fruit as it ripens. A number of parameters can be used to measure maturity and changes in maturity, such as colour, firmness, juice content, and levels of sugar, acid, and carbohydrate.

Maturity indexing information is used to plan harvesting, by determining whether fruit should be picked earlier or later than the historically recorded picking period, and to adjust orchard practices. Picking records are kept for the farming operation from which the picking period every year in the past can be determined. The trend that can be detected over a number of years gives an indication of the when picking should start.

Maturity indexing also gives one a general feel for how the internal physiological development of the fruit is progressing relative to other physiological factors, such as the colour and size development. Equally importantly, it allows the manager to assess how the fruit quality and timing, or readiness for picking, relate to the specific requirements and opportunities in the market.

The basic parameters that are assessed and monitored during maturity indexing can be divided into external and internal quality parameters.

## 2.1. External Quality Parameters

External quality parameters include factors such as fruit size, colour and firmness. These factors can be observed without having to pick or cut open the fruit. Colour is the most important external quality factor. Citrus fruit develop colour when it gets cold in autumn and winter. The difference between day and night temperatures plays the biggest role in colour development, but various methods have been developed to enhance colour development.

Standard colour plates are available for every cultivar against which the colour of the fruit can be assessed in various stages of maturity. Colour and blemish plates can be obtained from Citrus Research International (CRI), contact number (013) 759-8000.

## 2.2. Internal Quality Parameters

Internal quality parameters include the **juice percentage**, **Brix**, which is the total soluble solids or sugar content, the **acidity**, and the Brix to acid ratio of the fruit.

The internal quality norms for different varieties are set at different levels. In the case of lemons, the only deciding factor for export is juice percentage, as neither Brix nor acidity levels are generally used for table fruit. In the case of niche cultivars, higher standards, meaning higher Brix and Brix to acid ratios, have been set to place the fruit in a particular marketing bracket. The standard has to be maintained to assure the producer of the potentially higher return from that market.

| *Cultivar* | *Min Tss %* | *Min Brix %* | *% Acid* | *Min Sugar : Acid Ratio* | *Min Juice %* | *Average Max Seed Content* |
|---|---|---|---|---|---|---|
| Satsuma | 9.0 | 8.5 | 0.80 – 1.50 | 8.5:1 | 50 | 0 |
| Clementine | 10.0 | 9.0 | 0.80 – 1.50 | 8.9:1 | 50 | 3 |
| Nova | 10.0 | 9.0 | 0.80 – 1.50 | 8.9:1 | 50 | 3 |
| Tangerine | 10.0 | 9.0 | 0.80 – 1.50 | 8.9:1 | 50 | 10 |
| Minneola | 9.0 | 8.5 | 0.80 – 1.50 | 8.0:1 | 50 | 10 |
| Lemon | - | - | - | - | 40 | - |
| Marsh | 8.0 | 7.5 | ≤1.3 | 7.5:1 | 45 | 9 |
| Star Ruby | 8.5 | 8.0 | ≤1.6 | 7.5:1 | 45 | 5 |
| Navel | 9.5 | 9.0 | 0.80 – 1.50 | 8.0:1 | 48 | 0 |
| Navelate | 10.0 | 9.5 | 0.85 – 1.50 | 7.9:1 | 50 | 0 |
| Valencia | 9.5 | 9.0 | 0.80 – 1.50 | 8.0:1 | 50 | 9 |
| Midknight | 10.0 | 9.5 | 0.90 – 1.50 | 7.9:1 | 50 | 1 |
| Delta | 10.0 | 9.5 | 0.90 – 1.50 | 7.9:1 | 50 | 0 |
| Tomango | 9.5 | 9.0 | 0.70 – 1.50 | 8.5:1 | 50 | 6 |

**Table 2.1: Examples of Internal Quality Norms**

Orchard practices can be adjusted during the pre-picking period to enhance internal quality development. For example, if the sugar content of the fruit is not increasing as desired, the irrigation can be decreased.

Internal quality factors are measured through laboratory analysis. Fruit samples are picked regularly during the pre-picking picking period and sent for analysis to monitor the development of internal quality factors.

## 3. Sampling Procedures


**Sampling**

Sampling means taking a representative portion of a whole for analysis. Always remember the first principle of any sampling, which is that a sample must be **representative** of the bulk of the medium that is being sampled. A sample is not a piece or a section of a whole, but rather a whole reduced to a manageable volume.

Sampling for maturity indexing is generally **initiated two months before the historical start of the picking period of a cultivar**. In most cultivars, it is likely that any fruit sampled earlier than this will not have sufficient juice for analysis, or that the analysis will yield information that is so far out of specification that it will be of no assistance in guiding orchard practice leading up to harvest.

If strategies are employed to manipulate the internal quality of the fruit, sampling and analysis would generally be done weekly to monitor changes closely. Where fruit is merely being monitored as it approaches picking maturity, analysis would generally be carried out weekly only in the last month prior to harvest.

In line with the first principle of sampling, it is important that the correct fruit is sampled on a tree. Although a fruit sample must be taken randomly, there must be a focus on which fruit on a tree will constitute the bulk of the crop and will be picked in the earlier part of the season, referred to as the **first pick**. Large fruit with a coarse skin high in the canopy and small, pale fruit lower down inside the canopy are for example not fruit that one would include in a sample.

There is no prescribed procedure for maturity index sampling, but the following guidelines can be used:

- Divide the orchards into sample blocks according to cultivar and rootstock combination, tree age and condition, soil type and aspect.
- Start sampling two months before the historically recorded start of the harvesting period for the cultivar. In the month leading up to harvest sampling should be done weekly.
- Mark ten representative trees and use these as index trees throughout the season. Select two fruits per index tree which are representative of fruit on the tree. If it is clear that there will be more than one pick due to for instance colour differentiation, subdivide the sample accordingly. In certain orange-type cultivars there is a great deviation in internal quality between large and small fruit and it would be advisable in these situations to take a large and small fruit size sample.
- The fruit sample is placed in a bag and the orchard details and the date of sample is written on the bag or on a slip that are placed in the bag.
- The time that elapses before getting a fruit sample to the laboratory for analysis is not critical, but it should preferably be within a few days of the sample having been taken.

## 4. Analysis of Fruit Samples

In the laboratory, details relating to the sample are noted, including the producer, orchard number, and fruit size and colour. The fruit is then weighed, cut, its juice is extracted and the juice percentage, Brix, and acidity are measured.

The ratio of Brix to acidity is calculated from this information. This ratio is a further parameter used by the industry to determine acceptability of taste for different markets.

## 5. Recording Maturity Indexing Information

The results of the laboratory tests are plotted on a graph along with other information, such as fruit colour. Notes on the general fruit condition, referring to factors that may have a bearing on fruit maturity such as granulation, puffiness and fruit splitting, are also made.

If orchard practices need to be changed to manipulate fruit development, the maturity indexing graph is a key factor in making these decisions.

The data is also assessed relative to the management and planning schedule on the farm, and projections are made for the packing operation. It is a good idea to get the information to the packhouse, so that they are up to date on how fruit development is progressing.


**Internal Quality Monitoring Records**

| **Minimum** | | **1** | **48** | **9** | **0.8** | **7.5** |
|---|---|---|---|---|---|---|
| **Maximum** | | **4** | | | **1.5** | |
| ***Date*** | ***Week*** | ***Colour*** | ***Juice%*** | ***Brix*** | ***Acid*** | ***Ratio*** |
| 10/04/2010 | 15 | 4 | 46 | 8.5 | 1.6 | 9.4 |
| 17/04/2010 | 16 | | 47.8 | 8.7 | 1.55 | 9.7 |
| 24/04/2010 | 17 | | 49.3 | 8.8 | 1.43 | 10.1 |
| 01/05/2010 | 18 | | 45.8 | 9.2 | 1.44 | 7.8 |
| 09/05/2010 | 19 | | 47.2 | 9.3 | 1.41 | 8.3 |
| 11/05/2010 | 19 | | 50.1 | 9.6 | 1.3 | 9.1 |
| 16/05/2010 | 20 | | 45.3 | 10.1 | 1.29 | 7.9 |
| 18/05/2010 | 20 | | 53.5 | 10.3 | 1.26 | 9.8 |
| 29/05/2010 | 22 | 3 | 50 | 10.6 | 1.12 | 10.5 |
| 02/06/2010 | 22 | 3 | 51 | 11 | 1.11 | 11.3 |
| 03/06/2010 | 22 | 3 | 48 | 10.6 | 1.14 | 9.3 |
| 03/06/2010 | 22 | 3 | 50.5 | 11.2 | 1.1 | 9.1 |
| 14/06/2010 | 24 | 3 | | 11.2 | 0.82 | 13.7 |
| 22/06/2010 | 25 | 4 | 55 | 10.6 | 0.83 | 11.5 |
| 22/06/2010 | 25 | 4 | 51 | 10.6 | 0.84 | 12.6 |
| 25/06/2010 | 25 | 3 | 48 | 10.6 | 0.86 | 12.3 |
| 25/06/2010 | 25 | 3 | 48 | 11.8 | 0.8 | 13.7 |
| 29/06/2010 | 26 | 3 | 47 | 12 | 0.89 | 13.4 |
| 02/07/2010 | 27 | 3 | 49 | 12.2 | 0.81 | 15.0 |
| 05/07/2010 | 27 | 3 | 49 | 11.8 | 0.84 | 14.0 |


**Chapter 2**

- Fruit maturity can be defined as the point at which the fruit needs to be harvested from the tree.
- Monitoring fruit maturity assists in guiding orchard practices, indicating expected harvesting dates, indicating the picking window, and predicting postharvest fruit behaviour and susceptibility to decay.
- Maturity indexing is the process of monitoring the physiological development of fruit as it ripens.
- External factors that are monitored during maturity indexing are colour, size and firmness.
- Internal factors that are monitored include juice percentage, Brix, acidity, and the Brix to acid ratio.
- Internal factors are measured through sampling and testing.
- Sampling starts two months before the expected start of picking, and is generally done on a weekly basis.
- Juice is extracted from the sample fruit in the laboratory and the juice percentage, Brix and acidity is determined, from which the Brix to acid ration is calculated.
- The results are plotted on a graph over time, and the trends that become apparent is used to predict future maturation and the expected picking date.


Complete activities 5 and 6 in the **Learner Workbook**.

# Chapter 3

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

**Harvest crops**

## 1. Basic Harvesting Procedure

Citrus are generally picked by hand. The fruit is placed into picking bags, which are then emptied into bins or trailers placed in strategic positions in the orchard. Where trees are too tall to reach the fruit while standing on the ground, ladders are used.

The bins or trailers are transported to a central collection point on the farm, or directly to the packhouse.

Methods to pick citrus fruit mechanically have developed, but it is generally only useful where orchards are being stripped of fruit destined for juice processing. Mechanical picking is more likely to injure fruit.

## 2. Picking Methods

There are essentially two methods that are used to pick citrus fruit by hand, being:

- Snap picking
- Clipping

### 2.1. Snap Picking

Snap picking is a method whereby fruit is twisted off sharply by hand without using an tool to cut the stem.

Snap picking is not recommended for export fruit for a number of reasons. The calyx buttons are pulled out easily, oleocellosis develops because of the pressure on fruit as it is pulled and twisted, and stems are sometimes not cleanly broken off. It is however appropriate in certain situations, such as when a team is sent in to select and pick non-export fruit.

### 2.2. Clipping

Clipping makes use of specifically designed clippers that are used to cut the stem of the fruit. Clipping is generally recommended in most situations, but there are cases where snap picking, which is faster, is appropriate.

Purpose-built clippers are used to cut the stem as close to the button, or calyx, as possible without injuring the shoulder of the fruit. Long stems of between 1mm and 4mm, which result from inefficient cutting, are a frequent problem in harvesting and can lead to injuries to fruit when they are put into the picking bags, trailers or bins. Injuries of this nature can cause the fruit to decay at a later stage. If fruit is handled roughly or if the shoulders are cut by inexperienced pickers or pickers who are not taking enough time, it also increases the risk of fruit decay.

## 3. Harvesting Guidelines

Once picking starts, a few basics guidelines should be adhered to so that the quality of the crop of the crop is preserved, and so that food safety guidelines are adhered to.

- Picking bags must be suspended from the side of the pickers and not hang in front of them. This is to prevent damage to the fruit as the picker leans against a ladder or pushes into branches in the canopy.

- Pickers should walk with full picking bags and not run, as running will bounce and chafe the fruit, leading to the development of oleocellosis.

- To limit fruit injury when picking bags are emptied, the bag should be placed close to or on fruit lying in the bulk bins or picking trailers before being emptied.

- Once a bag has been emptied, it must be upended and shaken to remove loose twigs, leaves and sand that might have collected during the picking process.

- Fruit that were dropped during the picking process or are lying on the ground must not be picked up off the ground and put with export fruit.

- When varieties that are susceptible to oleocellosis are involved, bulk bins and trailers should not be filled completely. How far the bins or trailers are filled depends on the specific conditions, but as a rule of thumb, it should be filled only to between 50% and 75% of the capacity of the bin or trailer. As an added precaution, rubber or cardboard sheeting can be used as bin liners to give additional protection to the fruit. If bins are used, bins can also be left on the orchard floor overnight for a maximum of 24 hours, before being taken to the packhouse, allowing for a degree of wilting which reduces the risk of oleocellosis.

## 4. Postharvest Procedures

Harvested fruit must be taken to the packhouse within 24 hours after being harvest. If left in the loading zone for an extended period during this 24-hour period, particularly in the warmer autumn months, the fruit should preferably be kept under cover in a well-ventilated shed or under shade-cloth to prevent excessive wilting and softening of the fruit.


**Chapter 3**

- Citrus is generally picked by hand, either by snap picking or clipping.
- Snap picking is faster, but there is a greater danger of injury and damage to the fruit.
- Clipping is slower, but safer, and are used most often.
- To limit damage and injury to the fruit, picking bags must be suspended from the side of pickers, and placed against fruit that is already in the bin or trailer before being emptied, after which all loose twigs and leaves must be shaken from the bag.
- Pickers must walk and not run while carrying picking bags.
- Fruit that are lying on the ground must never be picked up and mixed with export fruit.
- For varieties that are susceptible to oleocellosis, bins and trailers must not be over-filled.
- Fruit must be taken to the packhouse within 24 hours after being picked.


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

# Chapter 4

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

**Harvest crops considering the necessary health, hygiene and safety during the procedure**

## 1. Introduction

Harvesting citrus fruit is most often a manual operation with a large number of pickers, tractor drivers and other personnel involved.

Every person in this team must be aware of the health, hygiene and safety regulations with regard to handling fresh produce and using the tools and equipment involved. Every person must take responsibility for limiting food safety and worker health and safety risks.

## 2. Safety Precautions

The most critical points in terms of worker safety are the picking of the fruit, especially where ladders are used, and the transport of fruit to the packhouse.

All pickers must be aware of the correct method of using tools such as clippers to avoid injury while picking. Pickers must also be aware of the correct method of using ladders and must ensure that they are placed securely against the tree canopy before climbing up, at the same time taking care not to injure the tree or fruit that are still on the tree.

Safety measures with regard to trailers and tractors include guards on trailer wheels and covers over moving machinery parts, such as belts, fans, and PTO shafts.

Procedures and checks are put in place by management to ensure that workers are protected. All workers must be aware of these procedures and supervisors must take the responsibility of ensuring that prescribed precautions are adhered to.

## 3. Protective Clothing and Equipment

Pickers are issued with overalls and headwear at the beginning of the picking process. This protective clothing must be worn at all times, and it is the responsibility of the pickers to ensure that the clothing is laundered regularly.

If sorters are posted at the bins or trailers to cull fruit that is obviously not suitable for export, they must where gloves.

Tractor drivers must where overalls and other prescribed protective clothing while driving.

## 4. Personal Hygiene

Prior to picking, all staff on picking teams should wash their hands with disinfectant soap at mobile washing facilities available in the orchard. After using the toilet facilities, they must again wash their hands. Disinfectant soap and water must be available at all times at ablution facilities.

A person that has a contagious disease must report it to the supervisor and not participate in the harvesting process until he or she is declared fit by a medical doctor. Though fruit undergoes a number of disinfectant and fungicidal treatments in the packhouse, it is unlikely but possible that contagious viral or bacterial diseases can be transferred to the end consumer through infected fruit.

## 5. Reporting Procedures

Should any of the picking staff injure themselves while picking, it must be reported to the team supervisor and an incident sheet should be filled in and signed before the injured person can return to the picking team.

All other unusual incidents must also be reported to the supervisor or harvesting manager to enable them to assess the possible risk to food safety and worker health and safety.


**Chapter 4**

- Every worker involved in the harvesting process must be aware of the health and safety procedures.
- In terms of safety, the actual picking of the fruit, especially where ladders are used, and the transport to the packhouse are the most critical points.
- Workers must wear the prescribed protective clothing at all times.
- Workers must be aware of personal hygiene requirements, including hand-washing and general cleanliness.
- Workers that are suffering from contagious diseases must report this to the supervisor or manager.
- All injuries and other unusual occurrences must be reported to the supervisor or manager immediately.


Complete activities 9 and 10 in the **Learner Workbook**.

# Chapter 5

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

**Ensure the requirements for the disposal of waste are adhered to**

## 1. Introduction

Orchard hygiene and proper waste disposal is critical in ensuring that pests and diseases are not given breeding ground and the opportunity to survive from one season to the next. Effective waste disposal is also essential in enduring that pathogens that cause pests and diseases are not spread to uninfected areas on the farm.

## 2. Orchard Hygiene

Orchard hygiene and sanitation is a crucial component in the chain of waste control. Micro organisms, most often in the form of fungal spores, infect even the smallest lesion on the rind of fruit. Often the progress of that infection into the fruit is such that packhouse treatments are unable to arrest the development of the pathogen and the fruit decays as a result. Reducing the spore load and consequent fungal infestation in the orchard therefore needs attention.

The origins of pathogens that cause waste and decay are diverse. Examples of pathogens are *Alternaria*, which causes stem-end, navel-end and core rot in citrus fruit. *Alternaria* survives from one season to the next and propagates on dead and hardened fruit still hanging on the trees or lying on the orchard floor. *Geothrichum* or Sour Rot spores are spread from fallen or infected fruit to other healthy fruit by fruit fly and vinegar fly. Blue and green mould spores from waste fruit on the orchard floor spreads in the orchard atmosphere infesting fruit damaged by hail, creasing, stylar-end split, and fruit fly or false codling moth stings. *Colletotrichum*, which causes *Anthracnose*, survives on dead wood in the tree canopy, and infests developing fruit that it comes into contact with lower in the canopy during rainfall.

Fallen fruit can also host pests such as false codling moth and fruit fly, allowing them to complete theur lifecycles and survive from one season to the next.

Orchard sanitation begins before harvest, with fallen fruit being removed from the orchard regularly. During the harvest period there is a marked increase in fruit ending up on the orchard floor. Fruit may be knocked off the tree by picking equipment or pickers moving through the orchard, it could have aborted and dropped off the tree, or it might simply have been culled out of the picking bins and dropped on the ground.

The process of collecting and disposing of fallen fruit must be continued until all the fruit from the orchard is harvested. Spores can develop within three days of lesions being infected, and good practice therefore dictates that orchard sanitation must be done more than once a week. It must however be done at the very least on a weekly basis to suppress spore load and control insects that complete their lifecycle in fallen fruit.

## 3. Disposal of Waste Fruit

Two methods are used for disposing of waste fruit, being chopping and burying waste fruit.

Chopping or breaking the fruit up in a thrasher and leaving it on the orchard floor to dry up is the easiest method, and generally acceptable in dry climates. Pathogens may however develop on this chopped waste in more humid climates. Burying waste fruit under at least 30cm of soil at a place away from the orchard is considered the most effective method of waste disposal.

Some producers compost the fruit waste with woodier material. If this waste material has been well-composted, it can be reintroduced into the orchard without causing problems.


**Chapter 5**

- Orchard hygiene and proper waste disposal is critical in ensuring that the spore load in orchards are minimised and in the control diseases and pests that are hosted in fallen.
- Fallen fruit must be collected and disposed of from before picking starts until all the fruit has been harvested.
- Waste fruit are disposed off in dryer climates by chopping it up and leaving it on the orchard floor to dry out.
- In more humid climates, the fruit must be buried away from the orchard at least 30cm under the soil.
- Waste fruit can also be used to make compost.


Complete activity 11 in the **Learner Workbook**.

# Bibliography

**Integrated Production Guidelines for Export Citrus – Volume 4: Harvesting and Packing Citrus**, Citrus Research International, Nelspruit