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Citrus Orchard Foreman Occupational Learning

Work Scenario Guide

G1: Harvest Planning

Qualification:	110667 – Occupational Certificate: Orchard and Vineyard Foreman
Work Scenario:	G1: Harvest Planning
Learning Area:	G: Plan and oversee the harvesting of citrus crop
Scenario Description:	You need to have a well-constructed harvest plan in place before harvesting can begin. You need to gather data to assess the maturity of your citrus fruit, and, using this data, draw up a harvesting plan.

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Alignment Information

Qualification

The content of this learner guide is aligned to the following occupational qualification:

SAQA QUAL ID	Qualification Title			
110667	Occupational Certificate: Orchard and Vineyard Foreman			
Originator				
Development Quality Partner – AgriSETA				
Primary Or Delegated Quality Assurance Functionary			NQF Sub-Framework	
-			OQSF - Occupational Qualifications Sub-Framework	
QUALIFICATION TYPE		FIELD		SUBFIELD
Occupational Certificate		Field 01 - Agriculture and Nature Conservation		Primary Agriculture
Abet Band	Minimum Credits	Pre-2009 NQF Level	NQF Level	Qual Class
Undefined	147	Not Applicable	NQF Level 04	Regular-ELOAC

Modules

The content of this learner guide is aligned to the following modules of the occupational qualification above.

Module Code	Module Title	Level	Credits
Knowledge Modules			
611202-001-00-KM-01	Plant Structure and Physiology	4	5
611202-001-00-KM-02	Vineyard or Orchard Establishment	3	2
611202-001-00-KM-03	Vineyard or Orchard Manipulation Processes	3	8
611202-001-00-KM-04	Harvesting	3	4
611202-001-00-KM-05	Basic Principles of Plant Nutrition	4	4
611202-001-00-KM-06	Crop Protection	3	3
611202-001-00-KM-07	Assets in Horticultural Production	3	2
611202-001-00-KM-08	Farm Business Management and Farming Process Management	4	8
611202-001-00-KM-09	Human Resource Management and Processes	4	8
611202-001-00-KM-10	Overseeing Farming Resource Utilisation	4	8
Practical Skill Modules			
611202-001-00-PM-01	Organise, Allocate and Monitor Availability and Productive Use of Resources	4	5
611202-001-00-PM-2a	Set Team and Individual Performance Goals to Enhancing Team Performance	4	10
611202-001-00-PM-2b	Control Vineyard or Orchard Practices	4	10

611202-001-00-PM-03	Supply Accurate Daily Orchard or Vineyard and Production Information	4	10
Work Experience Modules			
611202-001-00-WM-01	Vineyard or Orchard Resource Optimisation	4	20
611202-001-00-WM-02	Skilled and Motivated Work Team Output	4	20
611202-001-00-WM-03	Daily Orchard or Vineyard and Production Information Availability	4	20

Learning Outcomes

The content of this learner guide is aligned to the following learning outcomes of the modules above.

Knowledge Topics	
Outcome Code	Module Title
KM-04-KT01	Preparing for harvest
IAC0101	The timing and practices of yield and fruit size estimates are described
IAC0102	The timing and practices of pre-harvest orchard or vineyard sanitation are described
IAC0103	The timing and practices of pre-harvest pest control are described
IAC0104	The consideration of the prescribed withholding period for specific agro-chemicals when planning the harvesting date and application of chemicals is described
IAC0105	The specific maturity indexing procedure such as stage of growth of crop (DAFB-days of full bloom), sugar levels (TSS- total soluble solids), acid levels (TA titratable acid), fruit firmness, starch conversion, size, colour and level of ethylene production is outlined and discussed in terms of applicability to the given crop
Practical Skills	
PM-2a-PS04	Determine personnel requirements to meet production schedules
IAC0403	The sectional labour plan is correct
PA0401	Develop sectional (orchard) labour plans

Chapter 1

Maturity Indexing

learning outcomes

The content of this chapter is aimed at helping you to:

- Develop a maturity-indexing plan and interpret the data.
- Manage the maturity-indexing process.

1. Introduction to Fruit Maturity

Before we can talk about how to plan for harvest, we first need to determine when harvesting should take place. In citrus, this is determined by measuring your fruit's maturity. Maturity refers to when fruit is ready to be picked and eaten. Maturity indexing is the process of determining how mature a fruit is.

It is important not to confuse the terms 'ripe' and 'mature'. People often use these words interchangeably, but this is wrong. A mature fruit is one that has completed its growth phase, meaning that it has also completed its ripening phase. This fruit has reached optimal quality for selling and eating, because fruit cannot ripen until it reaches maturity.

Ripening, on the other hand, is a term used to describe the changes that occur within the fruit from the time it reaches maturity to the beginning of decay. These changes usually involve starches converting to sugars, a decrease in acids, softening, and change in the fruit's colour.

Unlike other fruit, citrus does not go through a ripening process in the sense that they become 'tree ripe'. Some fruits, for example cherries, physically mature and then continue to ripen on the tree. Other fruits, like pears, are picked when mature but before they ripen, and then continue to ripen off the tree.

Citrus fruits go from immaturity to maturity to over-maturity while still on the tree. Once they are separated from the tree, they will not increase in sweetness or continue to ripen, meaning that the internal quality of the fruit will not change further. The only change that happens after being picked is that they will eventually start to decay. It is very important to pick citrus only once the internal quality factors meet market requirements.

Maturity (and internal quality) can only be properly determined by internal quality. Unlike other fruits, you cannot simply look at external aspects like colour to know the fruit is ripe, because sometimes the rind turns of a citrus fruit turns colour long before the fruit is ready to eat. While internal quality will not change after picking, the colour of the fruit can still change, with chlorophyll pigments being broken down further and carotene pigments developing. If fruit is picked after colour-break – meaning once the first chloroform pigments have started breaking down – fruit colour will develop further after picking.

Citrus fruit can become over-mature if left on the tree for too long, with certain citrus types and cultivars being more prone to developing problems associated with over-maturity. Over-mature fruit is more vulnerable to postharvest diseases and have a shorter shelf-life than fruit that was picked at optimum maturity. It is very important that the farm's management can predict when picking will start so that harvest planning can be done in good time.

2. Maturity Periods

The maturity of citrus fruit is generally determined by the citrus type and cultivar, and regional climatic conditions. The citrus 'season', which means the time of the year when citrus is harvested, stretches from March to as late as October in some areas, but the picking period for a single cultivar is normally between two and four weeks.

On most farms there is a variety of cultivars, and the cultivar mix is in most cases designed to stretch the harvest period, so that all the fruit on the farm does not have to be picked in the same two-to-four-week period, so that resources can be used more efficiently.

In the table below are maturity charts for various citrus types and cultivars, and regions, as measured in the 2008 citrus season.

information

Maturity Charts

Cultivar	March				April				May				June				July				Aug				Sept			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Mandarin & Mandarin Hybrid Maturity Periods in Cold Regions																												
Note: Maturity per selection was based on a 3 week period peaking at a ratio of 11:1																												
Satsuma																												
Clementine																												
Fairchild																												
Nova																												
Minneola, African Sunset																												
Valley Gold, Kiyomi																												
Nectar																												
Nadorcott																												
Mor																												
Hadas Ellendale																												
Winola																												
Navel Maturity Periods in Cape Regions																												
Note: Maturity was based on a 3 week period peaking at a ratio of 10:1																												
PEN (Exp)																												
Fukumoto																												
Newhall/Navelina																												
Fisher																												
Dream, Tulegold, PAN																												
Bahianinha																												
Palmer																												
Washington, Cara Cara																												
EDPN 1, Chislett																												
EDPN 2, Autumn / Summer Gold																												
Powell Summer, Witkrans																												
Lane Late, Cambria																												
LBN, SUN																												
DSN																												

[illegible]

3. Maturity Development

Now that we know the importance of maturity indexing, let's discuss how internal quality is actually measured. When measuring maturity, we consider a few different quality factors as maturity parameters. We measure these over time, and when they reach certain values, we know the fruit is mature.

The qualities measured are:

- Fruit morphology
- Fruit colour
- Juice content
- Total soluble solids (sugar content or brix)
- Titratable acid
- Acid to sugar ratio

As we have said, the process of monitoring these maturity parameters is called maturity indexing. Maturity indexing information assists in predicting the best harvest time and in deciding to which market fruit will be sent, which depends mostly on the internal and external quality of the fruit.

Although the expected maturity time for various cultivars and regions can be predicted reasonably accurately, as can be seen from the table above, there may be small regional and yearly variations, depending mostly on weather conditions and production practices. While records are usually handy in predicting when the picking of the fruit of a particular cultivar should start, the maturity indexing that is done every year will give the best indication of when the fruit will reach optimum maturity.

Certain fruit characteristics are used as indicators of maturity and may develop differently or at varying rates from year to year. The development of these characteristics depends mostly on the weather conditions, although production practices may also play a role. These fruit characteristics are:

3.1. Fruit Morphology

Fruit morphology refers to the 'physical parts' of the fruit. In our case, this refers to qualities such as rind texture and thickness, and fruit shape and size, are all directly influenced by temperature and humidity.

Rind texture is determined early on during fruit development. Smooth-textured fruit is characteristic of cool, humid climates. These rinds are normally more easily damaged and have higher moisture content than fruit from hotter, more arid climates that tend to have coarser, textured rinds. The thickness of the rind is mostly determined by weather conditions during the later stages of fruit growth. Temperature, humidity, and water supply have the greatest influence. Water shortage during these growth stages will produce thicker skinned fruit with a lower juice content.

Cool, humid climates produce flatter fruit than warmer, arid climates. An example of the effect than climatic conditions can have on the size and shape of fruit can be clearly seen when looking at the easy-rind type mandarins. Satsuma mandarins produced in cooler more humid conditions are usually flatter, smaller and have no necks, whilst those grown in warmer drier climates are usually rounder and bigger with a more pronounced neck.

There are many more effects than climate can have on fruit morphology, but they are mostly season related. In general, the more humid climates with smaller daily and seasonal temperature fluctuation tend to produce fruit with a smoother skin texture that is flatter in shape than fruit produced in drier climates.

3.2. Fruit Colour

External fruit colour is the result of the concentration of the green chlorophyll pigment and the orange or yellow carotene pigments in the citrus rind. For citrus fruit to develop colour, there needs to be a notable difference between night and day temperatures. This is why citrus is generally not grown commercially in tropical areas, where the fruit tend to stay green, even after reaching internal maturity.

Cool temperatures during the last six to sixteen weeks before harvesting promote the rapid breakdown of chlorophyll pigments and the increase of carotene pigments. Night temperatures of below 13°C are required for the process to begin. If, for instance, there is a late onset of winter one year, meaning night temperatures remain high for longer, colour break will be delayed, and the fruit will need to be picked later.

3.3. Juice Content

Humidity and moisture availability have the biggest influence on the juice content of citrus fruit. Fruit with thick, coarse rinds tends to have less juice than fruit that was produced in cooler and more humid climates.

Moisture stress during the later stages of fruit development has a direct influence on the juice content of fruit. This happens as moisture stress causes the cell development within the fruit to slow down. Underdeveloped cells contain less juice than fully developed cells. Higher temperatures, often associated with drier conditions, also tend to cause fruit to have less juice. This is because that fruit respiration is higher in these conditions and more moisture loss occurs.

3.4. Total Soluble Solids (Brix)

The sugar content of a citrus fruit is measured by measuring the total soluble solid content (TSS) of the juice. About 70 to 90% of the soluble solids are sugar, but the total amount is usually given as the sugar content of the fruit. The TSS is also known as brix.

The sugar content of a citrus fruit increases as the acid in the fruit breaks down. Higher temperatures cause acid to break down quicker and sugar levels to increase. However, there does not appear to be a straightforward relationship between sugar content and temperature. In hot tropical climates with high night-time temperatures and heavy respiration losses, the competition with vegetative growth for carbohydrates tends to cause lower sugar levels. However, if moisture stress sufficient to check growth during the later stages of fruit development occurs, then higher sugar levels develop. This can be achieved by regulating irrigation.

In cool subtropical climates oranges tend to be lower in sugar than in warmer climates at the beginning of maturity. Sunlight hours are important, with the highest sugar levels occurring where the light intensity is the greatest.

3.5. Titratable Acid

The titratable acid in citrus fruit consists mainly of citric acid. In most citrus varieties, the breakdown of these acids in the fruit causes a rise of the sugar levels within the fruit.

During the later stages of fruit growth, acid levels decrease as temperatures increase. At higher temperatures, acid levels tend to decrease more rapidly, resulting in lower acid levels during harvesting. This inverse relationship between acid and temperature has been found under orchard conditions with oranges, grapefruit, pummelos and mandarins. Lemons and limes on the other hand appear not to be influenced by temperature levels.

3.6. Acid to Sugar Ratio

As fruit matures and the acid level in the fruit decreases relative to the remainder of the other soluble solids, the ratio increases. Once this ratio meets the required level, the fruit is classified as mature and ready to be harvested. If the fruit is left on the tree and the ratio becomes too high, fruit becomes insipid because the acid levels drop too low, and the fruit is classified as over-mature.

4. Sampling

Sampling refers to taking a representative portion of a whole for analysis. Always remember the first principle of sampling, which is that a sample must be representative of the bulk that

is being sampled. In our case, this means that the fruit chosen for a sample must represent the majority of the fruit in the orchard.

Sampling for maturity indexing usually starts two months before harvesting of the cultivar should start, as per records of previous seasons. Fruit sampled earlier than this will in most cultivars not have sufficient juice for analysis, or the results of analysis may be so far out of specification that it will be of little use. Best practice is to sample and analyse fruit weekly, especially if the information is being used to adjust production practices to manipulate internal quality of the fruit.

Although a fruit sample must be taken randomly, it is important to focus on fruit that will most likely be exported. 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. Divide the orchards into sample blocks, according to cultivar and rootstock combination, tree age and condition, soil type and aspect. Mark ten representative trees per block and use these as index trees throughout the season.

Then, select two fruit per index tree which are representative of fruit on the tree. If there will be more than one pick due to for instance colour differentiation, subdivide the sample accordingly. In certain orange cultivars there is a great deviation in internal quality between large and small fruit and it would be better 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 is placed in the bag.

Once these samples have been obtained, samples must be tested to determine their level of maturity. Sample testing must be done weekly from at least 8 weeks before the predicted harvesting period. Depending on the size of the farm or production area, sample testing can be done either on the farm itself or sent to independent laboratories for testing.

Let's discuss how each of the characteristics used for maturity indexing are measured during sampling:

4.1. Fruit Colour

Fruit colour tests are done by comparing fruit to colour charts. Colour charts are published by Citrus Research International every year and are based on international standards. Colour charts are available for each variety and cultivar and are numbered so that colour levels can be rated.

By keeping a record of colour development tests data can be obtained to indicate at what rate colour-change takes place and when fruit should be ready for harvesting. It is important to remember that the rate of colour-change in fruit is dependent on various climatic factors and might not be the same from one season to the next.

4.2. Juice Percentage

The juice percentage of fruit is one of the big determining factors of how fruit will be graded and what markets fruit can be sent to. Juice percentage is more important in some varieties than in others.

To test juice percentage a sample of twelve representative fruit must be chosen and weighed. The juice is then extracted from the fruit. The juice is then filtered through a cheese cloth to remove all solid parts and weighed.

By dividing the weight of the juice by the total fruit weight and multiplying the answer by 100 the juice percentage are obtained. The juice percentage is noted, and weekly changes monitored to determine when the fruit will be ready for harvesting.

4.3. Total Soluble Solids

The total soluble solid, or TSS, content of fruit juice is measured to determine the sugar content of the fruit. Although usually only between 75 to 85% of the total soluble solid content of the fruit juice is sugar the whole content is expressed as the sugar content or the brix.

The TSS is measured by using a refractometer. Refractometers have always been expensive pieces of equipment and that was one of the major contributing factors why most maturity testing was not done on the farm. These days however, cheaper handheld models with great accuracy have become available to farmers.

To measure the TSS the refractometer firstly needs to be zeroed or calibrated. Before starting the process ensure that the refractometer lens is clean by wiping it with a soft paper tissue and distilled water. This is done by covering the refractometer lens with distilled water and pressing the calibration or zero button. A zero reading must be obtained.

Once the refractometer has been zeroed, remove the distilled water from the refractometer lens with a soft paper tissue and ensure that the lens is dry. Place some juice extracted from the sample fruit on the refractometer lens, making sure that the lens is totally covered. Press the reading button and note the result. The test must be performed at least three times and the average of the three readings taken as the TSS.

4.4. Titratable Acid

When we use titration to measure the acid contents of fruit juice from sample fruit, it is the citric acid content of the juice that is measured. Citric acid normally makes up about 70 to 90% of the total acid content of the fruit juice.

To measure the titratable acid the following equipment are needed:

- 1 x Burette Stand with Clamps
- 1 x 25ml Burette with 0.02 graduation
- 1 x 250ml Erlenmeyer Flask
- 1 x Dropper
- 1 x 250ml Measuring Flask

The following chemicals are needed:

- Phenolphthalein
- 0.1562N Sodium Hydroxide

Place 20ml of the juice sample in an Erlenmeyer flask. Add 5 drops of phenolphthalein to the juice as an indicator. The phenolphthalein indicator is added to monitor the pH of the solution. Phenolphthalein changes colour once the pH of the solution changes from acidic to alkali. Fill the 25ml burette with sodium hydroxide and clamp it to the burette stand.

Now the juice and indicator solution are titrated with the sodium hydroxide by adding the sodium hydroxide slowly drop by drop. By adding the sodium hydroxide solution, the pH of the solution is increased. Whilst adding the sodium hydroxide it is important to continuously agitate the solution. Sodium hydroxide is added drop by drop until the solution changes colour to pink.

This colour change is known as the endpoint. The endpoint is when all the acid in the liquid has been neutralised and the pH of the solution rises to a neutral point.

Now a reading is taken of how much sodium hydroxide was used to obtain a neutral pH. The amount of sodium hydroxide used is then divided by twenty, the amount of juice used, and multiplied by 100 to obtain the titratable acid percentage.

4.5. Acid to Sugar Ratio

In most citrus varieties the acid to sugar ratio is the main determining maturity factor. As fruit becomes mature the acidity levels in the fruit diminishes and the sugar levels increases. This causes the ratio to increase. Once the ratio meets the set standard the fruit are classified as mature. If the ratio is allowed to increase to an excessively high-level fruit is classified as insipid and over-mature. To determine the ratio the TSS is divided by the titratable acid percentage.

5. The Maturity Indexing Plan

To accurately predict when fruit should reach optimum maturity, maturity parameters are monitored weekly, starting from about six weeks before when harvesting is expected to begin based on historical trends.

Twelve representative index trees are chosen and one fruit per tree, from similar positions on the trees and of similar size, are picked to make up the sample. This is done per unit, meaning per orchard or block or cultivar. The size of the unit for which a sample is taken should not be too large, because there may be variation in the rate of maturing, even among trees of the same cultivar. Samples must be taken from all the orchards and cultivars on the farm.

The parameters of the sample fruit are determined, and the changes in the parameters over time are plotted on graphs, one for each cultivar or orchard. Minimum and maximum standards can be added to the graph. Trends will become evident on the graph and the picking date can be predicted and problem areas identified.

Now that the start of the harvest can be predicted with some accuracy, the harvest plan can be developed and implemented, scheduling the harvesting for all the cultivars and orchards so that as much fruit as possible will be picked at optimum maturity, while using the available human and technical resources optimally.

Maturity indexing information must become part of the permanent record, because it serves as proof that fruit met the required set maturity parameters when it was harvested. This may become necessary in case of a dispute. It is important to indicate on records kept of maturity indexing when and where fruit was taken from and tested. Records must be kept for each cultivar and orchard.

6. Evaluating MI Data

Once all the maturity indexing tests have been performed and results obtained, results need to be evaluated. The evaluation of the test results plays an important role in determining when fruit will be ready for harvesting and thereby facilitate the development of a harvesting plan.

Before evaluating and measuring results, parameters against which results should be measured must be obtained. General fruit maturity parameters are determined by THE Department of Agriculture and published on their website. More commonly fruit export agencies supply producers with fruit maturity parameters that are set by overseas target markets. These parameters for the external and internal quality of fruit must be met before fruit can be exported those markets.

Juice percentage and fruit colour test result obtained during testing are measured against the set parameters and the differences noted. The rate that these parameters mature is

monitored by repeating tests on a weekly basis. Once a trend has been established the optimum harvesting time can be predicted.

Test results for TSS contents, the titratable acid percentage and ratio results are noted and plotted on a graph. The graph shows trends over time and are used to determine when fruit should be ready for harvesting. Historical data built up over a period of time can also be used to predict how fast fruit will reach maturity.

Historical data is obtained by compiling maturity indexing figures from previous season. This data is then used to predict when fruit can be expected to be mature. Climatic conditions are different from season to season and have a great effect on the TSS content of fruit. So, testing of fruit from season to season noting the differences in temperature and other climatic condition is important to obtain accurate historical records.

7. Distributing MI Information

Information gathered and evaluated during the maturity indexing process must be distributed along the correct channels to ensure that the information is used in an appropriate manner. Maturity Indexing information are mainly used to develop the harvest plan. Knowing when fruit will be ready for harvesting is the overriding factor when developing harvesting plan.

The maturity indexing information is also used to prove that fruit meets the required parameters before harvesting. This information can be presented as evidence that fruit was within the set parameters when harvested.

8. Recordkeeping

Keeping records of MI information and using those records to build up historical data is important for any citrus producer. Whether MI testing is done on the farm or production area or the testing is performed by an independent laboratory, MI is a costly operation. To justify the costs involved records of sampling and testing needs to be utilized to maximum effect.

Records must also show that the sampling and testing procedures followed are in line with Good Agricultural Practice regulations as set apart in accreditation schemes. This is critical to show the effectiveness of the MI process. Records must also give evidence that the MI process followed is adequate and authentic.

summary

Chapter 1 – Maturity Indexing

- A mature fruit is one that has completed its growth phase, while ripening is the term used to describe the changes that occur within the fruit from the time it reaches maturity to the beginning of decay.
- Citrus fruits pass from immaturity to maturity to over-maturity while still on the tree.
- Measuring and testing internal quality is the only way to know whether fruit is ready to eat.
- The maturity of citrus fruit is generally determined by the citrus type and cultivar, and regional climatic conditions.
- Although the expected maturity time for various cultivars and regions can be predicted with some accuracy there may be small regional and yearly variations, depending mostly on prevailing weather conditions and, in some cases, production practices.

- Fruit characteristics that are used as indicators of maturity and that may develop differently or at varying rates from year to year are fruit morphology, fruit colour, juice content, total soluble solids (sugar content or brix), titratable acid, and acid to sugar ratio.
- To accurately predict when fruit should reach optimum maturity, maturity parameters are monitored weekly, starting from about six weeks before when harvesting is expected to begin based on historical trends.
- Maturity indexing information must become part of the permanent record, because it serves as proof that fruit met the required set maturity parameters when it was harvested.
- Maturity Indexing is the process where samples of fruit are collected, and different maturity parameter test are performed on the sample fruit.
- Tests are performed either on the farm or at an independent laboratory.
- MI information can also be used to prove that fruit was mature at picking.
- Records must be kept of all maturity indexing processes to proof the effectiveness of the process and to show that the process followed Good Agricultural Practice guidelines.

assessment activities

- ✓ **Activity P1:** Complete this activity to test your knowledge of maturity indexing.

Chapter 2

Harvest Planning

learning outcomes

The content of this chapter is aimed at helping you to:

- Develop the harvesting plan for the crops according to the maturity indexing data.

1. Introduction to Harvest Plans

Now that we have finished maturity indexing, we know when we need to harvest the fruit. However, before we start harvesting, we need a plan to make sure that the harvesting process goes off without a hitch. For this, we need to make a high quality, detailed harvesting plan. In this chapter we discuss all the factors that must be incorporated into the harvesting plan.

2. Harvest Factors

When developing a harvest plan there are certain factors that will have a direct influence on the plan. These include factors such as:

- Fruit Maturity
- Labour availability
- Weather Conditions
- Picking Time Available

2.1. Fruit Maturity

The fruit maturity indexing plan, as described in the previous chapter, is used to obtain an indication of when fruit will be ready to be harvested.

2.2. Labour Availability

Citrus production in South Africa is normally concentrated in a few specific areas. This concentration of production and the fact that most producers in a specific area will harvest similar crops that are suitable to that area can cause a shortage of labour during the critical harvesting period. You must consider how many workers are available to you, and what their skill levels are, when developing the harvest plan.

2.3. Weather Conditions

As citrus cannot be harvested when the fruit are wet or when humidity is too high, long term weather predictions must be obtained when the harvesting plan is designed. Long term predictions can be obtained from either the South African Weather Bureau's website or from the Agri SA website. Prediction will give detailed information for up to a year in advance.

Different varieties of citrus are sensitive to different weather conditions. For instance, lemons cannot be picked within 48 hours after a cold front has passed. This is to inhibit the development of rind conditions such as Peteka spot. Ideally or citrus fruit

should be harvested only when temperature is between 13 and 30 degrees Centigrade to lessen injuries to fruit.

This variance in weather tolerance means that you should be very familiar with your specific cultivars and their specific weather tolerances when designing the harvest plan.

2.4. Picking Time Available

The picking time available is also known as the Normal Picking Period (NPP). This is an indication of the daylight hours available during each of the normal harvesting months. As picking cannot take place early in the morning when fruit might be wet from overnight dew, or the temperatures might be too low, the picking hours per day are limited.

The available NPP per day for each picking region can be obtained from the local Citrus Research International extension offices. These hours are determined by keeping records of the hours that harvesting was able to take place during previous seasons.

The NPP will not only determine the number of pickers that needs to be employed but also the length of the period that it will take to harvest a certain block or orchard of fruit.

3. Market

As you know, citrus can be sent to a few different markets, with their own pros and cons. The market that your fruit are destined for will determine what method of picking is used. This means that harvesting (and thus your harvest plan) will vary based on the target market of your fruit.

The three main markets you can send your fruit to are:

- Processing
- Local Market
- Export Market

3.1. Processing

Citrus fruit destined for the processing are usually sub-standard fruit that cannot be sold on the local or overseas markets. During fruit processing citrus fruit are processed into fruit juice concentrates and citrus oils.

Citrus fruit that are picked for processing is usually processed within 24 hours of picking. This means that fruit that is processed are not likely to develop any post-harvest diseases after picking and in most cases even the development of diseases is not of concern as the processing actions will destroy all post-harvest pathogens.

This means that fruit for processing can be harvested using the most cost-effective ways and that the handling of fruit is not as important as when picking fruit for other markets. The two methods most commonly used when harvesting citrus fruit is snap picking, where fruit is snapped of the tree by hand, or clipping, where fruit is clipped of the tree by using clippers.

Of these two methods snap picking is the fastest and most cost effective but are more likely to damage fruit. When harvesting fruit for processing snap picking will be used as preventing injuries to fruit is not as important as when picking fruit for the export market and snap picking is more cost effective and can be performed faster

than clipping. Most commonly, citrus fruit for processing will be harvested late in the season when fruit is over mature, or trees are stripped to remove all fruit.

3.2. Local Market

Citrus fruit is seldom harvested with the intention of sending the fruit directly to the local market. In most cases a citrus farm can only be profitable if most of the produce is exported, so most fruit will be picked with the sole purpose of being exported.

At the packhouse fruit is graded into different classes and the fruit not suitable for the export market are sent to the local market. This means that fruit going to the local market is harvested using the same clipping technique and careful handling as when harvesting fruit for export.

3.3. Export Market

Export market fruit is picked using clipping and careful handling. Utmost care must be taken when harvesting fruit for the export market to minimise injuries to the fruit. Any picking injuries can cause the development of post-harvest diseases or rind disorders.

4. Market Information

Various factors have an influence on when and how harvesting is done. One critical factor that needs constant attention is market information. Citrus production is only profitable if most of the fruit produced are sold on the overseas market. This means that fluctuations in the exchange rate and market price have a big influence on the ultimate profitability of the farm.

The price the market is willing to pay for fruit is usually only set when the fruit is ordered, while the exchange rate can change daily. Exchange rate and market prices fluctuations are difficult to predict but some export agents will predict prices and offer delivery contracts before the picking season starts.

These contracts require a producer to be able to deliver a set amount of fruit during a specific time frame. Having this information, a producer can adjust pre-harvest production practices to ensure fruit reaches maturity at the correct time.

Market prices are usually higher at the start of the citrus season and at the end of the season when supply dwindles. Some producers might attempt to force fruit to early maturity by degreening it chemically to improve profitability. The degreening process only changes the colour of fruit and does not change internal quality parameters, so fruit that are degreened to meet market specifications must already meet the required internal quality parameters before degreening can take place. A producer may also choose to delay the harvesting of fruit by treating fruit chemically. The chemical treatment process is described in the training material on Plant Manipulation.

Both the degreening process to ensure earlier maturity and the chemical treatment process to delay harvesting only have a slight effect on when fruit are harvested. Choosing the correct varieties and cultivars when the farm is developed is critical to ensure that fruit matures at the correct time and over a long period of time to extend the harvesting process and lessen the influence of price and exchange rate fluctuations on profitability. Thorough markets research must be done to ensure that fruit is sent to the most profitable markets at the correct time.

In some extreme cases, huge exchange rate fluctuations and a corresponding drop in price can cause exporting fruit to become unprofitable. Other markets such as processing and supplying fruit to the local market must then be investigated to see if losses can be minimised by lessening production and harvesting costs.

5. Storage of Fruit

When designing a harvesting plan another factor that must be considered is the available capacity of infrastructure. Once harvested, your fruit must be packed, transported, and stored before it is loaded onto ships for export. If during the height of the harvesting season the packhouse and storage facilities used for your fruit is inadequate great financial losses can be incurred.

Harvest planning must be done in close consultation with packhouses, transport companies and storage facilities. Transport and storage space must be reserved early in the season to ensure that the harvesting process takes place smoothly and that fruit quality is assured.

All exported citrus fruit is chilled. Fruit can either be pre-cooled at inland facilities, and transported in refrigerated trucks, or fruit can be cooled at harbour facilities or on ships. More commonly, the fruit is loaded into shipping containers after packing and cooled inside the containers to the required temperature.

All methods of cooling, transportation and cooling must be investigated before harvesting starts. Costs analysis must be done, and markets requirements obtained to determine the most cost effective and profitable way of harvesting, packing, and transporting fruit.

6. Harvesting Plan Calculations

Citrus in South Africa is harvested using either the snap picking or the clipping technique. It is not recommended to use the snap picking technique when harvesting citrus for the export market as snap picking can easily damage fruit. Clipping causes a lot less injuries to fruit, so snap picking in general is only used when trees are stripped of fruit and all fruit is sent for processing.

To accurately plan what tools and equipment is necessary for a certain harvesting period we need to know beforehand what type of harvesting we are likely to do. We also need an indication of how many staff we need to employ to complete the scheduled harvesting during the specified time period and we need to keep in mind any restrictions that weather condition might have on the harvesting process.

Most citrus harvesting takes place during the winter months in South Africa. This means that daylight hours during which harvesting can take place is restricted. All these factors must be considered when planning the harvest.

As the daylight hours that are available to pick fruit in differ from region to region it is important that you obtain the information regarding the NPP or normal picking period from your local CRI Extension Office. As an example, we will look at the picking hours available in the Western Cape area.

example

Western Cape Picking Time

Month	Picking Time (Hours per Day)
March	7
April	6
May	5
June	5

July	5
August	6
September	6

The table below shows the expected yield for some of the most common citrus varieties in the Western Cape region. It also indicates the average picking rate for pickers using the clipping method of harvesting. Taking this information into account we can then determine the man-hours needed to pick a hectare of fruit.

example

Expected crop, Picking Rate and Man-Hours

Cultivar	Yield (ton/ha)	Picking Rate (Kg/Hour)	Man-hours (per ha)
Navels	40	170	235
Valencias	50	170	294
Lemons	55	85	647
Oroval/Marisol	45	80	563
Other Clementines	45	60	750
Satsumas	50	60-80	833

In the table below we use all this information to determine how many pickers will be needed to harvest one hectare of a certain variety of citrus during a specific period.

example

Pickers Needed per Hectare

Cultivar	Picking time	Effective Picking Days	Available Picking Hours	Man-hours per Hectare	Pickers per Hectare
Miho Waste	March/April (3 Weeks)	10	$(7 \times 5d) + (6 \times 5d) = 65$	833	12.8
Owari	April (3 Weeks)	10	$6 \times 10d = 60$	833	14.0
Marisol	April (2 Weeks)	7	$6 \times 7d = 42$	563	13.4
Oroval	May (2 Weeks)	7	$5 \times 7d = 35$	563	16.1
Other Clementines	May/June (5 Weeks)	15	$5 \times 15d = 75$	750	10.0

Navels	May/June (6 Weeks)	20	$5 \times 20d = 100$	235	7.4
Valencias	Aug/Sep (7 Weeks)	25	$6 \times 25d = 150$	294	2.0
Lemons	April/Jun (8 Weeks)	30	$5 \times 30d = 150$	647	2.6

Now we can determine the number of pickers needed to harvest a certain number of hectares of fruit during a specified period. The table gives an example of pickers needed when 10 days are available to harvest a certain number of hectares of a certain variety of citrus.

example

Pickers needed to Harvest

Variety	Picking Rate per Hour (kg/hour)	Picking Time (Hours/day)	Picking rate per day (kg/day)	Yield (Ton/ha)	Proposed Area (ha)	Pickers Needed
Miho Waste	60	6	360	50	7	97
Marisol	80	6	480	45	7	66
Nules	60	5	300	45	10	150
Clemlate	60	5	300	45	5	75
Navelina	170	6	1020	40	2	8
Palmer	170	5	850	40	5	24
Eureka	85	5	425	55	6	78
Shamouti	170	6	1020	45	3	13

To explain this further look at the following example:

example

Calculating Labour Requirements

10 ha of Nules must be harvested in 10 days in June.

$10\text{ha} \times 45\text{t/ha} = 450,000$ kilograms to be picked

Number of man-days required to pick 450,000 kilograms of Nules at 300 kilograms per day:
450,000 kg

$300 \text{ kg per day} = 1500$ man-days

This means during the 10-day picking period 150 labourers per day will be needed

Now that we have determined the labour need a schedule needs to be designed to determine the number of pickers needed in a certain week. The table below is an example of:

example

Picking Schedule

Variety	Week															
	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Miho Waste	97	97	97													
Marisol				94	94											
Nules					150	150	150	150	150							
Clementine									50	50	50					
Navelina			4	4	4	4	4									
Palmer					12	12	12	12	12							
Eureka			26	26	26	26	26	26	26	26	26				26	26
Shamouti											5	5	5			
Total Pickers	97	97	127	124	286	192	192	188	238	76	81	55	5		26	26

As we can see from the table week 17 to 21 is the busiest harvesting period. To save on labour and training costs most farms in this situation will employ a workforce of about 180 labourers for this harvesting period and try to spread out the harvesting during the crucial 5-week period by harvesting earlier cultivars earlier or delaying the harvest of some cultivars by chemical means.

By using 180 pickers we can now determine the number of tools and equipment needed and when it will be needed.

7. Monitoring and Managing Harvesting

Even with a well-designed harvesting plan, it still needs to be properly implemented. Monitoring and managing harvesting is discussed in detail in the other harvesting material.

8. Harvesting Records

During the harvesting period records need to be kept ensuring that the harvesting plan is followed. These records are discussed in detail in other harvesting material.

summary

Chapter 2 – Harvest Planning

- Fruit maturity, labour availability, weather conditions, and picking time available will all influence the development of the harvest plan.

- This concentration of production and the fact that most producers in a specific area will harvest similar crops can cause a shortage of labour.
- As citrus cannot be harvested when the fruit are wet or when humidity is too high, long term weather predictions must be obtained when the harvesting plan is designed.
- Different varieties of citrus are sensitive to different weather conditions.
- The picking time available is also known as the normal picking period (NPP), which is an indication of the daylight hours available during each of the normal harvesting months.
- The two methods most commonly used when harvesting citrus fruit are snap picking or clipping.
- The three main markets you can send your fruit to are processing, local market and export market.
- Sub-standard citrus fruit cannot be sold on local or overseas markets, and are usually processed into fruit juice concentrates and citrus oils.
- In most cases a citrus farm can only be profitable if most of the produce is exported.
- Fluctuations in international exchange rates and market prices have a big influence on the ultimate profitability of a farm.
- Harvest planning must be done in close consultation with packhouses, transport companies and storage facilities.
- To accurately plan what tools and equipment is necessary for a certain harvesting period we need to know beforehand what type of harvesting we are likely to do.
- Most citrus harvesting takes place during the winter months in South Africa, which means that daylight hours during which harvesting can take place is restricted.

assessment activities

- ✓ **Activity P2:** Complete this activity to test your knowledge of harvest planning.
- ✓ **Activity F1:** Complete this activity to test your knowledge of the entire module.