LEARNER GUIDE

Enterprise Selection, Planning and Establishment

Level 4

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Title:		**Evaluate, Adjust and Implement Factors Influencing Agricultural Enterprises** **Implement Integrated Farm Layout and Site Selection**					
Applied Title:		**Evaluate, Adjust and Implement Factors Influencing Agricultural (Citrus) Enterprises** **Implement Integrated Farm Layout and Site Selection**					
Field:		Agriculture and Nature Conservation					
Sub-Field:		Primary Agriculture					
SETA (SGB):		AgriSETA					
Skills Area:		Enterprise Selection and Planning					
Context:		Citrus Production					
US No:	116293 116309	**Level:**	4	**Credits:**	3 3	**Notional Hours:**	30 30
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Based on the Production Guidelines of: citrus research international

Supported by: Citrus Growers' Association of Southern Africa — Grower levies working for you!

Unit standard alignment and assessment tool development:
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Directions

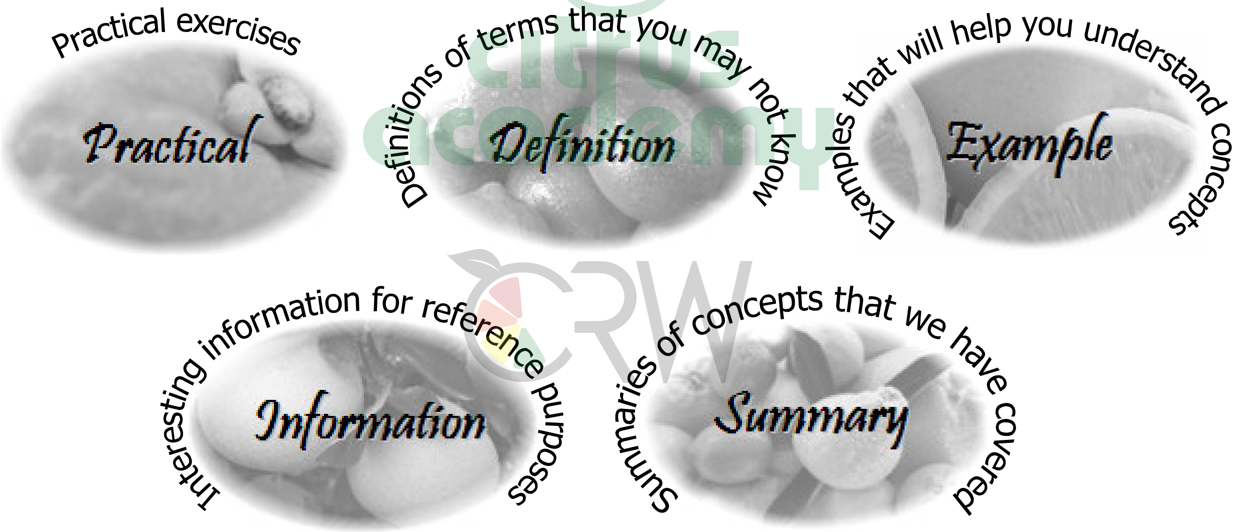
This learning material has been developed to assist the learner wishing to complete this unit standard. The guide contains all necessary learning to ensure that the learner will attain the competencies required by the unit standard.

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

1.1. Unit Standard 116293

Learners are capable of evaluating and adjusting the enterprise and production processes of animal and crop enterprises. In addition, they will be well positioned to extend their learning and practice into other areas of agriculture, specifically crop production and animal production systems. This training will benefit the profession by equipping learners with adequate skills to improve productivity and performance.

Learners will understand the importance of the application of business principles in agricultural production with specific reference to enterprise planning.

They will be able to operate farming practices as businesses and will gain the knowledge and skills to move from a subsistence orientation to an economic orientation in agriculture. Farmers will gain the knowledge and skills to access mainstream agriculture through a business-orientated approach to agriculture.

1.2. Unit Standard 116309

A learner achieving this unit standard will be able to contribute to the natural resource data gathering process, assist in determining the most appropriate and sustainable land-use for different parts of the land, supervise the implementation and maintenance of the selected infrastructure and maintain the most appropriate land-use on a farm by continuously assessing the natural resource base.

Competent learners will be fully conversant with agricultural regulations and aspects of conservation, providing the basis for the application of quality practices. Learners will gain an understanding of sustainable agricultural practices as applied in the animal-, plant- and mixed farming sub-fields.

They will be able to participate in, undertake and plan farming practices with knowledge of their environment. This unit standard will instil a culture of maintenance and care for both the environment as well as towards farming infrastructure and operations.

2. Learning Assumed to Be in Place

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

2.1. 116293

NQF Level	***Unit Standard Number***	***Unit Standard Description***
NQF3		Literacy and Numeracy
3	116214	Interpret factors influencing agricultural enterprises and plan accordingly

2.2. 116309

NQF Level	***Unit Standard Number***	***Unit Standard Description***
NQF3		Literacy and Numeracy
3	116274	Assist in farm planning and layout for conservation and rainwater harvesting
3	116271	Monitor and supervise a food safety and quality management system in the agricultural supply chain

Revision of Level 3

1. Natural Resources and Land Capability

- When a new citrus planting is planned, the inherent production potential of the land and the effects on the natural environment of the establishment of citrus orchards has to be determined and evaluated.
- Sustainable development requires consideration of all relevant factors, including avoiding or minimising the disturbance of natural ecosystems, avoiding the pollution and degradation of the environment, minimising and disposing of waste in a responsible manner, using natural resources responsibly, taking into account the consequences of resource depletion, and anticipating and preventing negative impacts on the environment and people's environmental rights.
- Natural resources required for citrus production can be described in short as those that would result in optimum yields of quality, marketable fruit to maximise on-farm income per hectare.
- Climate plays the most important role in what can be produced in any specific area, in addition to a well-drained soil and an adequate, good quality water supply.
- Land capability classification is a system of grouping land primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period of time.
- Land capability depends primarily on climate, a number of soil properties, for example depth and stoniness, wetness, erosion risk and slope. Also included is the overall pattern and variability and vegetation cover.
- The main climatic requirements for citrus often form the basis of the decisions regarding area and cultivar to be planted and the climatic factors that play the most important role in enterprise selection are temperature, day length and light, rainfall and humidity, wind, and hail.
- The concept of heat unit summation is a broad measure of the energy budget available to plants.
- Citrus responds to day length in that the longer the daylight period, the greater the total vegetative growth.
- Rainfall in South Africa is not sufficient to provide in the water requirements of commercial citrus production and citrus are therefore an irrigation crop.
- The frequency, velocity and seasonal distribution of wind influence suitability of a climate to citrus production.
- Hail occurs mostly in the northern production areas in South Africa, and causes blemishes and damage that may render fruit unsuitable for export.
- Apart from the general climate, there are a number of other climatic factors specific to an area that has to be considered when deciding where to develop and what to plant.
- The Institute for Soil, Climate and Water has a central website for the weather station network in South Africa where the climatic information collected throughout the country can be accessed.
- The type of climatic information which is required for enterprise selection and planning for as long a period as possible is average rainfall, relative humidity, average, maximum and minimum

evapotranspiration, average, maximum and minimum wind speed and direction, and average, maximum and minimum temperatures.

- Topography is important for enterprise selection and planning in terms of the lie of the land, and its slope and direction.
- The establishment of a citrus production unit has serious implications for the biodiversity of the natural environment.
- Planning is the single most important factor for ensuring the protection of indigenous species when a new citrus production unit is established.
- Invasive plants have been categorised by the Botanical Society of South Africa and the Agricultural Research Council (ARC) into three categories, depending on the threat that they hold for indigenous plant and animal species.
- Any control programme for alien vegetation must include initial control, follow-up control, and maintenance control.
- Soil maps are prepared that indicate the soil types over the area earmarked for development as part of planning a new citrus enterprise.
- The first step in determining the suitability of land for citrus production is a soil survey to examine the physical characteristics of the soil.
- Soil preparation, or profile modification, is an expensive process that can only be justified by an increase in production and the extension of the economic life of an orchard. The most commonly used soil preparation methods are mixing and loosening, or ripping.
- Chemical soil properties include those associated with its nutritional status, the soil salinity and the soil pH, meaning the degree of acidity.
- Aspects of water quality that influence crop production include the concentration of specific ions and their ratios relative to each other.

2. Natural Resources and Land Capability

- Infrastructure has a bearing on the practical implementation of all the day-to-day activities on a farm, and is the bare essentials required to operate a commercial farm.
- External infrastructure is mostly the responsibility of other people or bodies beside the farmer.
- Internal infrastructures include structures built, erected or bought on or for the farm to ensure profitable production of high quality crops.
- Infrastructure is not necessarily a determining factor in whether to establish a citrus farm, but it does play an important role in the planning process as development of a cost effective infrastructure can require a large capital outlay.
- Proper maintenance and repair of infrastructure on any farm is a prerequisite for success.
- Maintenance and repairs to external infrastructure has to be done by formal requests or applications to the relevant service providers through their regional representatives or through official organisations.
- Internal infrastructure must be maintained according to a well-prepared, ongoing maintenance plan.
- A formal monitoring system indicating actions per item, dates performed and responsible employee must be in use to ensure that all actions are carried out in good time.

- The employer must provide for the health and safety of persons at work and with regard to the use of plant and machinery, in accordance to the Occupational Health and Safety Act.

- To export fruit to Europe and some other countries, the farm must be registered for GlobalGAP which, amongst others, prescribe measures which has a bearing on infrastructure.

- When designing infrastructure for the new farm environmental protection structures must be taken into account and planned. These are structures such as bunds, gabions and mulching.

3. Enterprise Stock

- Stock required for citrus production refers to two different types of stock, being the crop that is produced and the production stock items that are required to produce the crop.

- Selecting the correct cultivar is important and knowledge must be gathered on all available cultivar and suitability must be investigated.

- Determining the production stock required for a certain operation, such as establishing a new orchard, is quite easy.

- Determining the stock requirements for ongoing production is more difficult as more factors affects this projection.

- Stock requirements can be calculated with the help of the plant protection, fertilisation, and weed control programs, the maintenance plan and the production report.

- Agrochemicals include soil preparation chemicals, fertiliser, plant protection products, and herbicides.

- The type and quantity of machinery and equipment that is required depends on the size of the farm and the production practices that are employed, and is normally determined when the original planning for the farm is done.

- The maintenance items that will be required in a specific period can be calculated from the maintenance plans that are put in place.

- The fuel that is required depends on the production practises, the size of the production unit and the number of vehicles in use on the farm.

- The types and quantities of other consumables required depend mostly on the production practices and the number of employees on the farm.

- Packhouse stock is not considered to be stock required on the farm, except if the farm has its own packhouse.

- Deciding on stock levels is about balancing two equally important factors: the cost of keeping the stock on hand and the possible loss in production if the stock item is not readily available.

- Systems for keeping track of stock requirements, ordering stock in time, controlling the issue of stock items, and monitoring current stock levels must be in place on all farms, and requires careful planning before the production unit is established.

- Any stock control systems must have components for purchasing, issuing, and managing stock levels.

- An asset register, or asset ledger, is a record of all the fixed assets on the farm.

- Management reports within any book year provide an overview of activities and results within that specific year and cover the progress in comparison to what was projected in the budget.

- Breakeven analyses calculate on a year-to-year basis what the minimum on-farm income before tax should be to cover all the production costs incurred for the product or range of products.

4. Production Processes

- The growth cycle of a citrus tree is closely related to the production actions that are taken at various times during the production season.

- The elements involved in production of a crop of the required quality are the following healthy orchards, correct production inputs at the right time, trained personnel, appropriate and well-maintained equipment, well-designed information systems, and sufficient funds to ensure necessary supplies.

- Observations and records of both historical and current season activities and crop response must be kept to enable the farmer to plan and react in order to produce a marketable crop.

- Records must be kept to show the results of similar practices during previous seasons and to facilitate traceability.

- Records are normally kept of pre-plant investigations, origins of plant material, staff qualifications, staff training, staff instruction, orchard numbers, fertiliser and spray material applications, testing and calibration of all equipment, maturity indexing, harvesting, cull analyses, and postharvest treatments.

- Market requirements influence decisions on what to produce and the production practices that are employed.

- Market information that is gathered of different markets in order to decide what to produce and to assist with production planning, include market preferences, expected income per unit, cost chains, price fluctuations over the production season, quality requirements, and production trends for the specific cultivar in local and overseas production areas.

- Production planning for citrus should at all times be based on the net on-farm returns from the markets for the types of citrus which can be produced successfully in the area which the farm is situated.

5. Harvest Processes

- The principles of harvesting are to budget, plan and forecast, not to harvest before the crop has reached required minimum standards, to adhere to instructions during harvest to maintain food safety and quality and to withholding periods for agrochemical applications, to maintain health and safety of workers during harvest, and to manage costs, equipment and staff to maximise profit.

- Harvest planning and preparation include deciding on the harvesting methods that will be used, crop estimates, maturity indexing and crop monitoring, personnel requirements and preparation, and equipment requirements and preparation.

- During the harvesting process, continuous attention to detail is required from management to ensure that the process goes according to plan.

- Harvesting records, including daily picking records are kept as part of the harvesting process.

6. Postharvest Processes

- The postharvest procedures which are considered are divided into transport and handling from orchard to packing line, the packing line, and chemical treatments and waxing.

- The main markets for citrus fruit are export markets, local fresh fruit markets and processing.

- The only way to ensure that correct practices are being followed is a recordkeeping system which is enforced and monitored on an ongoing basis.

- Apart from the legal requirements, registration for GlobalGAP also requires a number of specific actions with regard to postharvest handling of produce, being a hygiene risk analysis, staff training, documentation of implementing actions, water quality monitoring, filtering and monitoring of re-circulated water, water analysis, monitoring of all postharvest treatments, verification of all products used to treat the fruit.

7. Infrastructure Construction

- The equipment and tools used for the construction of basic infrastructure are governed by the design and purpose of the structures.

- Bunds are constructed to regulate and direct the flow of water, such as across roads.

- Gabions are cages, normally constructed using wire mesh, filled with stone.

- Wetland contours are used to protect wetland and are constructed by professional companies.

Agrochemicals

Agrochemicals are all chemical substances utilised in pre- and postharvest processes to produce horticultural products for fresh consumption. Agrochemicals include substances for soil preparation, fertilisers, and crop protection and postharvest chemicals.

Alien (Exotic) Species

Alien species, also referred to as exotic species, are fauna and flora that did not originate from the region or country, but that was brought to that region or country by humans.

Biodiversity

Biodiversity means the range of organisms present in a particular ecological community or system, and is measured by the numbers and types of different species.

Bunds

Bunds, also called bund walls, are small earthen barriers on agricultural land or dirt roads with slopes ranging from 1 to 6 percent.

Climate

Climate is the average weather, usually taken over a 30 year period, for a particular region and time period. Climate is not the same as weather, but is the average pattern of weather for a particular region. Climatic elements include precipitation, temperature, humidity, sunshine, wind velocity, phenomena such as fog, frost, and hail-storms, and other measures of the weather.

Ecosystem

An ecosystem is a localised group of interdependent organisms together with the environment that they inhabit and depend on.

Indigenous Species Indigenous species are fauna and flora that originated from and that are typical of a region or country. Certain indigenous species are considered endangered.
Infrastructure Infrastructure refers to services and facilities that support day-to-day economic activity, in this case a citrus production unit.
Invasive Species Around 1% of alien species become problematic to the local ecosystems into which they are introduced. These plants are referred to as invasive species.
Land Capability Land capability classification is a system of grouping land primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period of time. Land capability classification is subdivided into capability class and capability subclass.
Market The market is a network in which buyers and sellers interact to exchange goods and services for money.
Market Demand Market demand is the total demand or request for a product by all consumers.
Microclimate Microclimate refers to the climate of a small site. It may differ from the climate large of the area due to aspect, tree cover (or the absence of tree cover), or exposure to winds.
Natural Resources Natural resources are the various elements in any given farming environment which will contribute to the production of a quality product on a profitable and sustainable basis, without detrimental effects on the environment.
Soil Fertility Soil fertility refers to the nutrient content of the soil and its resultant ability of the soil to sustain plant growth.
Soil Potential Soil potential refers to the ability of the soil to support plant growth and produce a good quality crop.
Weather Weather is the specific condition of the atmosphere at a particular place and time. It is measured in terms of factors such as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. In most places, weather changes from hour to hour, day to day, and season to season.

Chapter 1

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

Prepare and categorise collected and recorded information in an agricultural environment to support the infrastructure development of an agricultural enterprise.

1. Collecting and Recording Information

The correct use of data and information is one of the main characteristics of a well run and successful farm. There are various types of data which has to be collected to provide information to management on a citrus farm.

The relationship between data and information can be defined as follows: information is the result of processing, manipulating and organising data in a way that adds knowledge to the receiver. In other words it is the context in which data is taken. It is therefore important to collect data in such a way that it can be processed to provide the required information. Management information would include the following:

- Financial data (budgets and cash flow)
- Administrative data
- Production data (inputs e.g. labour, materials, machinery and outputs e.g. crop produced)
- Productive use of inputs
- Human resource data
- Personnel records
- Manning levels for harvesting, packing, etc.

The ultimate aim is to ensure efficient and sound management to generate a profit. An efficient information system will therefore assist management to monitor the costs of input processes, materials and other resources, and the income generated through correct production and packing practices and judicious marketing.

The flow of data and information must be assessed and monitored throughout, and evaluated for whether it meets the requirements of management.

1.1. Financial Information

The flow of data form all areas where costs are incurred as well as income generated should be such that it can be collated in a monthly report to facilitate budget management. Data should also indicate cash flow figures – this enables management to balance income and expenditure.

1.2. Administration

Administration is the link between management and operations on a farm. Poor administration can cause a breakdown in communication of relevant information. All management reports are prepared by the administration department. They also have to ensure that relevant information on all aspects of the farming enterprise is filed and stored securely and available when needed.

1.3. Production

The management and control of the production process through a well organised monitoring process, is basic to good farm management.

The information systems within the production department form the basis of the broader management information systems, providing management with the necessary details to make meaningful decisions to manage, adjust and improve the enterprise. Production information must include the following:

- Use of personnel for all production processes like irrigation, spraying, pruning and harvesting
- Use and maintenance of machinery and equipment records
- Correct application of production chemicals
- Use of irrigation water records
- Crop statistics per cultivar per orchard
- Crop estimates including external and internal quality as well a fruit size
- Expected time of harvesting

2. Database Content and Management

A farm database contains information from multiple sources concerning production practices, orchard layout, financial records and historical records. Information about farm layout and the availability of resources also forms part of the database. One of the important factors included in the database are a listing of suppliers. Supplier listings give an indication of the size and scope of the enterprise. By inspecting the supplier and services provider listing one can determine the effectiveness and profitability of processes on a farm.

When collecting data to design a database for a farm, computers are used to correctly structure and store information. Having well trained staff that are able to efficiently use computers is a great asset to any organisation. The correct use of a database captured on a computer can relay relevant information effectively and in a range of different formats.

3. Organising Information

Tables, graphs and maps are all tools used to convey information. The layout of the information depends on the type of information and the audience or person to whom it is directed.

3.1. Graphs

Whereas tables provide exact data, graphs are mainly used to convey the general significance of data, such as general trends, relationships and proportions. The significance of a well-designed graph should be immediately clear, while the significance of a table becomes clear only by examination. People also tend to remember the meaning of data presented in graphs better than data presented in tables.

There are a great many types of graphs and variations on standard types. The type of graph that one uses depends on the sort of data that is being conveyed, and the significance (trend, proportion or relationship) that one wants to show. The major graph types that we will discuss in more detail are:

- Pie chart
- Bar or column graph
- Line graph
- Area graph

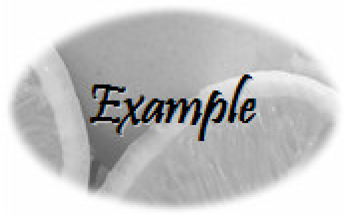
3.1.1. Pie Chart

A pie chart is a circle divided into a series of segments with each segment representing a particular category. It is a way of summarising the percentage distribution of each category in a set of data. The area of each segment is the same proportion of the circle as the category is of the total data set.

The use of the pie chart is quite popular, because they are simple to use and the circle provides a visual concept of the whole. Despite its popularity, pie charts should be used sparingly for two reasons.

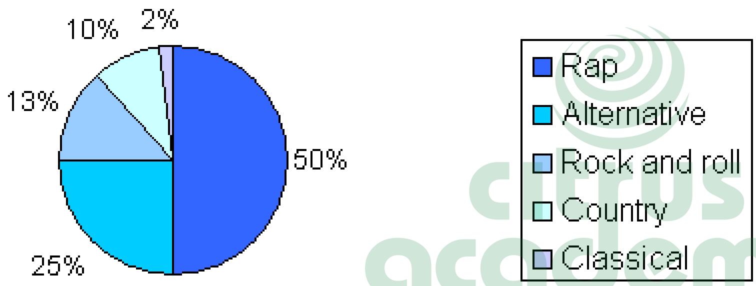
Firstly, pie charts are best used for displaying information when there are no more than six categories. More than six categories tend to make the chart too complex to understand. Secondly, pie charts are not useful when the values of one or more of the categories are too similar, because the differences between slice sizes are not significant enough.

To make a pie chart, the share of each category is converted to a percentage of 360 degrees.



Pie Chart

The pie chart below shoes the music preferences of young adults, ages 14 to 19.



The pie chart clearly shows that the majority of students like rap best (50%), and the remaining students prefer alternative (25%), rock and roll (13%), country (10%) and classical (2%).

3.1.2. Bar (Column) Graph

Bar, or column, graphs usually present categorical and numeric variables grouped in class intervals. They consist of an axis and a series or labelled horizontal or vertical bars. The bars depict frequencies of different values of a variable or simply the different values themselves. The numbers on the x-axis of a bar graph or the y-axis of a column graph are called the scale.

A bar graph may be either horizontal or vertical. The important point to note about bar graphs is their bar length or height – the greater their length or height, the greater their value.

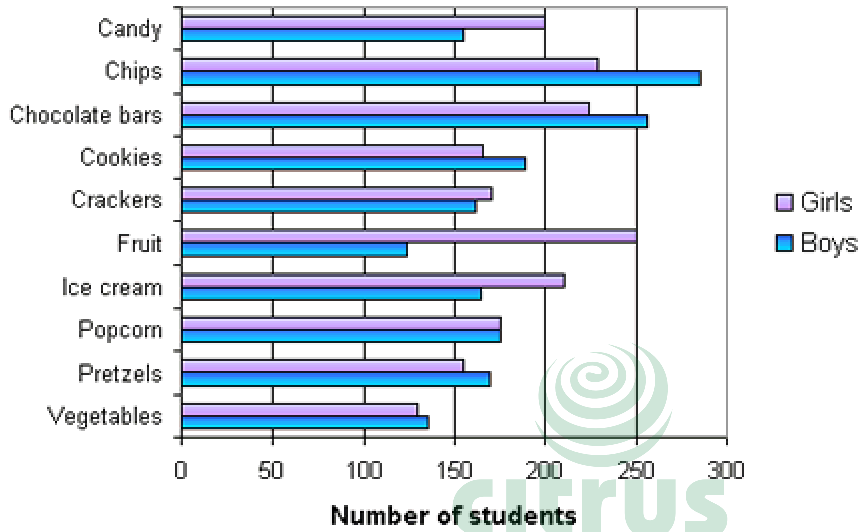
When developing bar graphs, a vertical or horizontal bar for each category or value is drawn. The height or length of the bar will represent the number of units or observations in that category (frequency) or simply the value of the variable. The bars can be any width, but this must be consistent between all the bars.

Bar graphs can be either horizontal or vertical – both typed work well when you need to compare values. However, in general, data comparisons are best represented vertically. One disadvantage of vertical bar graphs is that they lack space for text labelling at the foot of each bar. When category labels in the graph are too long, you might find a horizontal bar graph better for displaying information.

Example

Bar Graph

Below is a bar graph that shows the preferred snack choices of student at Hillary High School, also indicating the difference in snacks preferred by girls compared to boys.



3.1.3. Line Graph

A line graph is a visual comparison of how two variables, shown on the x- and y-axes, are related to each other. Line graphs shows related information by drawing a continuous line between all the points on a grid. Line graphs can take different shapes and be used to convey a wide array of information.

Line graphs are the most popular type of graph, because they are easy to create and their visual characteristics reveal data trends clearly. Line graphs are especially useful in the fields of statistics and science, and are one of the most common tools used to present data.

Although they do not present specific data as well as tables do, line graphs are able to show relationships more clearly than tables. Line graphs can also depict multiple data series. Time series data and frequency distribution are most commonly depicted using line graphs.

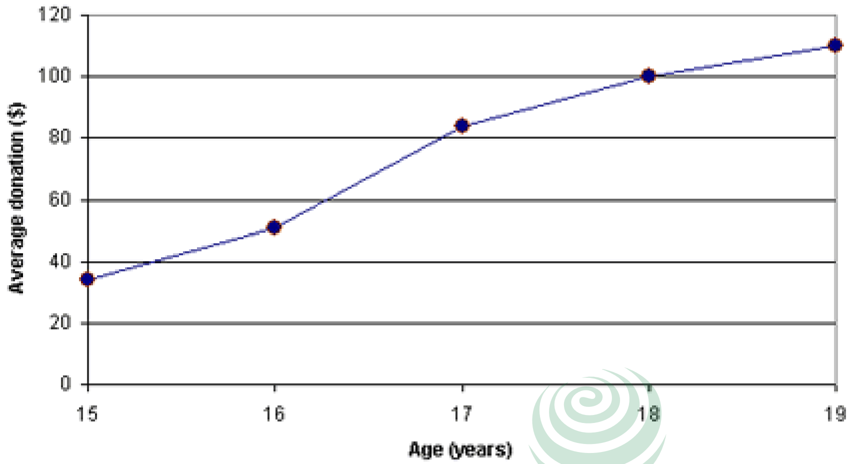
Bar, column graphs and line graphs share a similar purpose. The column graph, however, reveals a change in magnitude, whereas the line graph is used to show a change in direction. A multiple line graph can effectively compare similar items over the same period of time.

Be careful when selecting the scales for the x- and y-axes when creating a line graph, because this can give a distorted image of the data. If inconsistent scales on the axes of a line graph force data to appear in a certain way, then a graph can even reveal a trend that is entirely different from the one intended. This means that the intervals between adjacent points along the axis may be dissimilar, or that the same data charted in two graphs using different scales will appear different.

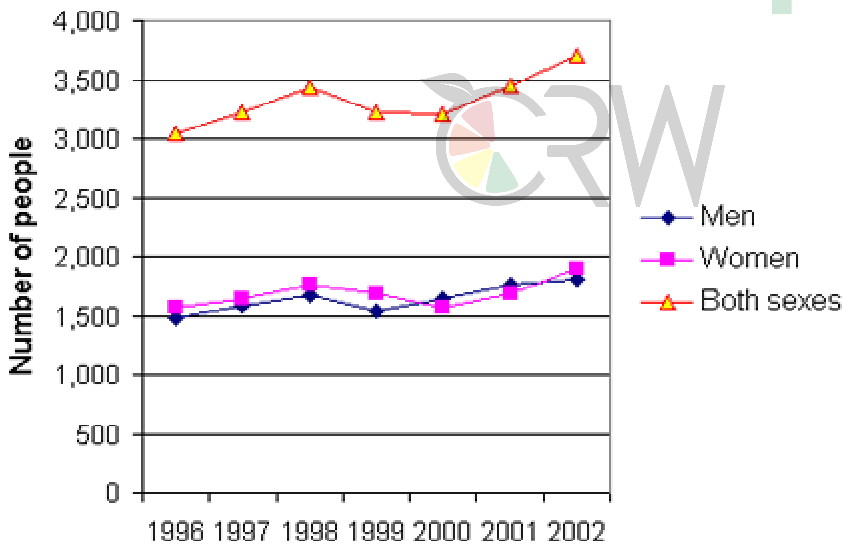
Example

Line Graphs

Below is a single line graph comparing the number of dollars donated by the age of the donors. According to the trend in the graph, the older the donor, the more money he or she donates.



Below is an example of a very good multiple line graph. It is easy to see from this graph that the total cell phone usage has been rising steadily since 1996, except for a two-year period between 1999 and 2000, when the numbers drop slightly. The pattern of use for women and men seems to be quite similar, with small discrepancies between them.



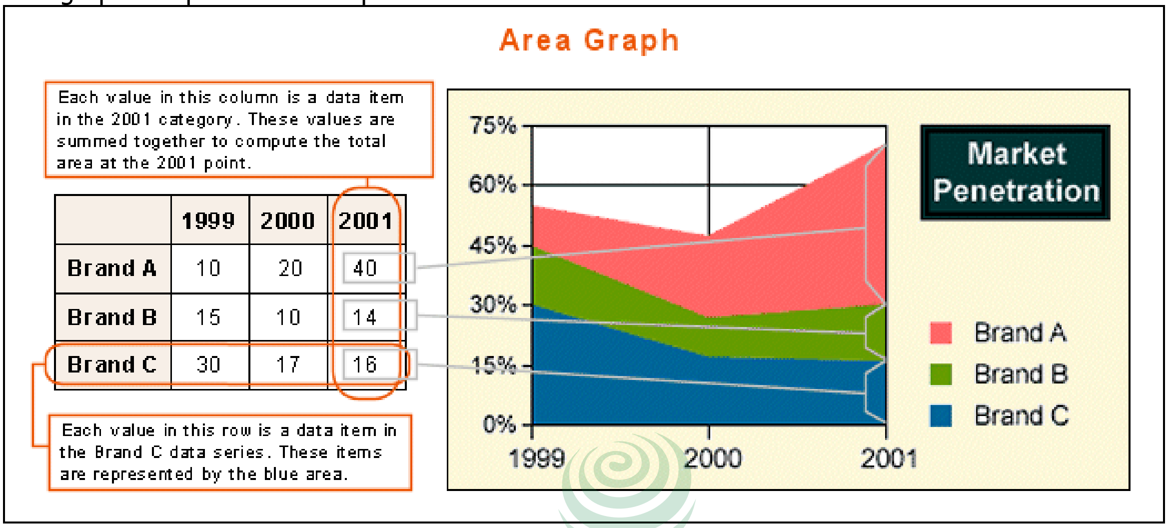
3.1.4. Area Graph

Area graphs combine the features of line graphs and stacked bar graphs by colouring the areas underneath each line. These area segments are stacked on top of each other, as in a stacked bar graph, so that the total size of the area at each category reflects the cumulative value of all data items in that category. Each data series in the graph corresponds to a coloured segment of the total area. The first series is always the top area segment.

Example

Area Graph

This graph compares markets penetration between different brands.



3.2. Tables

In its simplest form, a table is a group of rows and columns of data. At the top of each column is a column heading, which defines or identifies the contents of that column and often it indicates the unit of measurement as well. On the left edge of the table row headings are placed, which define or identify the contents of that row. Tables depict sets of figures in relation to certain parameters. It contains more detail than what is normally shown in graph form. If used in text or projected in submissions, it must contain only the information that is relevant and be as uncluttered as possible.

Tables permit rapid access to and relatively easy comparison of information. If the data is arranged chronologically (for example, sales figures over a ten-year period), the table can show trends, patterns of rising or falling activity. Tables are not necessarily the most vivid or dramatic means of showing such trends or relationships between data, which is why charts and graphs are more commonly used for this purpose.

Tables are mainly used for numerical data. Imagine that you are comparing sales of different products over a number of months, including the total sales of each product for the period, and the total sales each month. A table is perfect for showing this data. However tables are not strictly for numerical data. Tables can be used whenever different details of several items must be listed. For example, you can compare the characteristics of the products for which you listed the sales in the previous example. This is ideal information to be captured on a table, and it would be mostly words rather than numbers.

The following is handy tips for creating tables:

- Refer to the table in the text just preceding the table. Explain the general significance of the data in the table – do not expect readers to figure it out entirely for themselves.
- Do not overwhelm readers with monster 11-column, 30-row tables. Simplify the table data to just that amount of data that illustrates your point, without distorting that data.

- Do not put the word or abbreviation for the unit of measurement in every cell of a column. For example, in a column of measurements all in millimetres, do not put 'mm' after every number. Put the abbreviation in parentheses in the column or row heading.
- Right- or decimal-align numbers in the columns. If the 123 and 4 were in a column, the 4 would be right below the 3, not the 1. Normally, words in columns are left-justified.
- Column headings are normally cantered over the columns data, although this may vary depending on the type of data (numerical or text) in the column.
- When there is some special point you need to make about one or more of the items in the table, use a footnote instead of clogging up the table with the information.

Example

Table

Below is an example of a simple table, showing a production comparison.

Year	Total Production (quad. Btu)	Percent of Production			
		Coal	Petroleum	Natural Gas	Other[1]
1960	41.5	26.1	36.0	34.0	3.9
1970	62.1	23.5	32.9	38.9	4.7
1980	64.8	28.7	28.2	34.2	8.9

1. Includes hydropower, nuclear power, geothermal energy, and others.

Figure 3. Energy Production by Major Source from 1960 to 1980. Source: U.S. Energy Information Administration, *Annual Energy Review*.

3.3. Maps

A map is a graphic representation of a portion of the earth's surface drawn to scale as seen from above and a presentation of the physical and cultural environment where man finds himself. A map reduces the image of a large area so that is observable in one glance, and uses colours, symbols, and labels to represent features found on the ground. Features cannot be represented in true shape and to be understandable must be represented by conventional signs and symbols on a scale which can be interpreted and, in practice, converted to actual distances on site.

A map provides information on the existence, the location of, and the distance between ground features, such as populated places and routes to travel and communication. It also indicates variations in terrain, heights of natural features, and the extent of natural cover. Maps are used extensively on farms to indicate location of orchards, irrigation mainlines, power supply lines and the layout of other infrastructure.

In general maps are divided in two main categories, being topographic and thematic maps. Topographic maps are considered general purpose reference maps. The information that is found on such maps is for instance coastlines, rivers, lakes, roads, railway lines, buildings, canals, political boundaries, etc. In South Africa topographic maps are mainly prepared and published by the Director-General of Surveys.

Thematic maps are also known as special purpose maps or statistical maps. A thematic map depicts a graphic theme on a specific subject, e.g. soil, geology, population distribution, etc. To ensure that such a map is cartographically correct, a topographic map is normally used as a base map.

Summary

Chapter 1

- The correct use of data and information is one of the main characteristics of a well run and successful farm.
- Management information would include financial data (budgets and cash flow), administrative data, production data (inputs e.g. labour, materials, machinery and outputs e.g. crop produced), productive use of inputs, human resource data, personnel records, and manning levels for harvesting, packing, etc.
- When collecting data to design a database for a farm, computers are used to correctly structure and store information.
- Tables, graphs and maps are all tools used to convey information.
- Graphs are mainly used to convey the general significance of data, such as general trends, relationships and proportions.
- The major graph types are pie charts, bar or column graphs, line graphs, and area graph.
- A table is a group of rows and columns of data, with a column heading at the top of each column and row headings placed on the left edge of the table.
- A map is a graphic representation of a portion of the earth's surface drawn to scale as seen from above and a presentation of the physical and cultural environment where man finds himself.
- In general maps are divided in two main categories, being topographic and thematic maps.

Practical

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

Chapter 2

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

Evaluate and adjust production processes for sustainable management of required natural resources.

1. Evaluating Resource Use

In the level 2 and 3 Enterprise Selection, Planning and Establishment learning material, the resources that are required for citrus production are discussed extensively.

When evaluating whether the available resources are managed sustainably, it must be established whether the climate, soil and available water has been managed in a way that resulted in optimal fruit growth and production. The evaluation must also assess whether production practices caused excessive damage to the environment. To ensure that the required results are being achieved, an ongoing evaluation of the production process has to be implemented, through monitoring all aspects of resource use and management, and the consequent effects.

2. Evaluating Suitability of Management Practices

The establishment of a new orchard or enterprise must always be preceded by a careful study of the available resources and the environment as described in the level 3 learner guide for Enterprise Selection, Planning and Establishment.

The results of this study leads to a set of assumptions which forms the basis of all the decisions about the establishment and management of the new orchard or enterprise. These decisions have to be evaluated on an ongoing basis to confirm their correctness and relevance and, if necessary, adjusted where possible. Considerations must include the following:

- Where and how to establish the orchards:
  - Positioning of the orchards in relation to the topography
  - Row direction to provide optimum light interception for growth and production
  - Minimum disturbance of natural vegetation
  - Management of runoff from irrigation and rain to prevent erosion
  - Subsurface drainage to prevent excessive wetness in soils

- Soil preparation for optimum production:
  - Effectiveness of chemical ameliorates through regular soil and leaf analysis
  - Observation of vegetative growth
  - Production statistics on a yearly basis

- Management of the water resource including dams, pipelines and irrigation systems as well as runoff and drainage water:
  - Management of reticulation system of irrigation water to the orchards
  - Irrigation application and scheduling in the orchards
  - Effectiveness of measures to control runoff in prevention of erosion and sub-surface wetness.

- Cultivars/rootstock combinations best suited to the area:
  - Monitoring of production volume and fruit quality

- Establishment and operational costs per year to full production:
  - Costing of all actions on an orchard basis

- Production per year after planting with projected percentages marketable fruit and income:
  - Record production and fruit quality per orchard on a yearly basis

- Staff complement to handle the plantings:
  - Enough staff to handle all actions
  - Temporary staff during peak activities
  - Sufficient training to ensure maximum productivity

- Vehicles, tractors and equipment:
  - Matching availability with orchard management and requirements

Meaningful adjustment of and within resource management has to have a good administration and recordkeeping system as its base. It should also be supported by a well developed inspection and maintenance program to ensure that all physical danger areas are identified and inspected regularly. An example is areas where erosion is likely to occur after heavy rainstorms which has to be inspected immediately after such a storm and, if necessary, repaired.

3. Evaluating Production Cycles

The production cycle for citrus is a year-round process, and is closely related to the growth cycle of citrus. This cycle is discussed in the level 2 and 3 learning material. The production cycle is designed to provide the tree with what it requires to optimally support the current growth stage.

The production cycle is related to the growth stages of the tree as set out in the table below. Please note that in this table the approximate phenology of a valencia orange tree was used to develop the production cycle, and that the phenology of various types and cultivars of citrus fruit can differ appreciably.

Month	***Cell Processes***	***Fruit and Flower Development***	***Production Processes***					
			Fertilisation	**Pest and Disease Control**	**Irrigation**	**Pruning**	**Harvesting**	**Packing**
July	Flower Initiation	Flowering						
August	Cell Division							
September								
October		Fruit Set						
November								
December	Cell Enlargement							
January		Fruit Growth and Maturation						
February								
March								
April								
May								
June								

Table 2.1: Production Cycle of Valencia Citrus Tree

Production cycles also have a direct bearing on cash flow and profitability. It is important to evaluate the combined effect of the production cycles of the cultivars which can be grown in a specific area to establish the cultivar combination which will be best suited for providing the highest profit to the enterprise. Such a combination should:

- Provide a constant flow of fruit during the harvesting season;
- Result in optimal use of manpower and machinery throughout the combined production cycles; and
- Generate income over the longest possible period for healthy cash flow

The factors which therefore have to be considered when appraising cultivar combinations for suitability are the citrus type (orange, soft citrus, grapefruit or lemon), the cultural practices necessary to produce optimum crops and the timing of those practices, the time of maturing, and the picking period.

Production records should not only provide a record of physical production, but also an indication of the quality of the fruit produced historically on a yearly basis. This not only provides a base for evaluating physical orchard performance, but can also be used for economic analysis against pre-planting assumptions to calculate projected profitability. Production records should therefore include:

- Orchard detail, e.g. planting date, rootstock/scion combination, source of plant material;
- Production per year per cultivar per orchard;
- Fruit quality per year per cultivar per orchard (fruit size, internal quality, external defect analysis)

The income per cultivar and market should also be recorded in such a way to enable linkage with orchard production to calculate income and profitability per orchard.

We have already said that the decision of what and where to plant to achieve a balanced fruit flow and acceptable profitability is based on a set of pre-planting information and assumptions. These have to be evaluated after every season to establish whether the orchard performance and contribution of each cultivar to fruit flow is satisfactory and has resulted in the required profitability. If not, an adjustment to cultural practices, additional plantings or even removal of an orchard has to be considered.

There are many factors which are interrelated and which all affect the general management and smooth operation of a citrus farm and has to be considered in such an evaluation. They include the following:

- Cultivar performance (volume, timing of production, effect on picking and packing)
- Equipment (handling, transport and cultural practices)
- Human resources (management, supervision and labour requirements)
- Production (volume, quality and production practices)

4. Adjusting Farming Practices

The effect of farming practices on the tree and on the environment has to be monitored throughout the lifespan of an orchard. If necessary, adjustments must be made to optimise profitability and resource usage.

Few soils contain all the essential nutrient elements in sufficient amounts for optimum citrus production and nutrient elements therefore have to be supplemented through fertilisation. A fertiliser recommendation is the recipe whereby supplementation takes place. The objective of a fertiliser recommendation is to supply only what is necessary and to apply the minimum amount required for optimum production. Applying too much fertiliser is as detrimental as applying too little.

To make sure that the right adjustment is made to this farming practice, it is essential that the nutritional status of the soil and tree is evaluated on a regular basis. This evaluation is based on crop records, the condition of the tree and analysis of soil and leaf samples.

Soil and leaf analysis is not a management tool for all production practices. It cannot compensate for poor irrigation, inefficient fertiliser applications or other substandard practices. Soil and leaf analysis are merely methods which can be used to ensure that one of the factors determining production, namely fertilisation, is founded on sound scientific and economic bases. Recommendations based on analyses have to be made by a knowledgeable person after considering all relevant aspects.

Similarly, water analyses allow the farm manager to take the necessary preventative steps to improve water quality if it has the potential to negatively impact on crop production. Weather patterns are another factor that must be monitored on an ongoing basis, so that adjustment to management practices can be made if necessary.

4.1. Soil and Leaf Sample Analysis

Soil preparation prior to planting is fundamental to the long term productivity of the orchard. Only by analysing the soil is it possible to determine what should be added to render its chemical composition more favourable for plant growth. Adjustments after planting are not always as successful as adjustments made before planting. This is especially true of lime, gypsum and phosphate applications, which should be incorporated into soil as thoroughly and deeply as possible.

In producing orchards it is recommended that soil sample analysis is used in combination with leaf analysis. Provided that proper soil preparation was done, it is then only necessary to analyse the soil every three to five years, mainly to monitor soil acidity (pH), and the potassium and phosphorous levels in the soil.

The nutritional status of an orchard is determined through leaf analysis by using the plant itself as a measure. The sum total of the influences exercised by all possible growth factors is taken into account and tested to see if under this specific set of circumstances the plant has been able to reach the measured concentration of each element. Because these elements are related to production, leaf analysis reflects the potential production under given circumstances.

Leaf analysis is also used to maintain a balanced nutritional status. Optimum status in perennial trees is reached in two to five years, where after leaf analysis is used to maintain this status. Leaf analysis can also be used as early warning system by showing up nutrient imbalances which may be developing, as well as inefficient fertilisation.

4.2. Water Sample Analysis

Water quality describes the physical, chemical, biological and aesthetic properties of water that determines its fitness for a variety of uses and for protection of aquatic ecosystems. Producing citrus under irrigation depends on availability of water of suitable quality for sustained production of quality fruit.

In order to evaluate water quality, the potential of the water to lead to the following should be assessed:

- Possible crop losses
- Altered soil conditions which could impact on production and fruit quality
- Use of special management practices to maintain production levels

Problems with water quality are often complex and a combination of factors may affect production more than a single factor. It is important to establish the quality of the water to be used for irrigation at the planning stage of farm and orchard development. The results should be discussed with knowledgeable advisors to ensure that all possible future problems as well as management thereof are identified as early as possible.

The quality of water is usually at its poorest just before, and at its best during, the rainy season. If the quality varies greatly between the two periods, the water source must be sampled and tested continuously. In rivers, the quality of water deteriorates as the distance from its source increases.

Other aspects of water quality include, amongst others, the concentration of specific ions and their ratios relative to each other. In evaluating irrigation water, the following determinations have the most decisive influence on its quality:

- Total dissolved salts (TDS)
- Sodium absorption ratio (SAR)
- Boron, chloride and iron

4.2.1. Total Dissolved Salts (TDS)

Any natural water contains a certain quantity of salts in solution. The quantity can be measured in mg per litre but also indirectly by means of the specific electrical conductivity (EC).

Crops differ widely in their sensitivity to high salt concentration in the irrigation water. Citrus is generally classified as a salt sensitive crop and a 30% increase in salt concentration of soil can lead to a decrease of at least 10% in total production.

The electrical conductivity (EC) of a soil is closely related to the EC of the water. During irrigation a certain quantity of salts is also applied. Evaporation and water absorption by the plants concentrate the salts in the soil. If the subsequent irrigation does not remove some of the salts by leaching, situations can develop in which high salt concentration restricts production.

The higher the salt content (EC) of the irrigation water, the more irrigation has to be applied to leach out the excess salts in the soil to maintain 100% production. It is therefore essential that the quality of the irrigation water must be known to determine the leaching requirement. Provision must be made in the planning for the additional volume of water. Leaching is a necessary loss and the management of leaching can influence the production of citrus appreciably.

We can therefore say that the more salts in the water, the more water will have to be applied during irrigation and the greater is the possibility of salinisation. Guidelines for evaluation are given in the table below.

Possibility of Salinisation	TDS (mg/litre)	EC (mS/m)
None	0-150	0-25
Small	151-500	26-75
Reasonable	501-1,500	76-225
Big	1,500+	225+

Table 2.2: Limits for TDS and EC Values

4.2.2. Sodium Absorption Ratio (SAR)

An excess of sodium has a harmful effect on soil structure and, together with that, water infiltration, aeration and root growth. Consequently it is necessary to determine the ratio of the concentration of sodium to that of calcium and magnesium (SAR). The more sodium is present, the higher the SAR will be and therefore the possibility of salinisation.

The SAR and TDS (EC) are used jointly to classify irrigation water. When the EC is less than 75 mS/m the salinity hazard is low. The SAR is then also of little importance.

The following symbols are used to classify irrigation water:

(S = Sodium)

- **S1** Water low in sodium and suitable for irrigation on any soil and crop
- **S2** Water with medium sodium content which could give problems on fine-textured soils
- **S3** Water with a high sodium content which will cause problems unless good drainage and leaching is possible. Special attention and management is necessary.
- **S4** Very high sodium content and unsuitable for irrigation.

(C = Conductivity)

- **C1** Water low in salt which can be used on any crop. Some leaching is required.
- **C2** Medium salt water that can be used on all soils and crops provided adequate leaching and drainage are possible.
- **C3** High salt water that may not be used on all soils and crops. Adequate drainage, leaching and special management are essential.
- **C4** Very high salt water which can be used only under special conditions and management.

4.2.3. Boron, Chloride and Iron

Boron is a micro-nutrient, but the boron concentration easily reaches toxic levels. Boron toxicity is experienced if the irrigation water contains more than 1mg boron (B) per litre. The maximum limit for boron concentration in irrigation water is 0.3 mg/l for lemons and 1.0 mg/l for other cultivars.

The maximum allowable level for chloride in irrigation water for citrus is less than 3me/litre. Rootstocks show differences in their tolerance to the chloride concentration in the water, as indicated in the table below. A crop reduction of 4.3% can be expected for each me/l chloride increase above 5me/l in the irrigation water.

Rootstock	***Chloride Tolerance***
Rangpur Lime and Cleopatra Mandarin	25me/l
Rough Lemon, Tangelo and Lemon	15me/l
Sweet Orange and Citrange	10me/l

Table 2.3: Rootstock Tolerance to Chloride

Iron is another dissolved salt which can create problems. At the relatively low concentration of 0.5mg/litre iron can cause blockages of small jets or drippers.

4.3. Sampling

All samples for analysis, whether it is soil samples, leaf samples or water samples, has to be representative of the specific area, orchard or water source of which the information is required. The possibility of contamination of the sample at and after sampling must also be eliminated.

In the case of water the sample must be collected in a clean glass bottle as near as possible to the point of delivery to the irrigation system or storage dam. Identify the sample by attaching a label with all the necessary information to ensure that there can be no problems with identification. The information must indicate the farm, date and point of sampling as well as any additional info or request.

There are a number of independent laboratories that can do the water analyses. Their location can be established through any of the extension offices of the government or other agricultural service providers.

4.4. Weather Records

The interpretation of long, medium and short term forecasts plays an important role in planning production activities on a citrus farm. Also the projected effect of global warming on the various citrus production areas may influence the investment decision on where to develop a citrus production unit.

Long term forecasts on yearly weather patterns and rainfall as provided by the SA Weather Bureau are normally used for planning and allocation of water for irrigation.

Medium term forecasts for one to two weeks are also available from the Weather Bureau and private agencies. The information from the agencies are 7 to 10 day forecasts and focused on control of diseases on specific crops, such as Alternaria and blackspot control in citrus. The forecasts are updated on a daily basis and are therefore also used on the short term.

The projected data provided includes the following:

- Average, maximum and minimum temperatures
- Chances of rain with possible precipitation
- Radiation levels
- Relative humidity
- Wind direction and speed
- Evapotranspiration rate

Coupled to the above is a 5-day projection for spray conditions indicating day and time of day and based on projected wind, rainfall, dew wetness and frost data. The Weather Bureau also supplies forecasts on a one to four day basis in the daily papers as well as on television.

A wide base of information is therefore available to the citrus producer to use for planning production activities like irrigation and spraying as well as harvesting.

Chapter 2

- When evaluating whether the available resources are managed sustainably, it must be established whether the climate, soil and available water has been managed in a way that resulted in optimal fruit growth and production.
- Decisions about the production practices employed in a new enterprise or orchard have to be evaluated on an ongoing basis to confirm their correctness and relevance and, if necessary, adjusted where possible.
- Meaningful adjustment of and within resource management has to have a good administration and recordkeeping system as its base.
- It is important to evaluate the combined effect of the production cycles of the cultivars which can be grown in a specific area to establish the cultivar combination which will be best suited for providing the highest profit to the enterprise.
- Production records should not only provide a record of physical production, but also an indication of the quality of the fruit produced historically on a yearly basis.
- To make sure that the right adjustment is made to fertilisation, it is essential that the

nutritional status of the soil and tree is evaluated on a regular basis.

- Water analyses allow the farm manager to take the necessary preventative steps to improve water quality if it has the potential to negatively impact on crop production.
- Weather patterns are another factor that must be monitored on an ongoing basis, so that adjustment to management practices can be made if necessary.

Complete activities 3, 4, 5 and 6 in the **Learner Workbook**.

Chapter 3

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

Demonstrate the ability to identify high and low yield potential areas according to a range of land use options and criteria.

1. Agricultural Potential

The term 'potential' means that which is possible or can be achieved. The potential of something can be expressed in qualitative or quantitative terms only after the conditions and requirements have been specified.

Agricultural potential concerns only those factors and characteristics that must be taken into account agriculturally. This includes climate, soil, slope, vegetation and, at times, geographic location and the size of the unit. Agricultural potential is therefore the expression of possible production per unit time per unit area together with requirements with respect to management that are necessary to achieve this. Agricultural potential depends on the characteristics of land and management inputs, where land has natural characteristics that include climate, soil, slope and vegetation.

If it is accepted that agricultural potential reflects the production capacity of a land under specific management, it is logical that the individual components of land do not have an agricultural potential but are either suitable or not with respect to agricultural activities. In this way a certain climate can be suitable for cultivation of citrus, but if the soil is unsuitable, the potential is low. In the same way a certain soil can have all the characteristics that make it suitable for citrus, but if the climate is unfavourable, the potential is low. However, if the climate is favourable the potential is high.

The maximum potential return or capacity of a land can in practice only be achieved under optimum management practices. These practices include, among others, fertilisation, weed control, pest and disease control, careful picking and handling of fruit, and good labour management with the correct balance between the respective farming operations.

2. Land Suitability

It is evident that yield potential of a farm cannot be assessed before a land use suitability study has been done. Studies for determination of yield potential are complex and can only be carried out by well trained professionals with broad knowledge and experience of the requirements for production of specific crops.

By land suitability or capability is meant the extent to which land provides in the needs of one or more uses under defined management conditions, climate included. This utilisation includes pastoral, forestry and ranching. Land suitability classification thus means the grouping of land into classes with the same suitability or capacity. The land suitability classification is one of the best-known examples of integrated groupings of soils where the practical use of land as indicated in classes, categories or values.

2.1. Land Suitability Classification

The land suitability classification system that is most commonly used is the system of the USDA Soil Conservation Service (Klingebiel & Montgomery, 1961). Although it was developed for the USA it was adapted for use in several other countries. The system's purpose is the grouping of soil map units. Other characteristics of land, namely slope, climate and incidence of flooding are also taken into account.

The main concept used in the system is that of limitations, that is characteristics that affect land use unfavourably. Consideration is given to both permanent and temporary limitations. Permanent limitations are those limitations that cannot be changed by limited amelioration measures. They include, among other things, slope, soil depth and climate.

Temporary limitations are limitations that can be improved or eliminated by land management. They include low nutrient content and low degrees of wetness. The level of land management is accepted as the level that falls within the capability of the majority of farmers.

A system was developed for use in South Africa where land as well as soil can be placed in one of eight suitability classes, as shown in table 3.1.

The classification is based mainly on the system of the Soil Conservation Service of the USDA. The classes are arranged according to increasing limiting criteria.

In the case of the soil suitability classes, soil factors (effective depth, texture, internal drainage, mechanical limitations and other factors) and terrain factors (erosion danger and flooding) are used to describe the classes.

In the case of the land suitability classes, climatic factors are added to the soil and terrain factors to describe the land classes.

Class	General Description
Arable Land Suitability Classes	
I	Land has very few permanent limitations that restricts its use and has a very high potential for intensive crop production.
II	Land has some permanent limitations that reduce the degree of intensity of crop production but is nevertheless of high potential.
III	Land has severe permanent limitations that restrict the choice of alternative uses and the intensity of crop production.
IV	Land has very severe limitations that greatly restrict the choice of alternative uses and the potential for crop production.
Non-Arable Land Suitability Classes	
V	Land is unsuitable for the cultivation of annual crops, but has a slight erosion hazard under natural veld, established pastures, forestry or special crops (crops that give sufficient cover and maintains soil loss at acceptable level with special conservation measures).
VI	Land has permanent limitations that make it unsuited to cultivation and limits its use to natural grazing, veld re-enforcement, forestation or wildlife.
VII	Land has very severe permanent limitations that renders it unsuitable for cultivation or intensification and restricts its use to natural grazing, forestation or wildlife.
VIII	Land has permanent limitations that preclude its use for commercial plant production and restricts its use to wildlife, recreation, water supply or aesthetic needs.

Table 3.1: Land Suitability Classes for South Africa (Scotney et al, 1987)

Four agronomy classes and four grazing classes are used. From Class I and Class VIII production abilities decrease and danger of use and intensity of conservation techniques increase (Table 3.2). Suitability classes are divided into subclasses on the basis of the type of limitation or problem.

The same three categories as those used in the USDA system (Klingebiel & Montgomery, 1961) are also used here. A fourth category, namely the suitability order was, however added to accommodate use at reconnaissance level.

The suitability orders are:

- **Order A** – Arable land with high potential for a variety of crops and with few limitations is placed in this order (classes I & II).
- **Order B** – This too is arable land but here moderate to serious limitations occur (classes III & IV).
- **Order C** – This is non-arable land that is only suitable for pastoral or forestry purposes (classes V, VI & VII).
- **Order D** – This is not suitable for pastoral or forestry purposes (class VIII).

Order		Class	Wildlife	Grazing and Forestry	Crop Production	
					Moderate	Intensive
Arable	A	I	√	√	√	√
		II	√	√	√	√
	B	III	√	√	√	X
		IV	√	√	√	X
Non-arable	C	V	√	√	X	X
		VI	√	√	X	X
		VII	√	√	X	X
	D	VIII	√	X	X	X

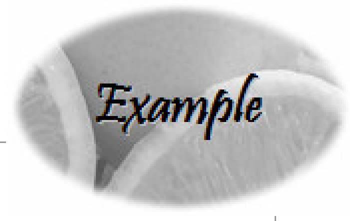
Table 3.2: Example of Recommended Land Use

In order to define suitability on a reconnaissance scale, one of two orders for land that is suitable for tillage and one of two orders for pastoral may be used. The criteria for the placement of soils, in other words without the influence of climate, and land, in other words soil and terrain along with the effect of climate, in one of the eight suitability classes are given in table 3.3 and it can also serve as key to place soils and land in suitability classes.

Soil Suitability Class	*Terrain Factors*		*Soil Factors*					*Climate Factors*	*Land Suitability Class*
	Erosion Hazard	*Flood Hazard*	*Effective Depth*	*Texture*	*Internal Drainage*	*Mechanical Limitations*	*Other Limitations*		
1	E1	F1	D1	T1	W1	M1	O1	C1	I
2	E2	F2	D2	T2	W2	M1	O2	C2	II
3	E3	F3	D3	T2	W3	M3	O3	C3	III
4	E4	F4	D4	T2	W4	M4	O4	C4	IV
5	E5	F5	D5	T3	W5	M5	O5	C5	V
6	E6	F5	D5	T3	W5	M6	O5	C6	VI
7	E7	F5	D5	T3	W5	M7	O5	C6	VII
8	E8	F5	D5	T3	W5	M8	O5	C6	VIII

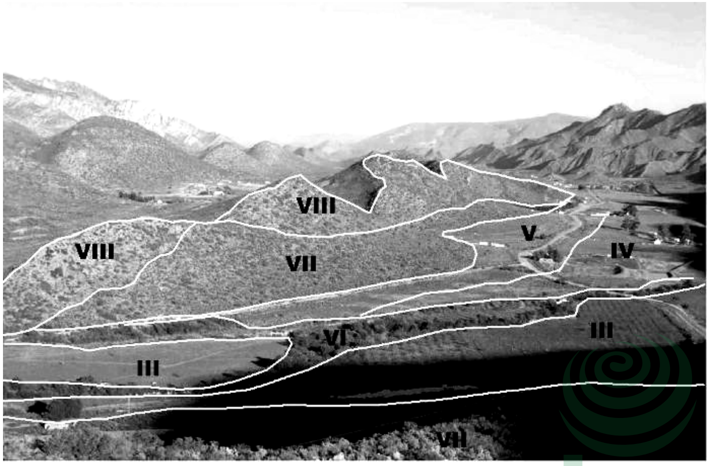
Table 3.3: Key for Different Factors Used to Place Land and Soil in Land Use Classes

In this approach the definitions of the eight soil and land suitability classes are more or less the same as those of the USDA system, with the exception of class V that does not only include level parts with little danger of erosion, but also areas where there are a danger of erosion, or stoniness or regular floods, in other words where permanent limitations exclude arable land. However, the criteria that were used to determine a suitability class differ from the USDA system.



Land Suitability – Montague Area

This is a landscape in the Montagu area in the Western Cape, described according to the RSA land suitability classification. Note that classes I and II are absent because of soil and climate limitations.



2.2. Productivity Indices

Several attempts have been made to develop a system by which a productivity index or rating can be provided by means of parametric methods. In these methods, the effect of individual land or soil characteristics is evaluated separately and then combined arithmetically. The combined effect of the individual factors has more of a multiplicative tendency than an additive tendency.

The disadvantages of systems of this type are their inflexibility and limited application. The reason is that such systems were developed for specific areas and purposes where the correlation between the productivity index and the return on a certain crop is very good. However, as soon as such a system is transferred unchanged to an area with a significantly different climate, the relationship disappears and the ratings must consequently be changed and adjusted considerably.

Harris & Hansen (1958) suggested an index system through which the effect of soil, water and climate on the productive capacity of land is easier to comprehend and also easier to evaluate.

A similar type of evaluation system is the so-called Storie index (Storie, 1976) that was developed to rate the value of agricultural soil for tax purposes and land zoning in the USA. However this system does not include management factors. The Storie index is obtained by giving a percentage rating to each determining factor (ideal condition is 100%) and multiplying them with one another. This is a simple quantified expression of soil productivity, that is, among other things, also dependent on the determining characteristics of the factors concerned, the values awarded to these and the validity of the expected interactions between each. The values that are awarded are subject to very subjective judgments but have already been tested over a long period under different conditions in the USA.

2.3. Global Initiatives

Working groups of the FAO (Food and Agricultural Organization of the United Nations) have since 1973 been busy formulating guidelines for land evaluation, especially for use in developing countries. The FAO's Land Evaluation Framework can be considered as a system that applies land suitability on a more general basis.

The principles and basic concepts, on which this system is based, are the following:

- Land suitability is investigated and classified according to a specific kind of use;
- The suitability classes are defined by economic criteria;
- A multidisciplinary approach is required;
- Evaluations take into account physical, economic, social and political aspects of environment;
- Suitability refers to the use of land on a sustainable basis; and
- Evaluations must include two or more alternative uses of land

3. Sustainable Land Use

Land use planning is the allocation of land for different uses according to criteria that are formulated during the land evaluation process. The scale of application can vary from very detailed planning, such as farm planning, to regional or national level planning, while the uses too are not limited to agriculture or forestry, but often also include economic, social and political dimensions. However, land use planning within the agricultural context also aims to protect the best agricultural soil.

During the last couple of years the computer has been used more and more in land use planning. The most important requirements for the use of computers in land use planning are that they should have access to:

- A Geographical Information System (GIS) that contains information of the area concerned regarding climate, land (including soil), land use, crop return, limitations, administrative data, etc.;
- A management database;
- Models that analyse physical land suitability under different technological conditions;
- Analytical aids for the evaluation of the suitability of alternative options to land use in order to achieve several socio-economical or environmental goals.

In order to make a reliable evaluation of the suitability, potential and production capacity of a land for a certain crop, it is essential that the requirements, adjustments and tolerances of crops with respect to soil and climatic conditions are known.

Unfortunately this is an area of study that does not receive the necessary attention because the cooperation of several disciplines is required. However, it is significant that the higher the production cost of an industry, the more the information that is available on the soil-climatic requirements of the crop. In this way, for example, the information on citrus and deciduous fruit is very good while it is fairly poor for small grains.

In planning a new planting or development, planning aids are available to assist potential growers to assess sites for a range of criteria. These aids include topographic maps that show contours, slope gradients and lengths, physical features, watercourses, etc. and aerial photo enlargements, in combination with matching transparent topographic map overlays.

Recommendations flowing from a suitability study should form the basis of a project plan which could greatly assist in handling the following:

- Slope and terrain
- Watercourse locations and identification of those to be retained/enhanced
- Infrastructure – roads, water supply, irrigation, etc.
- Proposed runoff and erosion control measures
- Row directions
- Windbreaks
- Retention of remnant vegetation

4. Sustainable Farming Practices

4.1. Land Clearing and Site Preparation

A range of regulations apply to clearing land prior to planting, including:

- Regional and municipal regulations regarding zoning
- Conservation of Agricultural Resources Act No 43 of 1983
- National Environmental Management Act No.107 of 1998

Timing is very important in planning clearing operations. In choosing the time of the year for clearing, it should be taken into account that choosing periods when rainfall is lower, minimises the risk of soil erosion and sedimentation. In addition, timing should allow for optimum seasonal conditions to allow ground cover establishment and growth on bare cleared areas. Where the method of clearing cannot retain a minimum of 70% ground cover, immediate seeding or fertilising of all disturbed areas to provide rapid vegetation should be carried out.

Watercourses should be left to grass or, if shaping or stabilisation is required, a grass cover must be re-established and maintained. Major watercourses, streams, creeks and rivers should have the riparian vegetation retained and enhanced.

The best time to construct inter-row drainage or ridges of tree rows is at the site preparation stage before the trees are planted.

4.2. Soil Degradation and Conservation

Soil degradation includes physical, chemical and / or biological deterioration. Examples are loss of organic matter, decline in soil fertility, decline in structural condition, erosion and increasing acidity.

A basic set of principles apply to minimising soil degradation and achieving erosion control in tree crops. Having appropriate soil tests taken will provide valuable information on the existing chemical status of the soil relative to both the original condition of the soil and to the nutritional requirements of the tree crop.

4.2.1. Organic Matter

Soil organic matter levels can be maintained or enhanced by fostering the establishment and growth of cover crops or ground covers, mulching all plant materials, reducing or eliminating cultivation and enhancing the chemical, physical and biological fertility of the soil.

4.2.2. Compaction

Deep tillage with suitable tined implements can break up compacted layers with minimal soil mixing or, if recommended by the soil scientists, the various layers and ameliorates mixed to form the required growth substrate for citrus trees.

4.2.3. Machinery Use

The frequency and weight of machinery moving over the soil should be reduced, especially those of wheel tractors which exerts ground pressure and may cause re-compaction of the topsoil layers.

4.2.4. Soil Erosion

To minimise soil erosion, maximum soil surface protection must be provided via pasture or mulch, the length of time that soil is left bare must be minimised, bare areas should be re-vegetated or mulched rapidly, and runoff water should be prevented from flowing over bare ground, by conveying runoff across the slope at designed intervals and down-slope via surveyed earth channels or banks discharging into natural water courses or constructed grassed waterways or by conveying water down-slope in the grassed or shaped inter-rows.

4.3. Water Quality Management

Growers should, like all land users in a water catchment area, be aware of and act on potential off-site effects of their operations. The two principal potential effects of horticulture on water quality exiting the property will be on suspended sediment and dissolved nutrients.

Soil conservation and runoff control strategies should be one of the basic considerations in planning orchard establishment. Inter-row drainage and ridging of the tree rows also reduce off-site loss of nutrients when the elevated tree row only is fertilised. A range of other measures can also reduce nutrient contamination of runoff water, being:

- Fertilise strictly according to the recommendations based on soil and leaf analyses.
- Base irrigation on the actual water requirement of the trees as determined through soil water and evaporation pan measurements.
- Avoid application of fertiliser prior to or during heavy rainfall.
- Avoid fertilising areas that carry runoff water, bare areas and near streams and watercourses other than for periodic ground cover enhancement.
- Maintain good ground cover around dams, water courses and streams.

4.4. Cover Crops and Ground Covers

Cover crops are annual and ground covers are perennial ground covering plants. Wisely selected cover crops or ground covers can provide organic matter, weed suppression, erosion control, increased water infiltration, nitrogen fixation as well as an improved micro-environment for establishing trees. Cover crops are also used in inter-row areas where they efficiently reduce the speed of run-off water after heavy rains to curb erosion.

4.5. Mulch

Mulch is any plant material used to cover the soil surface. It provides similar benefits to cover crops and ground covers without the competition to the trees. The application and / or accumulation of mulch are particularly appropriate in the shaded areas under trees in the tree row.

Soil temperature under mulch is lower than in uncovered soil. It is also used on heavy soils with high clay content where it will encourage higher concentration of micro-organisms and cause an increase in the earthworm population with a resultant improvement in soil texture.

Please note however that in the case of mulch, cover crops and ground covers, an expert should be consulted to select the correct plant or plant material to use. Some plants are attractive to citrus pests, and can cause an increase in the pest insect population in the orchard.

4.6. Orchard Floor Maintenance

Earthworks, such as inter-row drains, ridged tree rows or diversion banks, should be regularly checked to determine the need for repairs and maintenance. The nutritional status of the soil and trees, along with ground cover health and vigour, should be monitored on a regular basis. Any bare areas created by harvesting, vehicular traffic, erosion or other actions, should be promptly re-vegetated or have mulch applied.

5. Conclusion

Many opportunities exist in horticultural land use for conserving or restoring biodiversity in harmony with farming and rural living. Prior to clearing, plan to retain as much native vegetation as possible, particularly windbreaks, riparian areas, wildlife corridors, wet and steep areas.

Agricultural activities must accommodate conservation and enhancement as well as replanting and enhancing areas such as listed above.

Chapter 3

- Agricultural potential concerns only those factors and characteristics that must be taken into account agriculturally, including climate, soil, slope, vegetation and, at times, geographic location and the size of the unit.
- By land suitability or capability is meant the extent to which land provides in the needs of one or more uses under defined management conditions, climate included.
- Land suitability classification means the grouping of land into classes with the same suitability or capacity.
- The main concept used in suitability classification systems is that of limitations, that is characteristics that affect land use unfavourably.
- In the case of the soil suitability classes, soil factors (effective depth, texture, internal drainage, mechanical limitations and other factors) and terrain factors (erosion danger and flooding) are used to describe the classes.
- In the case of the land suitability classes, climatic factors are added to the soil and terrain factors to describe the land classes.
- Several attempts have been made to develop a system by which a productivity index or rating can be provided by means of parametric methods.
- Working groups of the FAO have since 1973 been busy formulating guidelines for land evaluation, especially for use in developing countries.
- Land use planning is the allocation of land for different uses according to criteria that are formulated during the land evaluation process.
- Sustainable farming practices pertain to land clearing and site preparation, soil degradation and conservation, water quality management, cover crops and ground covers, mulching, and orchard floor maintenance.
- Many opportunities exist in horticultural land use for conserving or restoring biodiversity in harmony with farming and rural living.

Complete activity 7 in the **Learner Workbook**.

Chapter 4

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

Putting new innovations in place to optimise the land use
Demonstrate the ability to monitor and maintain sustainability-based farm layout innovations that have been implemented in an agricultural environment as part of a land use plan.

1. Introduction

Soil erosion and land degradation problems are worsened by lack of planning, inadequate runoff control measures on cleared, bared, and cultivated areas, disturbed and eroded watercourses, poor road layout and design, and poor orchard layout. It is therefore important that all physical and geographical constraints of the area which is to be developed are identified in the suitability study and addressed in the subsequent planning phase. Physical and geographical constraints must include the following:

- Existing drainage patterns
- Slope and terrain components
- Soil types and associated constraints
- Incidence of surface and subsurface rock
- Vegetation and areas suitable for retention of windbreaks
- Any other limitations such as high water tables

The constraints should be addressed in a strategy which includes the complete farm with indications of how to handle future plantings to fit into the broader long term plan. Planning of each orchard then has to fit into the long term plan.

2. Anti-Erosion Measures

The layout of each orchard should be in harmony with the physiographical constraints identified, in particular with:

- **Drainage systems –** Identified natural watercourses need to be preserved as a drainage network for runoff water emanating from catchment areas. Drainage easements (right of way over other properties) should be negotiated. Retaining trees along natural watercourses can provide both windbreak and native habitat benefits.

- **Terrain and slope –** Ridge lines are preferable for location of major access roads with orchard layout designed around them where practical. Provision should be made in farm layout for drainage reserves to carry storm water emanating from the main road system identified on the plan.

2.1. Orchard Design and Layout

Before a suitable layout can be designed, a contour plan showing 1 meter contour intervals needs to be prepared. This detail is also necessary for irrigation design and the survey is carried out just prior or immediately after clearing operations is complete.

Although the design must accommodate measures to prevent erosion, the hydrological demands of the irrigation system, changes of soil type within the area to be planted, as well as linking with the water reticulation system and other infrastructural aspects, also has to be considered. This underlines the importance of drawing up a strategic plan for development of the complete farm where all these aspects can be included.

As far as erosion is concerned, it is important to consider the following design criteria:

- Tree row gradients should be 1-3%

- Grade maximum row length should be:
  - 1% 300 meters
  - 2% 225 meters
  - 3% 150 meters

- Row direction should preferably be north to south, but can be modified according to erosion risk. In citrus row direction is not very important.

- Orchard design should incorporate adequate control of storm water runoff using diversion banks, roads and waterways to safely convey runoff to the network of major watercourses retained for this purpose.

2.1.1. Diversion Banks and Waterways

Diversion banks are required to divert runoff to safe disposal areas where significant catchments exist above the orchard. In this situation they can sometimes be incorporated with roads. Diversion banks are also necessary where row lengths exceed design criteria.

Hydrologically designed waterways, based on a 1 in 20 year return period, should be planned to carry water discharging from ridged tree rows, diversion banks and road table drains and must safely down slope to major watercourses.

2.1.2. Roads

The primary engineering function of a road is to provide a surface giving good foot and wheel traction over a range of weather conditions. Usually this requires a relatively impermeable surface and a transverse crown, so that rainfall is shed, rather that absorbed, from the trafficking surface, as quickly as possible. Table drains, culverts and bridges isolate the road surface from water flows.

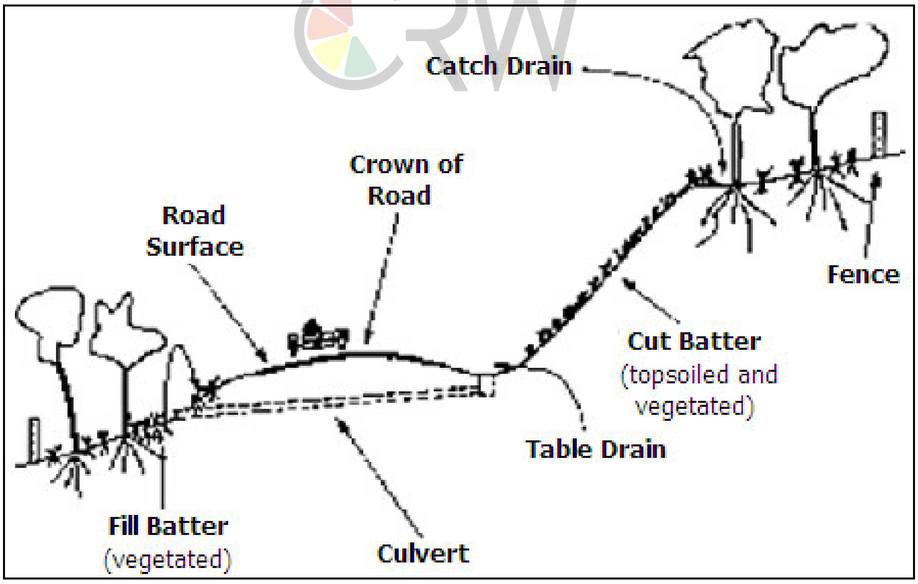


Figure 4.1: Cross-Section of Generalised Minor Road

Main roads should be located on ridgelines or at the top of slopes, as in midslope or footslope positions, so that they can catch and concentrate water flows that cause soil erosion. However, they may be used to divert water flows, provided table drains are designed with adequate hydrological capacity, adequate pipe drainage is incorporated and water is conveyed to a stable water disposal area (i.e. waterway or natural water course).

Minor access roads within the orchard can be designed in conjunction with waterways or should be located at the upslope end of tree rows. Wherever possible, minimise road grades and plan to drain runoff generated by roads to natural drainage lines via diversion banks or waterways.

If an existing road is a source of erosion and sedimentation problems, some or all of the following indicators will be visible:

- Turbidity in streams immediately downstream or of road run-off
- Table drains showing the presence of scour, V-shaped cross-section or undercut slopes
- Water discharge zones that have a heavy accumulation of sediments close to streams and drainage lines
- The receding slope might have a low level of vegetative cover, a presence of rill or sheet erosion or a presence of slumps
- The track surface condition shows an absence of crown or rilling, ruts, boggy patches, etc.

As part of maintenance, road condition should be monitored regularly. It is especially valuable to observe the road during rainfall.

2.1.3. Maintenance

Continuing maintenance (grading, drain cleaning) is essential – once every six months in hard setting soils and once every three months in loose soils and areas with a build up of leaf material. Poor maintenance can compromise good design. Vigilant maintenance means:

- Proper disposal of cleared material
- Keeping all planned drains operating
- Keeping the road crown effective
- Avoiding the development of earth windrows
- No V-shaped clearing of table drains
- Keeping drains broad bottomed to reduce velocity of run-off
- Not cutting into the toe of batters
- Avoid damaging discharge areas

2.1.4. Sequence and Timing

The sequence and timing of operations, as stated in the previous chapter, plays a big role in curbing erosion with the establishment of an orchard. Many on ground operations take place at times of the year when the risk of erosion is high. Factors which will effect planning and establishment of an orchard are the following:

- Winter or summer rainfall area
- Meso-climate of the immediate environment
- Replanting or new orchard
- Size of the planting
- Extent of anti-erosion construction work to be done
- Type of soil preparation for planting
- Irrigation reticulation and system.

Working back from the intended date of planting, all the above factors will play a role in the planning process and in the eventual success and sustainability of the development.

It is evident from the above that not only good planning, but also ongoing awareness of the dangers of erosion and ongoing maintenance of all areas and structures where it could occur should be part of a management culture in farming enterprises.

2.2. Soil Management Strategies

The planning of a soil management strategy on a farm will be aimed at optimal development and maintenance of the orchards for maximum yield of a high percentage marketable fruit. Actions will therefore be focussed on the following:

- Plant nutrition
- Irrigation
- Weed control
- Maintenance of orchard environment

2.2.1. Plant Nutrition

At soil preparation before planting ameliorates such as lime, phosphate and potassium must be applied and mixed with the soil to adjust the soil acidity and levels of individual elements for optimum growth of the trees. In managing the development of the newly planted orchard, small amounts of recommended nutrients should be applied regularly by hand or through the irrigation system, and the effect thereof monitored by regular weekly inspection of growth and tree development.

This should be supported by spray application of micro elements as recommended. Yearly leaf analysis to establish the nutritional status of the trees has to be done to monitor the effects of the applied fertilisers. In the case of bearing trees, the nutrient status of orchards is monitored through regular soil analysis (at least every three years) and yearly leaf analysis. In conjunction, the general tree condition and yield is used to determine the nutritional needs and used for the yearly fertiliser recommendation.

Application of the fertilisers has to be monitored to ensure that the correct amounts are applied at the right time. Ensure that the supervisors and workers know why the different fertilisers are applied and what the effects of mismanagement will be.

2.2.2. Irrigation

Proper management of irrigation is crucial to achieve good results. It is a determining factor of orchard development and is discussed in greater detail in the next section.

2.2.3. Weed Control

Weeds compete with the trees for fertilisers and water. It is therefore important to control weeds within the tree row at least one meter to each side of young trees and under the drip area of bearing trees. The weeds between rows are normally controlled physically by mowing. Chemical control – by applying low concentrations of herbicides to stunt growth of the weeds – is also used.

2.2.4. Maintenance of the Orchard Environment

This includes the following:

- Vehicular traffic in and around orchards should be limited to only the necessary activities. Wheel tractors cause soil compaction in the inter-row areas which can limit tree development in young plantings.

- Elimination of dust by watering the orchard roads. Dust from gravel roads settling on trees and fruit hampers insect control, especially scale insects, affect tree growth and reduce export percentage with dirty fruit delivered to the packhouse. Soil-borne pathogens that cause significant postharvest decay and losses can spread to healthy fruit through dust.

- Earthworks such as inter-row drains, ridged tree rows or diversion banks should be placed on a maintenance schedule to be checked regularly for necessary repairs and maintenance.
- Watercourses should be kept clean and free of unwanted weeds and trees, which could hamper water flow in the rainy season.

3. Water Management Strategies

Agriculture is one of the main users of water in South Africa. Water is becoming a scarce and sought after commodity and pressure on water users to utilise this commodity cautiously with minimal waste is increasing. It is therefore prudent to examine all practices and structures which influence its use carefully and make adjustments wherever necessary.

The quality of water has become a matter of concern and all water used for crop irrigation has to be tested regularly to ensure that it is clean and conforms to the required quality standards for fruit production.

3.1. Water Sources

The sources of irrigation water on a farm are rain, rivers, boreholes and canals from irrigation schemes.

Most farms have dams and, depending on the catchment areas feeding the dams, rain can form a small or large source of irrigation water. The dams could be replenished with water from drainage systems, normal runoff or storm water. In all these cases the catchment and flow areas should be managed to ensure that minimal sediment is transported to the dams, which implies good erosion measures above the dams.

Water from rivers normally has to be pumped to dams or directly into the irrigation system. In the latter case water will have to be filtered if used in micro- or drip irrigation systems. Water from boreholes can be of varying quality. It has to be tested prior to the development of the orchard to determine its suitability and regularly thereafter. The water level of the boreholes must also be monitored on an ongoing basis to ensure that it is not over-exploited.

Water from canals in irrigation schemes are either discharged into dams or pumped directly into irrigation systems. This water can also vary in quality and has to be monitored and tested regularly, and filtered if used in micro and drip irrigation systems.

3.2. Storage

Storage can be in farm dams, in which a large supply for future use can be built up, or in small holding dams, in which only an allocation for a specific period is held and which are replenished regularly. Water is drawn by means of a supply outlet valve installed at construction or pumped across the top of the dam wall, which is referred to as top draw. The latter is preferred when the water in the dam contains a lot of sediment.

Maintenance of dam walls is very important and should form part of the maintenance program of the farm. Trees developing from seeds germinating on the wall have to be removed at an early stage as it may weaken the wall. Rodent and ant nests normally occur on the lee side of the walls and have to be destroyed and the holes repaired. Ground cover plants have to be established on the lee side to prevent erosion.

3.3. Planning

When developing an orchard or a farm, the total volume of water required by the farm for irrigation must be considered. It is advisable to rather plan around the lower volume available during summer than bargaining on high rainfall during the wet season. Insufficient supply of irrigation water impacts on crop volume as well as fruit size and severely affects income.

Cost of water supply to and in orchards is high, especially in the case of sprinkler and micro systems. Location of orchards in relation to the power supply and water reticulation systems is an important factor in determining total capital required for development. It is prudent to consider the cost of getting water to the land when weighing up options of where to plant on the property.

4. Water Supply Management

Water supply management implies all the actions to move the irrigation water from the source to the irrigation system in the orchard. It includes management and maintenance of all structures and equipment like sluices, feeder canals, dam valves, motors, pumps, filters and supply pipelines to the side of the orchard. Water is becoming scarcer and more expensive and pumping costs higher.

4.1. Irrigation Systems

The one factor in citrus production which has the greatest influence and is also the most neglected is irrigation. Irrigation comprises three aspects, namely engineering, horticultural and soil science components. Irrigation systems can basically be divided into three types, namely:

- Flood irrigation
- Sprinkler systems
- Micro-irrigation systems

4.1.1. Flood Irrigation

Flood irrigation includes those systems by which water is flooded over a given surface of ground to water it. Examples are bed, furrow, basin and short-furrow irrigation systems.

As indicated by the names, water is diverted into a bed, furrow or basin. The most important advantages are the low energy and capital costs, as well as the fact that the plant itself does not get wet, which reduces the occurrence of leaf and fruit diseases. However, great water losses can occur if the system is not well designed and maintained. This system is also quite labour intensive.

4.1.2. Sprinkler Systems

Sprinkler systems, on the other hand, spread the water above the ground by means of sprinklers. Sprinkler systems can be divided into permanent and movable systems. With permanent systems, the pipes are left in the same position for the entire irrigation season. With movable systems, on the other hand, the pipes or sprayers, normally with quick-coupling pipes, draglines and canon sprayers, can be moved.

Although permanent systems are more expensive than movable systems, they are not as sensitive to wind and damage as movable ones. Also, moving a system around damages crops and is labour intensive.

4.1.3. Micro-Irrigation Systems

Micro-irrigation systems can be divided into drip and micro-jet systems. These systems differ from sprinkler systems in that the water is regularly applied close to the plant roots in small quantities. With micro-irrigation systems it is essential to install reliable filters to prevent the sprayers from becoming clogged.

4.2. System Design and Installation

The choice of an irrigation system for a specific case is often difficult, because the various systems each have a wide field of application. Many factors play a role, for instance the crop, water quality, soil type, the slope of the land, number of labourers available and the amount of money the farmer is able to spend. An expert in the field of irrigation must be consulted before purchasing an irrigation system.

The design of the system must be such that the required volume of water is applied to the right place and at the right time to fulfil plant needs at all times during the growth cycle. In order to apply irrigation effectively it is necessary to measure the requirements of the orchard which is difficult as the climate, soil and stage of the growth cycle of the tree all influences the amount of water required.

When a system has been decided on and bought, its installation is very important. Underground pipelines must be laid at a sufficient depth for them not to be damaged by soil cultivation practices. It is also very important to lay the pipes according to the plans and specifications of the manufacturers. Drain-cocks must be out of the way and painted in bright colours so that they will not be run over. It is also advisable to place permanent markers at suitable places on top of the ground to indicate the position of the underground pipelines.

4.3. Scheduling

There are various methods of measuring plant needs which can be used to determine the irrigation schedule. Each farming unit is different and the choice of scheduling is normally left to the grower.

Scheduling for newly planted trees is very difficult. The root system is limited and water is drawn from a very small volume of soil. For the first six months a general programme should therefore be followed which is based on observations of the area, soil type and takes into account the time of the year.

Scheduling for mature orchards involves replacement of water used by the crop plant and lost during the preceding period.

Water is lost through evaporation, run-off, leaching and transpiration. Transpiration is however coupled positively to production and should not really be regarded as a loss. Evaporation is largely determined by climatic factors, such as radiation, temperature, humidity and wind. Run-off is determined by infiltration rate, slope and application rate and should not occur during irrigation.

Leaching occurs particularly where water penetrates readily to below the root zone. A degree of leaching is necessary to prevent the accumulation of salts in the root zone. Mature trees planted to 250 to 400 trees per hectare require between 7,000 and 10,000 cubic meters of water per hectare per year for effective leaching. It is therefore important that the limited water resources are utilised effectively.

4.4. Maintenance

The maintenance of an irrigation system is also important because it is designed to last for as long as the crop is cultivated. Below is an example of a fairly comprehensive irrigation maintenance plan, which also includes essential monitoring actions.

Example

Irrigation Maintenance Plan

Frequency	***Item***	***Task and Action***
Daily	Block pressures	Check that block pressures are within prescribed limits.
	Emitter operation	Check for clogged, broken or misplaced emitters. Repair, replace, unclog or reposition emitters.
	Leaks	Check for leaks in pipes and other equipment and other water wastage, and repair if found.
	Primary filter	Flush primary filters as prescribed.
	Fertigation application	Check that fertigation applications are within specifications.
Weekly	Lateral lines	Flush lateral lines as prescribed.
	Secondary filters	Flush secondary filters as prescribed
	System pressure and flow	Check that system pressure and flow are as per irrigation design plan.
	Pump operation	Check that pump operation is within prescribed parameters.
	Block pressures for automated valves	Check that block pressures are as prescribed where automated valves are used.
	Pump oil levels	Check pump oil levels as prescribed.
	Fertigation plant	Inspect fertigation plant.
Monthly	Valves, water meters, and gauges	Visually check valves, water meters and gauges and look for damage and / or vandalism.
	Filters	Open and inspect filters as prescribed.
	Pump pipe work	Check for leaks at pump pipe work through which water is lost and for leaks through which the pump can suck air.
	Pump motor	Grease pump motor as prescribed.
	Coefficient of Uniformity (CU) tests	Perform CU tests
Annually	Valves	Service valves and physically check correct operation.
	Filters	Thoroughly clean filters. Replace sand in sand filters.
	Pump	Change oil in pump.
	Water sampling	Take a water sample at the end of lateral lines and send it for analysis.
2-10 years	Pump	Replace bearings and other wearing parts, such as bearings, on pump and motor every 5 years.
	Hydraulic valves	Replace diaphragms on hydraulic valves every 3 years.
	Poly-pipe and emitters	Replace poly-pipe and emitters every 7 to 10 years.

Summary

Chapter 4

- Soil erosion and land degradation problems are worsened by lack of planning, inadequate runoff control measures on cleared, bared, and cultivated areas, disturbed and eroded watercourses, poor road layout and design, and poor orchard layout.
- The layout of each orchard should be in harmony with the physiographical constraints identified, in particular with the drainage systems and terrain and slope.
- As far as erosion is concerned when it comes to orchard design and layout, it is important to consider tree row gradients, maximum row length, row direction, and adequate control of storm water runoff.
- Diversion banks are required to divert runoff to safe disposal areas where significant catchments exist above the orchard.
- The primary engineering function of a road is to provide a surface giving good foot and wheel traction over a range of weather conditions.
- Continuing road maintenance (grading, drain cleaning) is essential – once every six months in hard setting soils and once every three months in loose soils and areas with a build up of leaf material.
- The planning of a soil management strategy on a farm will be aimed at optimal development and maintenance of the orchards for maximum yield of a high percentage marketable fruit, and should include plant nutrition, irrigation, weed control, and maintenance of the orchard environment.
- The sources of irrigation water on a farm are rain, rivers, boreholes and canals from irrigation schemes.
- Storage can be in farm dams, in which a large supply for future use can be built up, or in small holding dams, in which only an allocation for a specific period is held and which are replenished regularly.
- When developing an orchard or a farm, the total volume of water required by the farm for irrigation must be considered.
- Water supply management implies all the actions to move the irrigation water from the source to the irrigation system in the orchard.
- Irrigation systems can basically be divided into three types, namely flood irrigation, sprinkler systems, and micro-irrigation systems.
- The choice of an irrigation system for a specific case is often difficult, because the various systems each have a wide field of application.
- There are various methods of measuring plant needs which can be used to determine the irrigation schedule.
- The maintenance of an irrigation system is also important because it is designed to last for as long as the crop is cultivated.

Practical

Complete activity 8 in the **Learner Workbook**.

Chapter 5

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

Compare and evaluate infrastructural factors affecting requirements.
Organise and plan infrastructure maintenance tasks related to the natural resource base of a farm, including the supervision of other workers.

1. Introduction

Infrastructure plays an important role in ensuring the efficiency and profitability of processes on a farm. Insufficient or poorly maintained infrastructure can slow processes down and ultimately affect productivity and therefore profitability on a farm.

In the learning material on Enterprise Selection, Planning and Establishment levels 2 and 3, the development of infrastructure and the maintenance of buildings, roads, power supply and other physical structures are discussed. In this section, we look at the infrastructural needs as far as the protection of natural resources, such as soil and water, and the administrative system is concerned.

The specific enterprise that is practiced on a farm or production area effects the infrastructural requirements of the farm. Looking at citrus production specifically, structures such as dams, retaining walls and diversion banks that are put in place to protect natural resources must be maintained and their condition carefully monitored.

2. Functioning of Infrastructure

The different infrastructure elements have different purposes and therefore function in different ways. It is however necessary to put procedures in place to monitor the functioning of the various elements so that changes to its functioning can be made when necessary.

Testing and monitoring the quality of natural resources, such as water and soil, indentifies potential problem areas with infrastructure and highlight areas where improvement are necessary. Once problem areas have been identified, records must be collected and data captured to facilitate the decision making process and to determine if any infrastructural changes are required. If changes are made to infrastructure, such as the constructing of new runoffs or a diversion bank to lessen erosion, the result of these changes must be monitored and their effectiveness recorded.

Any changes to infrastructure must be approved by local and national authorities according to legal stipulations. Other regulations that must be considered when planning changes to infrastructure are Good Agricultural Practice or other independent accreditation system stipulations. Maintenance and monitoring plans must be amended to include changes made to infrastructure. If new structures are put in place staff must be trained to ensure effective maintenance and monitoring of the structures.

3. Maintenance and Evaluation of Infrastructure

To ensure the effectiveness of infrastructure, structures must be maintained and evaluated on a regular basis. Maintenance schedules must be developed and implemented to ensure that resource protection structures are kept in a good order. Thorough evaluation procedures must form part of the maintenance strategy. Checklists monitoring the state of structures must be designed and completed as part of the maintenance plan.

Processes such as administrative duties must be evaluated on a regular basis to ensure effectiveness and to determine where systems can be improved.

4. Maintenance Duties

4.1. Tools and Equipment

As the layout and design of farms and production areas differ, tools and equipment necessary for maintenance also differs. When designing the maintenance plan tools and equipment necessary to complete maintenance tasks must be identified. Tools and equipment must always be available and in good working order to ensure effective maintenance. It is important that maintenance tools and equipment are placed on the general equipment maintenance plan to ensure that these tools are also maintained and kept in optimum condition.

4.2. Maintenance Responsibilities

Depending on the size of the farm or production area and the enterprises practiced on the farm, maintenance teams might be either permanently appointed or general labourers might be used when other duties on the farm allows it. Best practice is the permanent appointment of infrastructural maintenance teams that are given the responsibility of ensuring that the good condition of structures is maintained. Maintenance of infrastructure is an important facet of ensuring the sustainability of any farming operation and must be a priority for any producer.

The responsibility of completing records and evaluation checklist to show that maintenance tasks have been completed rests with the maintenance team supervisor. The maintenance team supervisor must be well trained and must be fully aware of the impact that poor maintenance can have on the profitability and sustainability of farming operations.

4.3. Monitoring Maintenance Tasks

Keeping records and completing checklist while performing maintenance and evaluation tasks is the only effective way of monitoring the process. Records must be completed by the maintenance team supervisor and analysed by the farm manager. Records and checklists must be monitored and the data on them captured to compile information concerning the state of infrastructure on the farm.

4.4. Fault Reporting

A fault reporting system must form part of the maintenance recordkeeping process. A system where faults can be reported by employees that is not part of the maintenance team must also be developed and implemented. Proof that an effective fault reporting system is in place and that faults that have been reported are dealt with adequately is a requirement of most accreditation schemes.

Chapter 5

- Several factors influence the development of infrastructure, such as the enterprise practiced on the farm and the physiographical features of the farm.
- New infrastructure must be developed in accordance with legal and other regulations and requirements.
- New structures must be included in maintenance plans and other recordkeeping systems.
- Maintenance team must be appointed and made responsible for the implementation of maintenance plans and strategies.
- The maintenance team supervisor is responsible for the monitoring and recordkeeping of the maintenance program.
- A systematic and effective fault reporting procedure must be developed and implemented.

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

Chapter 6

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

Evaluate and adjust required stock.

1. Introduction

The aim of stock control is to minimise the cost of holding stocks while ensuring that there are enough materials for production to continue and meet customer demand. In the case of a farm, the 'customers' in most instances are the production and maintenance departments. Obtaining the correct balance is not easy and the department dealing with stock control and purchasing has to work closely with the user departments.

2. Stock Levels

It is the responsibility of whoever deals with purchasing to order the correct quantity and quality of the input materials at a competitive price and from a reliable supplier who will deliver on time. As it is difficult to ensure that a business has exactly the correct amount of stock at any one time, the majority of farms will hold buffer stock. This is the 'safe' amount of stock that needs to be held to cover unforeseen rises in demand or problems of reordering supplies.

The decision of how much stock to keep depends on the nature and the size of the business, as well as the effect a stock shortage of a specific item can have on production, quality and supply of the product. It also depends on the location of the farm in relation to the supplier in question and whether stock is available at short notice.

Good stock management lowers costs, improves efficiency and ensures that the right input materials are available when required. But poor stock control can lead to problems associated with overstocking or stock shortages.

If too much buffer stock is kept, or the level of demand for materials is overestimated, the farm will overstock. Money spent on buying unnecessary stock could have been better spent elsewhere. Overstocking also increases storage space needed and can increase insurance and security costs. Overstocking may also lead to more stocks becoming damaged or obsolete, because it is kept longer before being used.

The scenario at the other end of the scale is when the farm runs out of stock which is necessary for a specific activity. A stock shortage can have severe consequences, such as loss of production. If production practices cannot be applied at the right time because of stock not being available, it can compromise the quality of the fruit, leading to a potential loss of sales and damage to the reputation of the business in the market.

3. Stock Control Systems

A stock control system is used to keep track of current stock levels, showing how much stock you have at any one time. A stock control system must include every item kept on the farm, from raw materials to finished goods. Stock control must cover stock at every stage of the production process, from purchase and delivery to the use and re-ordering of stock.

Efficient stock control allows for the right amount of stock in the right place at the right time. It ensures that capital is not tied up unnecessarily, and protects production if problems arise with the supply chain.

It also allows for ongoing evaluation of deficiencies in stock and is based on the following:

- A good stock control system, whether it be manual or computerised
- Knowledge of all stock items, quantities and when it must be available
- Value of the various items
- Importance of each item to production with effect of stock shortages on potential income

This is important in a seasonal enterprise like citrus farming where the various items may be required at different times of the year and in varying quantities. Examples are fertilisers, spray materials and picking equipment that are only used at certain time of the production cycle. Maintenance items like oil filters for tractors, light bulbs and consumables, such as stationery, has to be monitored throughout and purchased as required.

The cost of the stock and its effect on cash flow has to be monitored on an ongoing basis. Production materials like fertilisers and spray materials are expensive and management may have to make special arrangements for payment. Stock management is therefore an important aspect in sustainable farming.

There are a number of stock control systems, all involving making an inventory, or list, of stock and noting its location and value. Depending on the type and importance of the stock item, evaluation of the level of each item can be done on a daily, weekly, monthly or yearly basis.

Any stock control system must be able to track stock levels, indentify when to order stock and keep track of issued stock. It also helps if the stock control system can record what stock is on order and when it should be delivered.

3.1. Stock Books

The simplest manual stock control system is the stock book, which suits small businesses with few stock items. It enables one to keep a log of stock received and stock issued. A stock book can be used alongside a manual re-ordering system. For example, the two-bin system works by having two containers of stock items. When one is empty and the second bin is being used, new stock must be ordered to fill up the empty bin.

3.2. Stock Cards

Using stock cards allows for a more complex stock control systems. Each type of stock has an associated card, with information about the item captured on a card such as:

- Description
- Value
- Location
- Re-order levels, quantities and lead times
- Supplier details
- Information about past stock history

More sophisticated manual systems incorporate coding to classify items.

3.3. Computerised Systems

Computerised systems generally meet all the requirements for a stock control system, and although initially expensive, provides the required information on an ongoing basis and can generate re-order items with all relevant data on request.

The correct capturing of data by well trained staff, regular system maintenance and keeping electronic backup information in a safe and secure place are prerequisites to ensure the effectiveness of these systems.

The size of the enterprise will determine the type of system to use.

4. Adjusting Stock Shortages

When a stock shortage occurs, the first reaction should be to secure the required items in the shortest possible time. To this end, it is very helpful to have a list of suppliers per stock item on hand, that includes the contact details, physical location, payment terms, etc. of the supplier. This will allow the stock controller to address the stock shortage without delay.

Depending on how critical the stock item is, management may take a decision to increase the buffer stock level for the item after a stock shortage occurred, or to change the re-ordering process in some way to prevent future shortages. There are advantages and disadvantages to increasing stock levels.

Advantages are that it enables one to meet sudden changes in demand, there are less chance of loss in production, and the farm is able to take advantage of bulk buying economies of scale. Disadvantages include the cost of storing more items, having capital tied up in stocks and not available elsewhere, and large stocks subject to deterioration and theft.

Chapter 6

- The aim of stock control is to minimise the cost of holding stocks while ensuring that there are enough materials for production to continue and meet customer demand.
- As it is difficult to ensure that a business has exactly the correct amount of stock at any one time, the majority of farms will hold buffer stock.
- The decision of how much stock to keep depends on the nature and the size of the business, as well as the effect a stock shortage of a specific item can have on production, quality and supply of the product.
- A stock control system is used to keep track of current stock levels, showing how much stock you have at any one time.
- Any stock control system must be able to track stock levels, indentify when to order stock and keep track of issued stock.
- When a stock shortage occurs, the first reaction should be to secure the required items in the shortest possible time.
- Depending on how critical the stock item is, management may take a decision to increase the buffer stock level for the item after a stock shortage occurred, or to change the re-ordering process in some way to prevent future shortages.

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

Chapter 7

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

Evaluate and adjust harvest procedures as required.

1. Introduction

Harvest procedures have to be evaluated on a historical basis as well as during the harvesting season in order to enable management to make the necessary adjustments to ensure a successful outcome. This can only be done if the process is monitored and all relevant details recorded throughout the harvesting season. The harvesting principles, as set out in the previous module, must form the basis of such an evaluation. The principles of harvesting are:

- Budget, plan and forecast
- Do not harvest before the crop has reached the required minimum standards
- Adhere to specific instructions during harvest to maintain optimum food safety and crop quality and to withholding periods for agrochemical applications
- Maintain health and safety of workers during harvest
- Manage costs, equipment and staff to maximise profit

Adherence to the above principles should be evaluated during and immediately after the harvesting season to provide enough time for both minor and major adjustments. Major adjustments in many instances dictate capital investment or changes to labour management, which in turn may involve intensive training of both management and other employees. In contrast, minor adjustments normally involve small actions to ensure smooth running of the process, but will in the end contribute substantially to success.

2. Health and Hygiene Procedures

A hygiene risk analysis encompassing, amongst others, harvesting procedures, should be carried out prior to, during and after harvesting. All identified actions should be communicated to all persons involved in the harvesting process through training, and must be strictly enforced by supervisors and management. All such actions must be documented and monitored throughout. The following applies:

- Only healthy people must be involved in the harvesting process. All workers must undergo a medical examination before appointment and their health monitored throughout the harvesting period. All results of such examinations must be recorded and filed.
- Workers must have access to clean toilets and hand washing facilities in the vicinity of their work area. Enough facilities must be available and must be cleaned and maintained throughout. Cleaning and maintenance of facilities should be recorded and monitored on a regular basis.
- Training in hygiene and personal cleanliness during harvest should be assessed and adjusted if found to be ineffective.
- Cleanliness, condition and care of protective clothing must be monitored and brought to the attention of the workers on a weekly basis.

- All subcontractors and visitors must be aware of the relevant demands on personal hygiene. They should acknowledge that it was brought to their attention by signing a document.

- A person trained in first aid must be available whenever on-farm activities are carried out. Training must be done on a yearly basis, the stock in the first aid box replenished regularly and all workers must know to whom and where to go for first aid.

- Treatment and the worker involved must be recorded throughout.

- The accident and emergency procedures must be clearly understood by all workers.

Workers must be made aware of the possible dangers to their health and safety during the harvesting process, and training around handling and maintenance of picking equipment must be revised during the postharvest assessment. Management must ensure that all involved in supervision are sensitised on an ongoing basis to apply the measures as well as monitor the understanding of the workforce of such measures by questioning a sample of the workers on a regular basis.

Health and hygiene regulations are amended regularly, and it may be difficult for the individual farmer to keep abreast of developments in this field. It is important to have access to a human resources practitioner who will monitor the field continuously and give feedback to the farming enterprise of any changes. It is important to discuss the matter with such person on at least a yearly basis. Implementation of changes will depend on the nature of the change and whether it implies training or just informing the involved persons.

Worker health and safety is prescribed and regulated by the Occupational Health and Safety Act. The act prescribes what employers should do to create a safe working environment for workers and how workers should adhere to the health and safety policies and procedures in the workplace. The requirements of the Act were described in detail in previous modules.

The Occupational Health and Safety Act of 1993 (OHSA) provides for the health and safety of persons at work and when using plant and machinery. It also provides for protection of persons other than those at work against hazards to health and safety arising out of activities of persons at work.

2.1. Employers

According to the OHSA, employers have the basic duty towards employees to provide and maintain a working environment that is safe and without risk to the health of the employees. The matters to which these duties refer include the following:

- Providing and maintaining systems of work, plant and machinery that are safe and without risk to health. This dictates a rigid and ongoing maintenance program which must be documented and monitored on an hourly, daily, weekly and monthly basis depending on the type of equipment involved. The quality of the maintenance program must also be assessed regularly.

- Taking steps to eliminate or diminish any hazard or potential hazard to the safety or health of employees.

- Identifying the hazards to the health or safety of persons attached to any work which is performed, and devising and applying any necessary precautionary measures.

- Providing such information, instruction, training and supervision as may be necessary to ensure the health and safety of his employees.

- Not permitting any employee to do any work unless the precautionary measures which may be prescribed have been taken.

- Ensuring that the work is performed under the general supervision of a person trained to understand the hazards associated with it and who has the authority to ensure that the precautionary measures taken by the employer are enforced.

The above necessitates evaluation of all systems, plant and equipment at all times according to a scheduled, enforced and monitored system in a culture driven by management.

2.2. Employees

Employees also have a responsibility under the OHSA, as follows:

- Taking reasonable care for the health and safety of himself / herself and of other persons who may be affected by his or her acts or omissions.
- Cooperating with his or her supervisor to comply with any health and safety measures.
- Carrying out any lawful order given to him or her in the interest of health and safety.
- If any unsafe or unhealthy situation comes to his or her attention, reporting it as soon as possible to the supervisor and or employer.
- If he or she is involved in any accident which may affect his or her health, reporting the incident as soon as possible.
- Cooperating with safety committees whenever required.

Reaction of employees to their responsibility will, to a large extent, depend on the relationship with their supervisor. It is therefore important that all supervisors as well as management be well trained in building and handling relationships.

3. Evaluating Quality

Quality standards of fruit delivered to markets vary between countries, and within countries, and were established in response to market preferences. Various market outlets within specific countries, e.g. chain stores, have developed their own sets of quality standards and packing requirements.

Apart from the above, the South African Government, in cooperation with the citrus industry, developed a set of minimum standards to which fruit for both export and local markets must conform. Fruit inspection services have been established at packhouses, markets and harbours to ensure that the fruit conforms to the required standards.

Inspection of the final product merely confirms compliance with standards. It does not produce quality. That can only be achieved by applying quality management throughout the production process in the orchard and packhouse.

Markets and individual fruit outlets have lately insisted that fruit be produced according to a set of requirements, or Good Agricultural Practices as set out in, for instance, GlobalGAP. This introduced the concept of traceability whereby the history of a fruit sold on a market could be traced back to its origin and where proof of all the production processes involved should be available and recorded.

External or internal fruit quality can be compromised during production, harvesting, packing, transport and cold storage, and in the market.

3.1. Production

Imbalances in nutrition, over- or under-irrigation, and trees that are planted too close together resulting in too little light penetration are factors which can cause poor internal quality and non-conformance with quality standards.

It could also lead to poor rind development, which may cause fruit splitting and the development of decay in the packed fruit. Skin blemishes caused by wind or insects, such as thrips or bollworm, detract from the external appearance of the fruit and lead to a low pack-out percentage and loss of income.

3.2. Harvesting

At harvesting, supervision and precautions should be adequate to manage the critical aspects in preventing the development of oleocellosis and rind pitting and other postharvest diseases and conditions. Oleocellosis and rind pitting are rejection factors and are caused by rupturing of oil glands through rough handling and transport under conditions of high humidity or if the fruit are too turgid at picking.

At each trailer or bin which is being filled by pickers, a checker must be designated to check for long stems, injuries, plugging and that the bags are properly filled and do not contain rotten fruit. The harvesting process and quality of supervision of each picking team must be monitored regularly by conforming compliance with the aspects listed in a harvesting checklist. It is suggested that this be done by personnel not involved with harvesting and that it be done at random.

Harvesting defects can also be monitored at the packhouse, together with a cull analysis, and the information should be fed back to the picking supervisors regularly. Analysis of cull factors provides information on the extent and nature of external quality defects, presence of phytosanitary pests and the decay potential arising from mechanical and insect damage to the fruit. The only external cull factors considered serious enough to render the product 'non-conforming' are the presence of phytosanitary pests such as fruit fly and false codling moth and developing factors such as oleocellosis.

Internal quality checks should also be done on an ongoing basis on fruit from each orchard, using fruit of different counts to ensure that fruit of all sizes comply with the relevant standards.

In summary, among the factors which have to be managed at harvesting for good results are the following:

- Internal quality must confirm to the required standards and be carefully monitored before picking.
- External colour development of the skin must be sufficient for immediate packing or for colouring up in de-greening chambers.
- Fruit must not be picked when wet or in conditions of high humidity as it may cause oleocellosis.
- The equipment used for picking must be in good condition and not cause injuries to the fruit.
- Supervisors and pickers must be well trained with regard to all aspects of the picking process like health and hygiene standards and careful handling of the fruit.
- Transport to the packhouse must be done with care as not to cause damage to the fruit. Factors that require attention include dust on the roads, high speeds during transport, pressure of tractor, and trailer tyres.

3.3. Packing

Factors that have to be carefully managed and monitored after arrival of the fruit at the packhouse and during packing are:

- Ideally fruit should be drenched with chlorinated water on arrival or in the water dump when fed into the packhouse.

- If fruit is washed under high pressure water nozzles the water should also be chlorinated and the pressure and condition of the nozzles be monitored as not to cause harm to the fruit.
- Chemical treatment prior to packing must be well monitored and the allowed chemicals applied at the correct concentrations.
- Machinery and feed belts in the packhouse must be fruit-friendly with no sharp edges or points which may damage the fruit.
- Supervisors and packers must be well trained and monitored.
- Size grading must be correct.
- Packed cartons must be handled carefully before and during palletising.

3.4. Transportation and Handling of Packed Fruit

The process after packing also has to be managed carefully to ensure that fruit of the required standard is delivered at the retail outlet to the customer.

- The time between picking and placement of the packed fruit in cold storage should be as short as possible.
- The fruit should be brought down to the required temperature for shipment as soon as possible.
- Temperatures before and during shipment must be monitored to ensure that there are no large temperature changes.
- Fruit should not be allowed to heat up between discharge and cold storage at the market.
- Storage time between discharge and actual selling should be within the limits laid down in the fruit handling protocols and in general be as short as possible.

Adjusting practices that have an influence on fruit quality cannot be done without monitoring and recording all actions between picking and the point of sale. This must be done in such a way that it is possible to make adjustments at any time during the season, and contribute to a post-mortem immediately after the season.

It is very important to have sufficient information available to evaluate all actions after the season to determine if anything went wrong and what adjustments have to be made before the next season. Possible adjustments are:

- Nutrition to adjust nutrient imbalances.
- Irrigation systems to ensure proper water supply to the trees.
- Training of supervisors, pickers, packers and other workers in handling and other production practices.
- Acquiring new or the improvement of maintenance of current machinery and equipment to improve harvesting.
- Changes to the packhouse.

Most, if not all, of the adjustments require capital inputs and therefore have to be handled in the budgetary process of farm management. All changes will have time limits attached and have to be well managed to ensure that it has the required result.

The changes therefore have to be well planned and enough time has to be allocated for supply of materials and execution. In many instances outside expertise and contractors have to be employed to ensure correct and cost effective changes and the work therefore has to fit into their schedules. Proper planning and coordination with such outside parties is essential.

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- Harvest procedures have to be evaluated on a historical basis as well as during the harvesting season in order to enable management to make the necessary adjustments to ensure a successful outcome.
- A hygiene risk analysis encompassing, amongst others, harvesting procedures, should be carried out prior to, during and after harvesting.
- Workers must be made aware of the possible dangers to their health and safety during the harvesting process, and training around handling and maintenance of picking equipment must be revised during the postharvest assessment.
- Implementation of changes in health and hygiene regulations will depend on the nature of the change and whether it implies training or just informing the involved persons.
- The Occupational Health and Safety Act of 1993 (OHSA) provides for the health and safety of persons at work and when using plant and machinery.
- The act specifies regulations that employees and employers must comply with.
- The quality of fruit must be evaluated on a regular basis to ensure that fruit complies with minimum standards of different markets.
- Shortcomings in quality must be identified and the reason investigated.
- Where necessary production, packing, transport or handling practices must be adjusted to ensure better quality fruit.
- Any adjustments made to practices must be monitored and recorded to ensure their effectiveness.

Complete activity 12 in the **Learner Workbook**.

Chapter 8

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

Compare and integrate the postharvest factors.

1. Introduction

It is important to bear in mind that after picking, fruit quality cannot be improved but only maintained or, if not handled well, decreased. A lot of money has been spent on the production of the fruit up to this stage and this money should not be wasted now. Careful postharvest treatment is essential to minimise injuries to fruit and therefore preserve shelf-life.

2. Good Postharvest Practices

Trained, fulltime supervisors should be designated to all picking teams to make sure that the correct harvesting techniques are used and that the fruit is handled carefully. On arrival at the packhouse, managements' responsibility is to add value to the crop by washing, treating, sorting and packing fruit to yield quality products which meet the requirements of the market. Attributes including freedom of decay, shelf-life and presentation are determined to a large extent by the effectiveness of the packhouse operation.

An important requirement for the effective operation from picking through to the packhouse is that the responsibility, authority and interrelation of personnel who manage, perform and verify work affecting quality, must be clearly defined. This implies that the management and organisational structure and job functions are documented and communicated to all personnel. This is important to personnel who need the organisational freedom and authority to:

- Initiate actions to prevent the occurrence of any nonconformity relating to product, process and quality systems;
- Identify and record any problems relating to product, process and quality system;
- Initiate, recommend or provide solutions through designated channels;
- Verify the implications of solutions;
- Control further processing or delivery of nonconforming product until the deficiency or unsatisfactory condition has been corrected.

3. Evaluating and Adjusting Postharvest Practices

In the packhouse, spot checks must be done to ensure that all equipment is in a good working order and sound condition to prevent injury to fruit. This is very important on the packhouse lines, especially after the fruit has been waxed, as the wax tends to build up on corners to form sharp points that can injure the fruit. These areas must be cleaned regularly.

Thorough application of postharvest fungicides is very important and the concentration of the fungicide must be monitored regularly throughout each packing day. All the above monitoring processes must be recorded, checked by the supervisory staff on an hourly basis and filed for future reference in the case of a query.

4. Postharvest Health and Safety

A hygiene and food safety risk analysis encompassing farming practices should be carried out prior to the packing season. Postharvest hygiene risks must be identified during this analysis. All identified actions should be communicated to all persons involved in the harvesting process through training, and must be strictly enforced by supervisors and management. All such actions must be documented and monitored throughout. The following are the most common postharvest hygiene risks:

- Only healthy people must be involved in the packing process.
- Workers must have access to clean toilets and hand washing facilities in the vicinity of their work area.
- Basic verbal and written instructions in hygiene must be given before handling fruit, including personal cleanliness, washing of hands after meals and ablutions, wearing of jewellery, fingernail-length and personal behaviour.
- Workers must be made aware of the importance of wearing and caring of protective clothing.
- All subcontractors and visitors must be aware of the relevant demands on personal hygiene.
- A trained person in first aid must be available whenever on-farm activities are carried out.
- The accident and emergency procedures must be clearly understood by all workers.

The employer must ensure that the workers have all the tools and equipment that they require to perform their tasks, and that the tools and equipment is in a good working condition. The employer must furthermore ensure that workers are well-trained for the tasks that they have been given, and that they are given clear instructions on what is expected from them. Developing and enforcing health and safety policies and procedures are also the responsibility of the employer.

A handy system for performing a risk analysis and for implementing health and safety management is to use the following steps:

- Hazard analysis
- Identifying critical control points
- Establishing critical limits
- Monitoring implementation
- Measuring outcomes

4.1. Hazard Analysis

The implementation of postharvest practices has to be based on a hazard analysis. A hazard analysis and identification of associated control measures may identify needed modifications to a process or product so that product safety is further assured or improved, and it provides a basis for determining critical control points.

The process of conducting a hazard analysis involves two stages. The first, hazard identification, can be regarded as a brain storming session. During this stage the team reviews all the actions during the process as well as the equipment used and the final result required. Based on this review, a list is developed of potential biological, chemical or physical hazards which may be introduced, increased or controlled at each step in the postharvest process.

After the list of potential hazards is assembled the hazard evaluation is conducted. Each potential hazard is evaluated based on the severity of the potential hazard and its likely occurrence. Considerations of severity can be helpful the potential health impact of the hazard. Consideration of the likely occurrence is usually based on experience and information in technical literature. The potential consequences if the hazard is not properly controlled and the effects of poor control should form an important in considering impact of the hazard.

4.2. Identifying Critical Control Points

Critical control points (CCPs) in monitoring the process are then established and are located at any step where hazards can either prevented, eliminated or reduced to acceptable levels.

4.3. Establishing Critical Limits

The next step is to establish critical limits for each critical control point. It is a maximum and / or minimum value to which a biological, chemical or physical parameter must be controlled at a CCP to prevent, eliminate or reduce to an acceptable level the occurrence of a safety hazard. A critical limit is therefore used to distinguish between safe and unsafe operating conditions at a critical control point.

Where there is a deviation from established critical limits, corrective actions should include determining and correcting the cause of non-compliance and recording the corrective actions that have been taken

4.4. Monitoring Implementation

Success of implementing all types of regulations and legislation lies in establishing proper monitoring procedures. Monitoring is a planned sequence of observations or measurements to assess whether a CCP is under control and to produce an accurate record for future use in verification. Monitoring serves three purposes:

- It is essential to safety management in that it facilitates tracking of the operation.
- It is used to determine when there is loss of control and a deviation occurs at a CCP, i.e. exceeding or not meeting a critical limit.
- It provides written documentation for use in verification.

Personnel who monitor CCPs are often associated with production and quality control. Those individuals must be trained in the monitoring technique for which they are responsible, fully understand the purpose and importance of monitoring, be unbiased and accurately report the results of monitoring. In addition, employees should be trained in procedures to follow when there is a trend towards loss of control so that timely adjustments can be made to assure that the process remains under control.

The person responsible for monitoring must also immediately report an action, process or product which does not meet critical limits. When it is not possible to monitor a CCP on a continuous basis, it is necessary to establish a monitoring frequency and procedure that will be reliable enough to indicate that the CCP is under control. All records and documents associated with monitoring should be dated and signed or initialled by the person doing the monitoring.

4.5. Measuring Outcomes

The outcomes determined through a thorough hazard analysis and applied in the packhouse should include the following:

- The hygiene procedure determined in the risk analysis will be implemented and all the workers would be fully informed.
- Workers will have access to clean toilets and hand washing facilities in the vicinity of their work and would have received and implementing basic instructions in hygiene before handling produce.
- Water used in the facility will be declared suitable for use by a competent authority and be monitored throughout the process.

- All postharvest treatments will executed as prescribed with only products which have been formally approved.
- All chemicals will be stored in secure and clean areas and handled by trained individuals without causing risk to their or others' health and safety.
- All workers operating dangerous or complex equipment would have received training and clear instructions on handling the equipment.
- There will be at least one person trained in first aid present in the working environment and his whereabouts will be known to all the workers.
- Clear accident and emergency measures will exist.
- All hazards will be clearly identified by warning signs.
- All workers who are in contact with pre- and postharvest chemicals will be submitted to annual voluntary health checks.
- All workers will be equipped with suitable protective clothing which is regularly cleaned after use.
- A member of management is assigned and clearly identified as person responsible for worker health, safety and welfare issues.

Application of health, safety and welfare issues should be a culture on any farm and packhouse handling citrus for local and export markets.

Chapter 8

- Careful postharvest treatment is essential to minimise injuries to fruit and therefore preserve shelf-life.
- Attributes including freedom of decay, shelf-life and presentation are determined to a large extent by the effectiveness of the packhouse operation.
- In the packhouse, spot checks must be done to ensure that all equipment is in a good working order and sound condition to prevent injury to fruit.
- A hygiene and food safety risk analysis encompassing farming practices should be carried out prior to the packing season.
- A handy system for performing a risk analysis and for implementing health and safety management is to do a hazard analysis, identify critical control points, establish critical limits, monitor implementation, and measure outcomes.
- A hazard analysis and identification of associated control measures may identify needed modifications to a process or product so that product safety is further assured or improved, and it provides a basis for determining critical control points.
- Critical control points (CCPs) in monitoring the process are then established and are located at any step where hazards can either prevented, eliminated or reduced to acceptable levels.
- The next step is to establish critical limits for each critical control point.
- Monitoring is a planned sequence of observations or measurements to assess whether a CCP is under control and to produce an accurate record for future use in verification.
- Application of health, safety and welfare issues should be a culture on any farm and packhouse handling citrus for local and export markets.

Practical

Complete activity 13 in the **Learner Workbook**.

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