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LEARNER GUIDE

Crop Farming

Table of Contents

Welcome

Welcome to Learning Unit: Crop Farming of the Further Education and Training National Certificate in Mixed Farming Systems. This is an NQF registered qualification 48977 level 2. This qualification is for any individual who is, or wishes to be involved in the Agricultural industry and serves to support and advance the functioning of individuals in this industry – specifically for the following occupations:

- Farmers
- Farm managers

Chapter 1

Enterprise Selection, Soil Fertility and Plant Nutrition

In this session we explore the following concepts:

- Soil
- Water
- Climate
- Indigenous vegetation
- Topography
- Infrastructure
- Stock required for the enterprise
- Production cycles
- Harvest practices
- Health and Hygiene principles
- Quality standards
- Post-harvest practices
- Minerals in soil health
- Nutritional deficiencies

INTRODUCTION

Each commodity that is grown or produced has its own requirements in terms of inputs. It is important to understand the commodity with which you intend to work; needs and outputs, cyclic and seasonal events. The farmer must understand these factors in order to select the most appropriate enterprise for the local conditions.

Background

All plants and domestic livestock are adapted to their areas of origin and their production cycles are maintained without man's interference. However, a farmer optimises production by applying effective production practices. Production management, together with the selection of superior varieties, species and plant improvement, can be seen as an on-going effort to influence the natural tendencies of the commodity.

Consumers want the produce of their choice to be available at all times. Produce should look good, be unblemished, well-coloured (superior exterior quality), taste good (high interior quality) and be of the right size. At the same time, the farmer wants production areas that will provide high yields over a period of time. In addition to this, the production area must be managed in such a way that production practices have the least possible impact on the natural environment.

Placement and layout

The placement and layout of a production area is determined by the commodity to be farmed; for example, citrus trees are planted in rows in orchards with a specific planting distance, also called tree spacing or escapement, between rows and between trees. The spacing is determined by numerous factors including climate, variety, soil type, etc.

Definition:

Yield: The amount of produce that can be harvested from a production area in terms of weight and/or volume per hectare/plant.

Lifespan

Each commodity has a specific lifespan. Obviously annual crops and some domestic livestock have a lifespan of a few months and there is an annual planting / production cycle. The average economic

lifespan of a commercial citrus orchard varies between 18 and 30 years, and the average cow will be productive for approximately 10 years. These would be viewed as long term production commodities. In order to be profitable, the commodity should produce high yields of quality harvests every year and do this consistently over a long period of time.

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

Phenology

Definition:

Phenology refers to regularly recurring biological phenomena and the environmental and climatic factors that influence them.

Understanding the Phenology of the commodity is essential to understand the reasoning behind many of the practices and actions employed in the production of a specific commodity. For example, the timing of fertiliser applications is linked to the phenology of the commodity, with most fertilisers being applied at appropriate times to optimise the development of the part of the plant to be harvested (fruit/seeds/leaves/roots).

NATURAL RESOURCES REQUIRED FOR THE SELECTION OF AN ENTERPRISE

Any farming enterprise is a business which has to be planned very carefully for it to succeed. In order to do so the farmer must begin with the end in mind. S/he should consider what has to be achieved, or delivered to the market, to result in a profitable outcome. The starting point should therefore be to consider who is going to buy the produce. This would enable the farmer to select a product for which there is the greatest demand. However, not all commodities can be grown successfully in any area. Production should be matched with local climatic conditions and natural resources.

Thus, an enterprise is selected based on a range of information:

- ✓ What commodities *can* be produced in an area, and
- ✓ For which of these commodities is there the highest demand.

Definition:

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.

Natural resources in the farming environment include:

- Soil
- Water
- Climate
- Indigenous vegetation
- Landscape and topography

SOIL

Soil is the result of the soil formation processes as a result of local environmental factors (rain, temperature). Soil types differ from one place on the surface of the earth to the other, as the result of the differences in both environmental factors and the nature of the parent rock material.

Soil potential

Definition:

Soil potential refers to the ability of the soil to support plant growth and produce a good quality crop.

Soil potential is important to agriculture. The soil potential determines the type of crop that can be grown in a specific soil, and the volume and quality of crops that can be produced.

Soil potential is judged by the following criteria:

Soil fertility
Availability of soil water (for plant absorption)
Soil permeability

These criteria are all influenced by the soil characteristics, specifically soil texture. Soil fertility and plant available water is especially affected by the texture of the subsoil and topsoil, while soil permeability is affected mostly by the texture of the topsoil.

Soil Fertility

Definition:

Soil fertility refers to the nutrient content of the soil and its resultant ability of the soil to sustain plant growth.

Plants absorb sunlight, oxygen and carbon dioxide from the air, and water and nutrients from the soil. Soil fertility is the amount of food that the soil contains for the plants.

Plants need seventeen elements for normal growth. They are:

- ***Carbon***, ***hydrogen*** and ***oxygen***, which come from air and water.
- ***Nitrogen*** as the major essential nutrient element, and also a major plant constituent. Although the atmosphere is 78% nitrogen, it is not directly available for plant use from the air. In plant production, nitrogen is taken up from the soil.
- The ***other thirteen essential nutrient elements*** are iron, sodium, calcium, phosphorous, potassium, copper, sulphur, magnesium, manganese, zinc, boron, chloride, and molybdenum. These elements come from the soil.

In normal circumstances, the nutrients naturally available to plants from the soil vary with clay content – the higher the clay content, the higher the soil fertility, but the fewer nutrients are available to the plant.

Soil water holding ability

The water holding capacity determines the amount of water that is available for water, and which can be stored to provide for the water requirement of plants in the periods between rains and irrigation applications.

The soil infiltration rate plays an important role in the amount of water that is available to the plant.

Definition:

Soil infiltration rate: The rate at which water is able to infiltrate the soil.

There is a considerable variation in the capacity of soils to store water and release it for plant use. In some clay soils, water holding capacity may be as high as 25mm water per 100mm soil, whereas it can be as low as 6mm per 100mm soil in sandy soils.

Although clay soils can store more water than sandy soils, the water may not be available to the plants during periods of fast growth. Sandy soils retain less moisture, but the water is more readily available to plants.

The water absorption capacity of a soil must be taken into consideration at all times when preparing land for planting or planning an irrigation system.

Definition:

Irrigation is an artificial application of water to the soil. It is usually used to assist the growing of crops in dry areas and during periods of inadequate rainfall. With irrigation you give the correct amount of water on the correct time.

IRRIGATION SYSTEMS

Irrigation is an artificial application of water to the soil. It is used to assist in the growing of agricultural crops, maintenance of landscapes, and revegetation of disturbed soils in dry areas and during periods of inadequate rainfall. Additionally, irrigation also has a few other uses in crop production, which include protecting plants against frost, suppressing weed growing in grain fields[2] and helping in preventing soil consolidation. In contrast, agriculture that relies only on direct rainfall is referred to as rain-fed or dryland farming. Irrigation systems are also used for dust suppression, disposal of sewage, and in mining. Irrigation is often studied together with drainage, which is the natural or artificial removal of surface and sub-surface water from a given area.

TYPES OF IRRIGATION

Basin flood irrigation of wheat.

Various types of irrigation techniques differ in how the water obtained from the source is distributed within the field. In general, the goal is to supply the entire field uniformly with water, so that each plant has the amount of water it needs, neither too much nor too little. The modern methods are efficient enough to achieve this goal.

SURFACE IRRIGATION

In surface irrigation systems, water moves over and across the land by simple gravity flow in order to wet it and to infiltrate into the soil. Surface irrigation can be subdivided into furrow, borderstrip or basin irrigation. It is often called **flood irrigation** when the irrigation results in flooding or near flooding of the cultivated land. Historically, this has been the most common method of irrigating agricultural land.

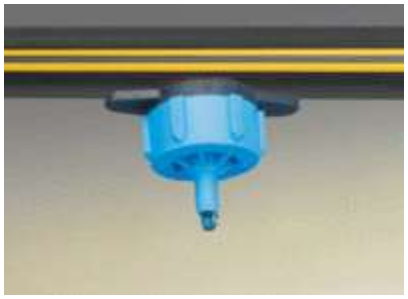
Where water levels from the irrigation source permit, the levels are controlled by dikes, usually plugged by soil. This is often seen in terraced rice fields (rice paddies), where the method is used to flood or control the level of water in each distinct field. In some cases, the water is pumped, or lifted by human or animal power to the level of the land.

LOCALIZED IRRIGATION

Brass Impact type sprinkler head

Localized irrigation is a system where water is distributed under low pressure through a piped network, in a pre-determined pattern, and applied as a small discharge to each plant or adjacent to it. Drip irrigation, spray or micro-sprinkler irrigation and bubbler irrigation belong to this category of irrigation methods.

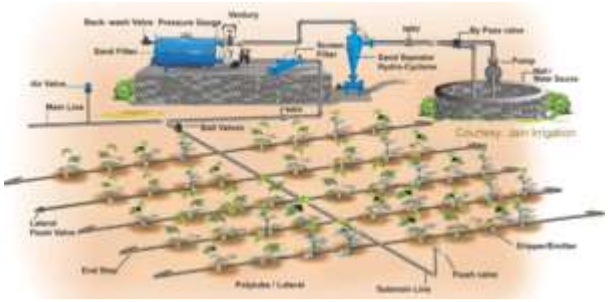
DRIP IRRIGATION



Drip Irrigation - A dripper in action

Grapes in a very dry area, just possible in this semi arid area due to drip irrigation.

Drip irrigation, also known as trickle irrigation, functions as its name suggests. Water is delivered at or near the root zone of plants, drop by drop. This method can be the most water-efficient method of irrigation, if managed properly, since evaporation and runoff are minimized. In modern agriculture, drip irrigation is often combined with plastic mulch, further reducing evaporation, and is also the means of delivery of fertilizer. The process is known as *fertigation*.



Drip Irrigation Layout and its parts

Deep percolation, where water moves below the root zone, can occur if a drip system is operated for too long of a duration or if the delivery rate is too high. Drip irrigation methods range from very high-tech and computerized to low-tech and labour-intensive. Lower water pressures are usually

needed than for most other types of systems, with the exception of low energy centre pivot systems and surface irrigation systems, and the system can be designed for uniformity throughout a field or for precise water delivery to individual plants in a landscape containing a mix of plant species. Although it is difficult to regulate pressure on steep slopes, pressure compensating emitters are available, so the field does not have to be level. High-tech solutions involve precisely calibrated emitters located along lines of tubing that extend from a computerized set of valves. Both pressure regulation and filtration to remove particles are important. The tubes are usually black (or buried under soil or mulch) to prevent the growth of algae and to protect the polyethylene from degradation due to ultraviolet light. But drip irrigation can also be as low-tech as a porous clay vessel sunk into the soil and occasionally filled from a hose or bucket. Subsurface drip irrigation has been used successfully on lawns, but it is more expensive than a more traditional sprinkler system. Surface drip systems are not cost-effective (or aesthetically pleasing) for lawns and golf courses. In the past one of the main disadvantages of the subsurface drip irrigation (SDI) systems, when used for turf, was the fact of having to install the plastic lines very close to each other in the ground, therefore disrupting the turfgrass area. Recent technology developments on drip installers places the line underground and covers the slit leaving no soil exposed.

SPRINKLER IRRIGATION

Sprinkler irrigation

In sprinkler or overhead irrigation, water is piped to one or more central locations within the field and distributed by overhead high-pressure sprinklers or guns. A system utilizing sprinklers, sprays, or guns mounted overhead on permanently installed risers is often referred to as a *solid-set* irrigation system. Higher pressure sprinklers that rotate are called *rotors* and are driven by a ball drive, gear drive, or impact mechanism. Rotors can be designed to rotate in a full or partial circle. Guns are similar to rotors, except that they generally operate at very high pressures of 40 to 130 lbf/in² (275 to 900 kPa) and flows of 50 to 1200 US gal/min (3 to 76 L/s), usually with nozzle diameters in the range of 0.5 to 1.9 inches (10 to 50 mm). Guns are used not only for irrigation, but also for industrial applications such as dust suppression and logging.

A traveling sprinkler

Sprinklers can also be mounted on moving platforms connected to the water source by a hose. Automatically moving wheeled systems known as *traveling sprinklers* may irrigate areas such as small farms, sports fields, parks, pastures, and cemeteries unattended. Most of these utilize a length of polyethylene tubing wound on a steel drum. As the tubing is wound on the drum powered by the irrigation water or a small gas engine, the sprinkler is pulled across the field. When the sprinkler arrives back at the reel the system shuts off. This type of system is known to most people as a "waterreel" traveling irrigation sprinkler and they are used extensively for dust suppression, irrigation, and land application of wastewater. Other travellers use a flat rubber hose that is dragged along behind while the sprinkler platform is pulled by a cable. These cable-type travellers are definitely old technology and their use is limited in today's modern irrigation projects.

CENTER PIVOT IRRIGATION

A small centre pivot system from beginning to end

The hub of a centre-pivot irrigation system.

Rotator style pivot applicator sprinkler.

Centre pivot irrigation is a form of sprinkler irrigation consisting of several segments of pipe (usually galvanized steel or aluminium) joined together and supported by trusses, mounted on wheeled towers with sprinklers positioned along its length. The system moves in a circular pattern and is fed with water from the pivot point at the centre of the arc. These systems are found and used in all parts of the nation and allow irrigation of all types of terrain. Newer irrigations have drops as shown in the image that follows.

Centre pivot with drop sprinklers.

Wheel line irrigation system

LATERAL MOVE (SIDE ROLL, WHEEL LINE) IRRIGATION

A series of pipes, each with a wheel of about 1.5 m diameter permanently affixed to its midpoint and sprinklers along its length, are coupled together at one edge of a field. Water is supplied at one end using a large hose. After sufficient water has been applied, the hose is removed, and the remaining assembly rotated either by hand or with a purpose-built mechanism, so that the sprinklers move 10 m across the field. The hose is reconnected. The process is repeated until the opposite edge of the field is reached. This system is less expensive to install than a centre pivot, but much more labour intensive to operate, and it is limited in the amount of water it can carry. Most systems utilize 4 or 5-inch (130 mm) diameter aluminium pipe. One feature of a lateral move system is that it consists of sections that can be easily disconnected. They are most often used for small or oddly shaped fields, such as those found in hilly or mountainous regions, or in regions where labour is inexpensive.

SUB-IRRIGATION

Sub irrigation also sometimes called *seepage irrigation* has been used for many years in field crops in areas with high water tables. It is a method of artificially raising the water table to allow the soil to be moistened from below the plants' root zone. Often those systems are located on permanent grasslands in lowlands or river valleys and combined with drainage infrastructure. A system of pumping stations, canals, weirs and gates allows it to increase or decrease the water level in a network of ditches and thereby control the water table.

Sub-irrigation is also used in commercial greenhouse production, usually for potted plants. Water is delivered from below, absorbed upwards, and the excess collected for recycling. Typically, a solution of water and nutrients floods a container or flows through a trough for a short period of time, 10–20 minutes, and is then pumped back into a holding tank for reuse. Sub-irrigation in greenhouses requires fairly sophisticated, expensive equipment and management. Advantages are water and nutrient conservation, and labour-saving through lowered system maintenance and automation. It is similar in principle and action to subsurface drip irrigation.

MANUAL IRRIGATION USING BUCKETS OR WATERING CANS

These systems have low requirements for infrastructure and technical equipment but need high labor inputs. Irrigation using watering cans is to be found for example in peri-urban agriculture around large cities in some African countries.

- ***Automatic, non-electric irrigation using buckets and ropes***

  Besides the common manual watering by bucket, an automated, natural version of this also exist. Using plain polyester ropes combined with a prepared ground mixture can be used to water plants from a vessel filled with water.

  The ground mixture would need to be made depending on the plant itself, yet would mostly consist of black potting soil, vermiculite and perlite. This system would (with certain crops) allow to save expenses as it does not consume any electricity and only little water (unlike sprinklers, water timers, ...). However, it may only be used with certain crops (probably mostly larger crops that do not need a humid environment; perhaps e.g. paprikas).

- ***Irrigation using water condensed from humid air***

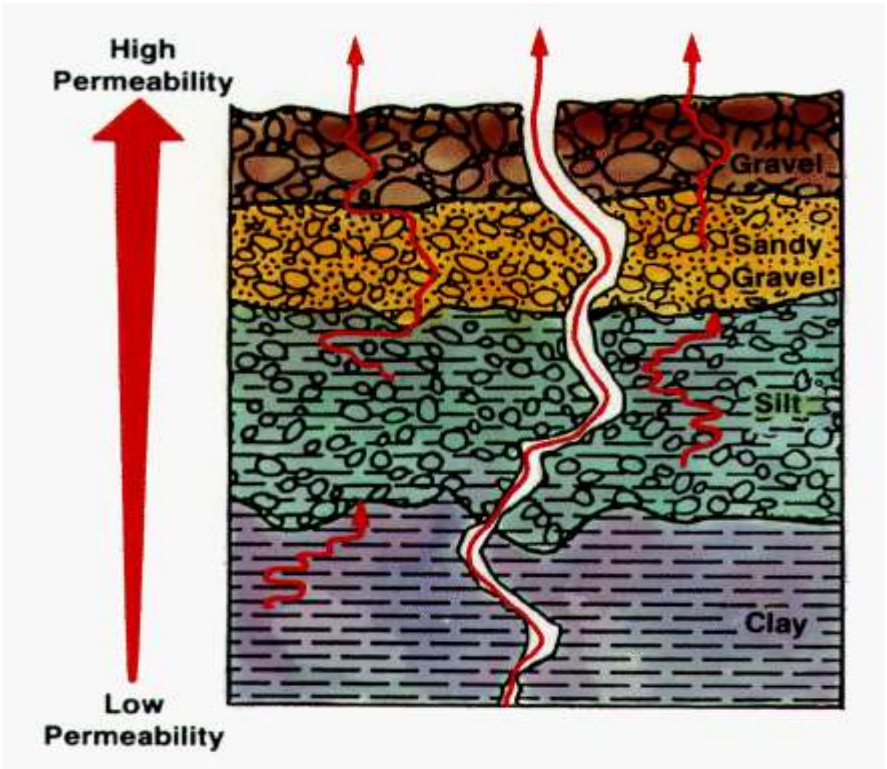
  In countries where at night, humid air sweeps the countryside, water can be obtained from the humid air by condensation onto cold surfaces.

Soil Permeability

The ease with which air, water and roots can penetrate soils is determined by the number and size of the open spaces, or pores, in the soil. Clay soils have a large number of pores, but they are very small. Such soils do not allow air, water or roots to move freely through it. Sandy soils on the other hand have less but larger pores, and air and water movement is much quicker.

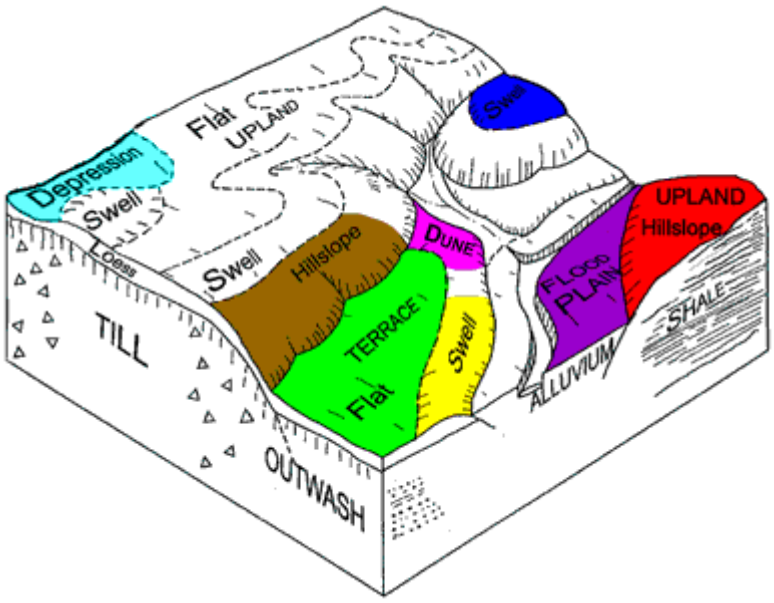
As a result, the infiltration rate of water varies between soil types. The infiltration rate in sandy soils is relatively fast and could cause difficulty in ensuring even distribution with irrigation. The density of clay soils on the other hand impedes water penetration. Water movement within the soil is also closely related to the soil structure.


Permeability Coefficients
2.00E-07
1.50E-07
1.00E-07
5.00E-08
0.00E+00
"Un-Suitible" Soil
"Suitable Soil"
"Un-Suitable" soil treated with Top-Seal


High Permeability
Low Permeability
Gravel
Sandy Gravel
Silt
Clay

Example of a slope:

Example of land surface shape:



Example of land surface gradient:

Soil Erosion

Cultivation has a marked effect on soils. In its natural state in any natural environment, soil is covered and protected by natural vegetation. Removing the natural vegetation, through cultivation for crop production or any other use, results in irreversible changes to the soil. Utmost care must be taken in any such action that all the possible dangers are considered. Over-cultivation can destroy the topsoil structure, impeding movement of air, water and roots with a resultant decrease in soil potential. The dangers of cultivation vary, with sandy soils being more sensitive than clay soils.

Soil erosion occurs when soil is removed through the action of wind and water at a greater rate than it is formed, and is often the result of farming practices that expose open soil to the elements, because it does not take into consideration that the soil can be washed or blown away and.

When a raindrop hits the soil that is not protected by a cover of vegetation and where there are no roots to bind the soil, it has the impact of a bullet. Soil particles are loosened and washed away. The topsoil is removed first. The topsoil is the nutrient-rich layer and, when it is gone, the production potential of the soil decreases severely.

Various factors determine soil erodibility, of which the most important are slope, soil texture, soil structure, terrain position, organic material, and vegetation cover. Silt and fine sand soils, with their smaller particle sizes, are normally the most prone to erosion.

Example of soil erosion:

THE PROPERTIES AND STRUCTURE OF SOIL

THE IMPORTANCE OF SOIL IN CROP PRODUCTION

The ability of plant roots to grow, take up nutrients and water, and "breathe" is influenced by the physical and chemical properties of the soil. It is therefore essential that these properties are well understood.

In most cases, the soil available for crop cultivation is not ideal. This means the farmer has to correct or improve on these soil conditions.

In almost all cultivation practices, plants require soil to grow in. Plants need soil for four main purposes, they are:

- Stay Upright – Plant roots anchor the plant in the soil. This means that the roots must be able to penetrate the soil sufficiently to enable the plant to be anchored.

- Nutrient Absorption – Plants take up, or absorb, nutrients from the soil through their roots. Plants can also absorb nutrients through their leaves, or foliage, but most often they use their roots.

- Water Absorption– Plants absorb water through their roots from the soil.

- Absorption of Oxygen (Air) – The roots of a plant, like the rest of the plant above the soil, has to absorb the air that the roots need for metabolic processes.

SOIL STRUCTURE AND SOIL TEXTURE

Soil properties can be divided into two groups, namely physical soil properties and chemical properties.

- **Physical Soil Properties**

  The physical properties of soil are to a great extent fixed and cannot easily be changed in the short term. These properties play a vital role in the sustainable productivity of soils. The physical properties can be evaluated visually.

  The most important physical properties of soils are:

  - Texture.
  - Structure.
  - Depth.
  - Layering or stratification.
  - Aeration.

Soil texture is generally determined in a laboratory but can be estimated fairly accurately in the field. To do the field, estimate the following:

- Take about 50g soil;
- Add water to wet the soil;
- Knead the soil into a thick paste;
- Roll the soil between the palms of your hands into a sausage; and

- Shape the soil "sausage" into a circle.

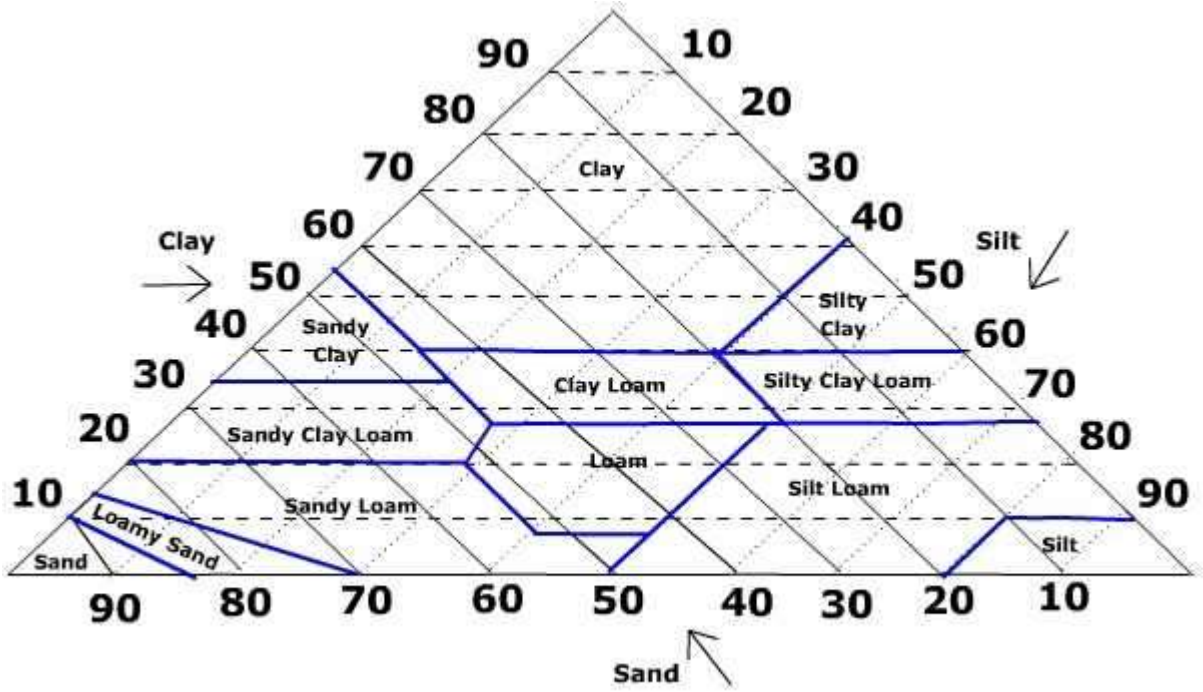
The soil textural class can then be determined as follows:

Textural Class	Shape of Sausage	Clay Content	Illustration
Sand	It is not possible to roll a sausage in the palm. The soil does not stick together.	Less than 10%	
Loamy Sand (LoSa)	It is possible to roll a sausage, but the sausage cannot be bent at all without cracking or breaking.	10 to 15%	
Sandy Loam (SaLo)	The sausage can be bent slightly, with the tips bent downwards for about 10mm without the sausage cracking in the middle.	15 to 25%	
Sandy Clay Loam (SaClLo)	The sausage can be bent down at the tips to about 20mm without cracking in the middle.	25 to 35%	
Sandy Clay	The sausage can be bent to form a semi-circle without cracking in the middle.	35 to 50%	
Clay	The sausage can be bend to form a complete circle without cracking in the middle.	>50%	

- **Textural Triangle**

A soil texture triangle is used to classify the texture class of a soil. The sides of the soil texture triangle are scaled for the percentages of sand, silt, and clay. Clay percentages are read from left to

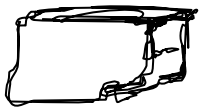
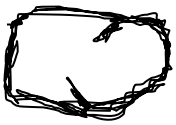
right across the triangle (dashed lines). Silt is read from the upper right to lower left (light, dotted lines). Sand from lower right towards the upper left portion of the triangle (bold, solid lines). The boundaries of the soil texture classes are highlighted in blue. The intersection of the three sizes on the triangle give the texture class. For instance, if you have a soil with 20% clay, 60% silt, and 20% sand it falls in the "silt loam" class.



Soil Structure

Soil structure refers to the manner in which all the soil particles, including organic material, are arranged to form structural units. The structural units are named according to their physical appearance, as follows:

Structural Unit	Description	Illustration
No structure	This is usually the case in sandy soils where no aggregation of soil particles is present. The soil falls apart when removed from the profile.	
Plate-like	The natural cracks are horizontal.	

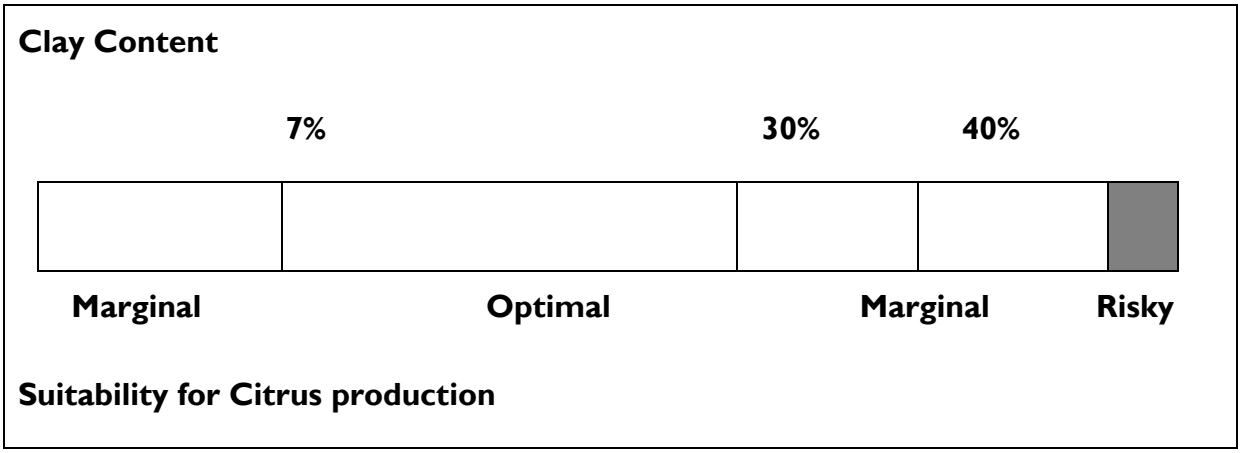
Structural Unit	Description	Illustration
		
Prismatic	The vertical cracks are better displayed than the horizontal ones. The units are 2 to 5 times as long as they are broad.	
Blocky	The vertical and horizontal cracks are evenly developed, and the dimensions of the units are about the same. The units have sharp edges and smooth faces. The unit's range in size from 1mm to 50mm.	
Granular	These units have rounded edges with rough faces. They range in size from 1mm to 10mm. When wet, these units trap more air than the blocky or prismatic units.	

Soil structure is a very important property that regulates processes related to plant production. These include aeration, water penetration and drainage. If the structure of the soil is destroyed, the soil becomes anaerobic (containing no oxygen) and waterlogged.

Soil can also be classified using other systems where the relationship between the percentage clay, silt and sand are presented in a triangle. This is a more sophisticated classification. This triangle shows twelve different textural classes. The sand section is for instance split into three different classifications, being course, medium and fine sand. The average size of the clay particles is <0.002mm, that of silt 0.05mm to 0.002mm and sand 0.05mm to 2mm.

An aspect of soil texture is the content of particles larger than 2mm. This fraction is referred to as gravel and/or stones. When the gravel content of the soil exceeds 10%, it should be taken into account when interpreting the chemical composition of the soil. Gravel dilutes the concentration of available nutrient elements.

Clay and organic matter (humus) are the active materials in soil. The humus content of soil can be intentionally increased, but it is more often decreased by agricultural practises. The clay content, however, is a fixed property and cannot be changed economically. The type and concentration of clay determines the cation-exchange capacity, water-holding capacity, aeration, and many other soil properties. The type of soil preferred by different crops differs between crops. The ideal soil for example for citrus production is one that contains less than 50% small particles (fine sand, silt and clay) and less than 25% clay. The figure below shows the relationship between clay content and soil suitability for citrus production.



Clay Content of Soil vs. Suitability for Citrus Production

- **Soil Depth**

The depth at which impermeable layers and/or parent material are present determines soil-depth. Soils with a depth of less than 500mm are generally regarded as soil of low potential. The effective depth of a soil is the depth to which the crop roots can penetrate with ease.

- **Soil Layering or Stratification**

It takes about 1,000 years for a 25mm layer of soil to develop. During the formation of soil, soil particles are separated and accumulate at various depths. Soils are also carried and deposited by water and wind to form soil layers with different soil properties.

The soil layers have an influence on the potential of the soil. If the properties, especially the texture, of two underlying soil layers differ too much, plant roots will not grow into the next layer. Similarly, water will not penetrate the second layer, but rather flow away along the merger of the two layers. A simple way to determine if layering could be a problem is by determining the texture of both layers. If the texture differs by more than 50% the layer will cause a problem. If for example, if the

topsoil contains 20% clay and the next layer more than 30% (50% of 20=10%), the stratification of the soil is too severe and will impede root growth and water movement.

- **Soil Aeration**

Plant roots respire (use oxygen and excrete carbon dioxide) and so soil oxygen must be replaced constantly. The rate at which oxygen-carrying air moves through soil depends on factors such as soil pore-size. The size of the soil pores depends on the texture, structure and strength of the soil.

The soil pores are filled with water and air, with the ratio between air and water being determined by the water content of the soil. At field water capacity (FWC), the soil air content is at its minimum. As the plant roots absorb the water in the soil, the air content in the soil increases. In soils that are poorly drained, the pores are filled with more water than at FWC and less air (oxygen) will be present. Waterlogged soil therefore contains very little oxygen and the anaerobic conditions that develop cause roots to die.

Definition:

Field Water Capacity (FWC): is reached when there is no free water is present in the soil. All the water present is bound to the soil particles. This means that water does not move out of the soil profile through leaching.

- **Chemical Soil Properties**

The chemical properties of soil are constantly changing and can be changed. The most relevant chemical properties of soil are:

- pH.
- Resistance or electrical conductivity.
- Fertility.
- Salinity.
- Cation exchange capacity.
- Organic matter.

Soil pH

pH is a measure of the concentration of the hydrogen ion (acid ion). A pH reading can range from 1 (extremely acidic) to 14 (extremely alkaline). A pH value of 7 is neutral.

When the pH of soil is measured, a suspension of the soil is prepared. pH values are reported as pH (water) and pH (KCl). Remember that the pH (water) is on average one unit higher than pH (KCl) for the same soil.

The optimal pH (water) of soil for most crops' ranges between 6.50 to 7.50. When the pH (water) drops below 5.30, too much aluminium is present in the soil. Aluminium is toxic to roots and root growth will be affected. If the pH (water) exceeds 7.50, nutrient elements like phosphate, zinc and manganese become insoluble and deficiencies can be induced.

In soils with a neutral to acid pH, the pH of the subsoil will usually be lower than that of the topsoil.

Electrical Conductivity and Resistance

Definition:

Electrical Conductivity: Electrical conductivity refers to the ability of soil paste to conduct electrical current and can be expressed in various units of conductivity. The international standard (IS) unit is Siemen.

Resistance: Resistance is the opposite of electrical conductivity and refers to the resistance of soil paste to the conductance of electrical current. Resistance is expressed in ohms.

The resistance of soil is an indication of the total dissolved salts in the soil solution. The measurement of resistance is a quick method to scan soils for salts. If the sample is too salty the electrical conductivity (EC) of the saturated paste is measured.

The resistance is expressed in ohm and the following general classification can be used:

Clay Content	Optimal Resistance
> 35%	250 to 500 ohms
20 to 35%	500 to 750 ohms
10 to 15%	750 to 1,000 ohms
< 10%	>1000 ohms

- **Soil Fertility**

Soil fertility is a collective expression to describe the status of the soil in terms of phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and to some extent, nitrogen (N). Fertile soil contains these nutrient elements in adequate quantities to sustain plant growth.

If too little plant nutrients are present, it poses less of a problem in commercial agriculture than if too much is present. It is relatively quite easy and fairly cheap to add nutrient elements to the soil, but seldom easy and cheap, if possible, at all, to remove excess nutrients.

- **Soil Salinity**

Salts accumulate in soils due to poor drainage and irrigation using saline water. This is usually a slow process and affects the fertility of the soil and eventually also the physical properties and soil structure.

- **Cation Exchange Capacity (CEC)**

Clay particles carry electrical charges of which the majority are negative. These negative charges can attract and bind with cations in the soil solution. The cations, which are positively charged forms bonds with the clay and can be displaced by other cations. The magnitude of negative charges presents to absorb cations, is referred to as the cation exchange capacity (CEC) of the soil and is expressed in centi-molar charge per kg soil (cmol+/kg). Organic matter also has a CEC, as well as an anion exchange capacity similar to the CEC, but that absorb negatively charged anions.

The CEC of soil depends on the clay content, the type of clay, and the organic matter content. Under certain circumstances CEC may be pH dependant, i.e. it will change when the pH changes.

Soil Organic Matter

Organic matter present in soil ranges from dead plant and animal material, organic debris, microbial debris and all stages of humus. Humus is processed and condensed organic matter and it takes thousands of years to reach a stable form. Humus contributes to the activity in soils and consists of humic acid (or humates, the salts of humic acids), fulvic acid (or fulvates, the salts of fulvic acid) and humins (a very stable form).

- **The Role of Soil Minerals**

Soil is composed of minerals, most of which are essential nutrient elements for plant growth. Each essential nutrient element has a particular role or roles in the physiology of plants. These nutrients are called essential elements, because without them plants cannot complete their lifecycle from seed through the vegetative and reproductive stages to the seed formation stage. The essential elements are grouped into macro and micronutrient elements.

Macro elements are required in relatively large amounts, while micronutrients are required in very small amounts. The roll of each element is complex, and elements are involved in many physiological processes of which some are still not understood.

Information – The Role and Function of Essential Nutrient Elements (Summarised)

Essential Nutrient Element	Function
Nitrogen (N)	Forms part of all protein and enzyme molecules and is therefore involved in almost every physiological process in plant production.
Phosphorus (P)	Is involved in all energy transfer reactions in the plant. It is also part of the nucleic acids in cells.
Potassium (K)	Has many rolls, including cell-division and transport of photosynthetic products from the leaves to the roots and other parts.
Calcium (Ca)	Forms a vital part of all cell-walls, keeping the cells together in the same way as cement in a brick wall.
Magnesium (Mg)	Forms the centre metal ion in the chlorophyll molecule, which is required for photosynthesis, apart from its role in other

	physiological processes.
Sulphur (S)	Is involved in the production of the sulphur-containing amino acids and in reproductive processes. A sulphur deficiency will reduce flowering and fruit set.
Sodium (Na)	Can replace potassium to some extend in certain plants.
Chloride (Cl)	Is in fact also a micro-nutrient, with plants requiring about 20mg per litre in their nutrient solution. Chloride is involved in the reactions where water molecules are split during photosynthesis.
Micronutrient elements Cu, Fe, Mn, Zn, B and Mo	Are involved in many physiological reactions as catalysts.

WATER

Irrigation in agriculture is dependent on the availability of water of a suitable quality. Water quality is assessed by the potential problems which can develop as result of long-term use.

The extent of potential problems varies and is determined by soil, climate and crop, as well as the skill and knowledge of the water-user. The judicial use of high-quality water normally does not result in any problems.

In practice however, a very large proportion of problems experienced are directly related to water use and quality. The quality of the water used for irrigation can for instance vary greatly depending on the soluble salt content. A variety of soil and crop problems could develop with an increase in salt content. Special management practices are necessary to ensure acceptable yields.

In planning an enterprise, it is therefore most important to carefully assess the following aspects:

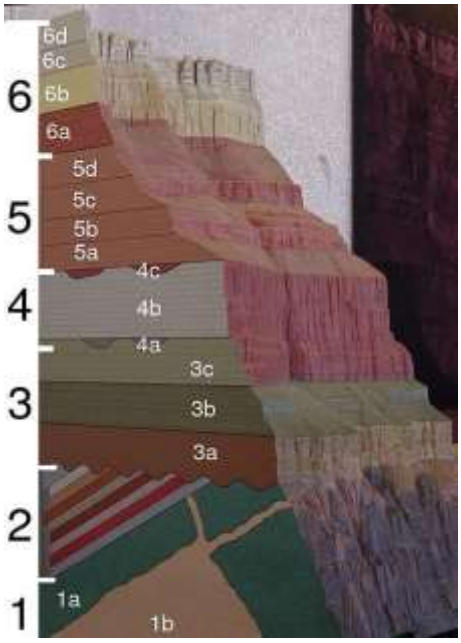
The Water Source

There are three main types of water sources, being rivers, dams and boreholes. The permanence of all three water sources depends on the natural rainfall in the specific area and the underlying geological formations.

Definition:

Geological formations: A formation or geological formation is the fundamental unit of lithostratigraphy. A formation consists of a certain number of rock strata that have a comparable lithology, facies or other similar properties. Formations are not defined on the thickness of the rock strata they consist of and the thickness of different formations can therefore vary widely.

The concept of formally defined layers or strata is central to the geologic discipline of stratigraphy. A formation can be divided into members and are themselves grouped together in groups.



A geologic cross section of the Grand Canyon.

Black numbers correspond to groups of formations and white numbers correspond to formations

The quality of the water from these three water sources varies according to origin and has to be tested before use. Irrigation water is either pumped directly from rivers or boreholes or received from a central canal system for storage in the farm dams or for direct distribution in the production area through an irrigation system. Filtration of the irrigation water may be necessary, depending on the quality of the received water, and the irrigation system being used. The degree of filtration needed adds substantially to the initial cost of installation of a system.

The water source must be secure and guaranteed to deliver a sustained and sufficient volume for the identified form of production.

The water source must be able to provide a large enough volume of water to sustain the hectares under production at the rates required by the specific crop as per the individual crop's cycles. . It is also good policy only to develop within the capacity of available water and build in a safety factor for water supply.

Water Quality

Water quality should always be good enough to ensure production of acceptable volumes of high-quality produce. If obtained from sources like rivers or boreholes, the salt and / or pollution levels should never rise above acceptable norms, as this will not reflect good agricultural practices.

Water quality can be tested by a number of laboratories. Crops differ in their sensitivity to high salt concentrations in the irrigation water. It is important to know what the quality of water is suitable for the planned crop.

Irrigation Design

The microclimate of the area is a determining factor in the design of any irrigation system. This includes whether it is a summer or winter rainfall area, the average monthly precipitation, the average minimum and maximum temperatures, as well as the frequency, velocity and seasonal distribution of wind.

The type of soil should be taken into consideration to ensure that the volume applied does not exceed the infiltration capacity of that particular soil. The rate of application must be calculated to supply in the crop requirement for optimal growth and production throughout the year.

Irrigation Capacity

The irrigation capacity of a water source determines the size of the plantings which can be irrigated with the available water on a sustainable basis.

According to the National Water Act (1998), the fair distribution of water is of extreme importance, and water measuring is applied to verify the extraction of water against an allocation. Most water sources are managed by Water Users Associations, which has to see to it that only the quantity of water allocated to each specific farm is pumped by or delivered to the farm for irrigation purposes. It is the farmer's prerogative to utilise the allocated amount to the best of his ability through choice of irrigation system and good management.

Water measuring, or determining of flow rate, is an aid for the effective distribution of water and is usually applied for the sake of legal requirements, management requirements, or both. A wide variety of measuring devices is available commercially and at the onset of implementation of water measuring, the following must be considered:

- What functions must the measuring equipment be able to perform?
- Which level of operation is required?
- How much are they prepared to spend?

Possible functions include the measuring of flowrate in cubic meter per hour and the volumetric flow over a period in cubic meter. A number of registering devices are available, ranging from very basic to highly sophisticated.

CLIMATE

Definition:

Microclimate:

Microclimate refers to the climate of a small area. It may differ from the surrounding climate as a result of aspect, tree cover (or the absence of tree cover), or exposure to winds.

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 hailstorms, and other measures of the weather.

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.

Climate is an integral part of the climate-soil-culture complex, and the factor that mostly determines the yield in food production. It is also the overriding factor influencing the type and quality of produce that can be grown in a particular area.

Different plants require different climatic conditions in order to produce the right quality and quantity of produce for the farmer to sell for a profit. Extreme climate conditions make farming more challenging.

Factors limiting farming enterprises in some areas are:

- **High spring/summer temperatures**
- **Low relative humidity**
- **Water stress during critical growth periods due to poor availability**
- **Hail**
- **Wind, which causes damage to produce**
- **Climatic Conditions**

Climatic conditions that should be taken into account are wind, rainfall, heat, frost and cold and hail.

Wind

Extremely windy conditions can affect growth, plant development and yield. Windy conditions hamper applications of liquids, such as spraying and irrigation. It also evaporates soil moisture rapidly, in particular in uncovered soils.

In the establishment of any production unit, prevailing winds and the possible effects thereof on plant development and subsequent income has to be considered carefully.

Rainfall

Sufficient rain to ensure enough water for irrigation purposes is one of the main requirements for successful plant production. The effect of too much or too little rain can, depending on the intensity, vary from negligible to catastrophic.

Prolonged dry periods, which occur in most parts of the South Africa, can have a severe effect on yield and product size, and subsequently profitability.

Prolonged rainy spells in the summer rainfall areas during the spring and summer hampers spray programs and can result in heavy pest or disease infestations. Late summer or autumn rains can also have a negative effect on the quality of harvests, which in turn will influence how much can be marketed in specific ways (e.g. exports), with subsequent reduction in income.

Rain during the harvest season, can affect the quality of harvests and increases the potential for post-harvest decay.

Heat

Extreme heat can have an impact on flowering events, which will have a direct effect on the crop yield. For example, in citrus production, during the November drop period, severe heat can cause a moisture deficit in the tree which also leads to an excessive drop of fruit lets.

Cold and Frost

Not all plants are impacted upon by frost in the same way; it is important to know firstly what the frost occurrence is in an area in order to select plants that can withstand local conditions.

Hail

Hail damage is a real threat in the northern production areas. Hail causes extensive damage to corpses.

It is prudent to examine the incidence of hail in any of the northern areas before developing a new production unit. The information on the incidence in the various areas is available from the crop insurance companies, who can also provide information on costs of insurance against hail damage.

Analysing Local Climatic Conditions

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 web address is www.155.240.219.9/agric/ver1 and e-mail address is opsroom@arc.agric.za.

To establish which weather station is the closest to the farm, the exact geographical position of the farm should be known.

The type of information which is required for enterprise selection and planning for as long a period as possible, is the following:

- ✓ Average rainfall
- ✓ Relative humidity
- ✓ Average, maximum and minimum vapour-transpiration.
- ✓ Average, maximum and minimum wind speed and direction
- ✓ Average, maximum and minimum temperatures

All the above are available on an hourly, daily, monthly and yearly basis and the information can be accessed at all times.

INDIGENOUS VEGETATION

South Africa is ranked as the third most biologically diverse country in the world, mainly due to the richness of plant life. South Africa has one tenth of all plant species in the world, in an area that is 1% of all land surfaces. The indigenous vegetation of South Africa is divided into seven biomes, each with its own distinct characteristics.

- Forest
- Fynbos
- Grassland
- Nama Karoo
- Savanna
- Succulent Karoo
- Thicket

It is important to know the indigenous vegetation of the area in which the farming enterprise is going to be established and identify the possible effects of such development on the environment.

Land use alters the natural environment and has already been the cause of tremendous environmental degradation in South Africa. A very small percentage of our indigenous vegetation is conserved in nature reserves and national parks, and the rest grows on private land. Conservation of indigenous vegetation is therefore largely dependent on landowners.

Prior to developing land, it is important to do a survey on and around the area to be planted to establish whether it may endanger the surrounding environment and what should be done to do an ecologically sensitive development.

TOPOGRAPHY

Definition:

Refers to the 'lie of the land', or the physical and geographic characteristics of land in terms of elevation, slope and orientation, or aspect (facing north).

An understanding of topography is critical for a number of reasons. In terms of environmental quality, agriculture, and hydrology, understanding the topography of an area enhances the understanding of watershed boundaries, drainage characteristics, water movement and water quality.

Understanding topography also aids in soil conservation, especially in agriculture. Contour ploughing, which is the practice of ploughing along the topographic lines, is an established practice of enabling sustainable agriculture on sloping land.

When planning planting areas, an understanding of topography is important when deciding on placement of the field, or orchard, and row direction, keeping the effect of irrigation runoff and storm water management in mind.

The direction the slope faces is important, as those facing north receive more sunlight. The angle of the sun's rays also changes, especially in more southern areas.

In windy areas, planted areas at the top a hill facing the prevailing winds will suffer much more wind damage than one on the lee side of the hill.

Topography is also important in determining weather patterns. Two areas in fairly close proximity may differ radically in climatic characteristics, such as rainfall, because of elevation differences or position relative to a nearby hill or mountain range. It is also well known that topography influences occurrence of hail with incidence of hail on two farms relatively near to each other differing greatly.

Knowledge of the possible effects of the topography on the development of a specific farm can therefore have a strong bearing on the eventual profitability of the plantings.

INFRASTRUCTURE REQUIREMENTS FOR AN ENTERPRISE

INTRODUCTION

Infrastructure has a bearing on the practical implementation of all day to day activities. Examples are roads, transport, electricity, stores, houses, packing facilities and other support services. Infrastructure therefore supports the production process and can be either internal (on-farm) or external.

Definition:

Infrastructure

Infrastructure refers to services and facilities that support day-to-day economic activity. Infrastructure includes roads, electricity, telephone service, and public transportation. Infrastructure has traditionally been provided and maintained by the government. However, some nations are currently experimenting with privatization of some elements of the infrastructure as governments seek to cut their expenditures.

THE ROLE AND FUNCTION OF INFRASTRUCTURE

The basis of a decision of whether to plant and develop a farming unit in a specific area will always be the production potential of the farm, with climate, soil and water as the most important aspects. Infrastructure, although important, will always be a secondary element in the decision-making process.

Although infrastructure will therefore not necessarily be a determining factor in whether to establish a specific farm, it does play a very important role in the planning process.

Infrastructure supports the production process. The size of the farm or planned enterprise determines the type and extent of the infrastructure which will be necessary. A large farm will need a large internal infrastructure to support all the many activities in the production process, and even for instance warrant a pack house with all the necessary equipment and manpower. A small farm on the other hand would need to make use of more external support, as the extent of its activities would not warrant too large expenditure on internal infrastructure.

Other factors are considered with establishment of an additional production areas on an existing farm. Factors such as utilisation of existing infrastructure and whether the chosen product will make a contribution to the current product mix will be main considerations.

INTERNAL (ON-FARM) INFRASTRUCTURE

The internal, or on-farm, infrastructure that is required is planned along with the orchard layout, as part of the land utilisation plan. On-farm infrastructure includes:

Access roads
Irrigation and water supply systems
Electricity supply
Communication systems
Boundary fencing
Structures, including:

- Buildings
- Vehicles
- Housing
- Farm roads

✦ **Access roads**

Access roads refer to roads that lead to the farm and are generally the concern of the local Department of Public Works or the local municipality. The quality of access roads must be considered when the decision is taken to develop a farming enterprise. These are the roads that workers must use to get to the farm, and over which produce must be transported to the pack house or the market.

✦ **Irrigation and Water Supply Systems**

The main aim in development of an irrigation reticulation system is to optimise the use of energy. Placement of dams and pump-houses will therefore be critical in determining the cost of electricity for irrigation purposes. Infield irrigation systems also differ with regard to energy requirement.

Irrigation infrastructure includes:

- Dams
- Main supply – pump-houses and pumps
- Secondary reticulation (in-field) system

- **Electricity Supply**

  A cost-effective power supply system should be planned carefully to include possible future development of production areas and infrastructure. Installation of new power supply points is costly and careful attention to initial planning will save costs at a later stage.

  - Electricity infrastructure includes:
  - Main supply – buildings, pump-houses and pumps
  - Reticulation to in-field installations

- **Communication Systems**

  Communication infrastructure refers to telecommunication and radio systems. In some areas, telephone connections are not available, which makes the management of a farming enterprise more difficult.

- **Boundary Fencing**

  A farm is private property and should therefore be well fenced off with limited access to ensure control of movement and necessary security.

  Depending on what is required, the type of fence can vary from ordinary six strand wire to stock-proof, game- or security fencing. The cost will also vary greatly and if the fencing on a farm is not suitable for the purpose when developed, it can be a large additional capital cost.

- **Structures**

  Buildings

  Placement of the various buildings in relation to the other action centres and activities need to be considered carefully in developing a new farm. Offices, stores and a pack house must be situated so that it will complement the farm activities as well as management and control.

  Buildings include:

  - Housing – permanent and temporary management and workers
  - Stores – for vehicles, tractors, implements, chemicals, produce
  - Offices
  - Communication – telephones, radio and computers
  - Vehicles and Equipment

The appropriate equipment for the terrain and crop is essential. The output of tractors must for example be linked to the equipment which has to be handled, e.g. ploughing, spray machines, picking trailers, etc.

Housing

The extent of housing needed on a farm depends on the size of the farm as well as the distance to the nearest labour source or town. The number of houses that are required increases with the distance from a town or labour source, and provision must be made for management, middle management and supervisory staff.

Farm Roads

Main roads on a farm should be positioned to serve all main action areas without causing too much farm traffic in and around production areas. It is ideal to have the offices, pack house, stores and housing area situated as near as possible to the farm entrance, so that movement in and around production areas is limited and only linked to production.

EXTERNAL INFRASTRUCTURE

External infrastructure depends on the location of the farming unit. The transport of supplies and produce over long distances from remote farming units is costly and has a negative impact on the efficiency of production management.

The following factors must be investigated carefully:

Locality
Availability of service providers
Community services

Locality

The following is important in terms of locality:

- Surrounding production area
- Proximity to town
- Road and rail transport
- Well-developed access roads
- Distance to pack house and road condition

In many parts of South Africa local production areas are well established. This manifests itself in the products and services available for specific commodities, as well as expertise regarding all production orientated activities. Consider the infrastructure around the Western Cape and around Upington for the production of grapes, or the production of sugar cane in KwaZulu Natal.

Availability of Service Providers

The availability of the following types of services providers must be taken into account:

- Suppliers of equipment and stock
- Maintenance services, irrigation design and installation
- Extension services
- Pack house and cold storage

Service providers, to a large extent, oil the wheels of an enterprise by providing support and production materials in the technical and maintenance fields. Ease of access to their services and goods therefore plays an important role. Day-to-day management becomes more and more demanding and costly with distance, and therefore availability, of service providers.

Community Services

The following community services play an important role:

Shops
Schools
Medical services
Churches

Farming enterprises in outlying areas has to make additional provision in remuneration and time for employees and their families to enable them to access the above services.

EVALUATING EXISTING INFRASTRUCTURE

When a farm is being purchased as a unit, the existing internal infrastructure must be evaluated to ensure that repairs or redevelopment of infrastructure will not lead to high additional costs.

Fencing

Establish whether the fences around the farm have been erected according to the title deed of the farm. This is easiest done by having the farm surveyed.

All fences should also be in a good condition and effective for what is required, for example a cattle fence will not control movement of game or be effective as security fence around a citrus orchard. Having to erect new fences is costly and should be considered at purchase

Housing

If there is insufficient housing on an existing farm, developing additional housing is a major factor to be considered as it requires substantial capital outlay.

Good and sufficient housing on a farm is therefore a positive factor. Even with enough housing, the placement of the houses in relation to the workplace, farm entrance and water courses can pose problems with regard to transport, security and pollution.

The quality of the housing with regard to water supply, electricity, ablution and runoff has to confirm to health, safety and Eurepgap requirements.

Water Supply

Water supply has to be sufficient for both farming activities and domestic purposes, and water sources must be tested for quality. Ensure that the sources are sustained throughout the year and that enough water is available in dry seasons.

A good reticulation system for current and planned plant production areas, as well as to the housing, offices and other infrastructure must exist.

Electricity

Electricity supply to housing, offices, pump-houses and other structures is required. The quality of the reticulation system, as well as wiring in all existing structures, must conform to local governmental standards and safety regulations in the Occupational Health and Safety Act.

- **Roads**

  The two points to consider are access onto the farm and access on the farm to offices, workshops, orchards and other structures like stores and a pack house.

  Access onto the farm should be secure and entrance controllable. Access on the farm to the various workstations and production areas should be such that the daily traffic does not impact on production areas of the farm.

PLACEMENT OF INTERNAL INFRASTRUCTURE

Ideally all offices, workshops, pack houses and housing should be placed near to the borderline of the farm and in the vicinity of the entrance. In this way, the buildings can be accessed easily, but access can be controlled for security purposes.

The logistics of transporting produce should be considered when placing loading areas and storage (as per the enterprise) so that there is minimum time lost in transporting produce.

Water and electricity distribution must be well planned with cost effective reticulation systems with provision made for handling of sewerage and wastewater to prevent polluting water sources.

STOCK REQUIRED FOR THE ENTERPRISE

INTRODUCTION

Although plant material may not necessarily be a stock item, the process of buying and handling is, as in the case of the other items, prescribed in the Eurepgap requirements for fresh produce production. Registration for Eurepgap is a requirement for entry into most fresh produce markets.

Eurepgap sets out a framework for Good Agricultural Practices (GAP) on farms and defines essential elements for development of best practice for global production of horticultural products. It is a means of incorporating Integrated Pest Management (IPM) and Integrated Crop Management (ICM) practices within the framework of commercial agricultural production.

PLANT MATERIAL

The correct choice of cultivar is one of the most important decisions that a grower must make. Producing high quality produce, which will satisfy consumer preference in the various markets, is of utmost importance in achieving and maintaining profitability.

Some of the factors which influence the choice of cultivar and rootstock include:

- Locality, in terms of the microclimate;
- Soil and water quality and availability;
- The need to produce good yields of good quality and size;
- Market demand for a specific cultivar;
- Existing cultivar spread on the farm; and
- Pack house capacity and its effective utilisation

AGRO-CHEMICALS

Definition:
Can be defined as all chemical substances utilized in pre- and post-harvest processes to produce horticultural products for fresh consumption.

Agro-chemicals includes ameliorates for soil preparation, fertilisers, and crop protection and post-harvest chemicals.

Eurepgap requirements for handling chemicals are explicit and most compliance criteria are not considered as negotiable. All chemicals must be handled according to the parameters set out under the registration certificate. Chemicals banned in the European Union cannot be used on crops destined for sale in the European Union.

Recommendations for the use of agro-chemicals must be made by technically responsible persons able to demonstrate competence to determine types and quantities to be applied. All products must be applied appropriate for the target recommended on the product label.

People handling the products must be trained in the correct and safe handling procedures.

Application of all chemicals must be recorded indicating crop name and variety, application date, product trade name and active ingredients, as well as that the required pre-harvest interval has been

observed. Residue testing must be carried out prior to shipment to ensure that the maximum residue restrictions of the target markets are met.

Chemicals must be stored in a safe place in such a manner that no contamination will take place. Empty containers must not be re-used and must be disposed of in a manner that avoids exposure to humans and contamination of the environment.

MAINTENANCE ITEMS

Maintenance items include lubricants, spare parts, tyres and other equipment held in a workshop to maintain vehicles and equipment on the farm. It also includes pipes, fittings and micro-jet or drip emitters to maintain the irrigation system and water supply to the farm structures and housing.

Holding too many of these items constitutes dead capital lying in the stores and it is important to maintain a good balance of the quantities held without jeopardising the farming operation.

All these items must be stored safely on shelves in secured stores with proper control on issuing for maintenance to avoid misuse and to have ongoing information on the level of items in the stores.

FUEL

Fuel must be stored in appropriate containers to ensure that it is secure, and to prevent contamination of the environment.

Preventative measures must be in place to ensure that any spillage can be handled in an ecologically responsible manner.

The storage, replenishing of stock and issuing of fuel should be done in such a way that losses are prevented, and that the use of fuel is controlled.

PRODUCTION CYCLES

The production cycle for most agricultural enterprises is a year-round, ongoing process, and is closely related to the l growth cycle of the plants and/or animals involved.

REPORTING AND RECORDING OBSERVATIONS AND ACTIONS

A system of recording all factors influencing outcome of the crop must exist on every farm.

Record Keeping is a way of monitoring external and internal factors, as well as procedures which can influence the outcome of the production process.

It is important to develop a formal record keeping system which is kept up to date and can be referred to at any time. It should be designed in such a way that the information will also conform to Eurepgap norms, which sets out a framework of Good Agricultural Practices (GAP) on farms for production of horticultural products.

GAP certification and registration has become a requirement for exporting fresh produce to most countries. In order to be certified and registered farmers should be able to demonstrate their commitment to:

- Maintaining consumer confidence in food quality and safety;
- Minimising the detrimental impact of farming practices on the environment, whilst conserving nature and wildlife;
- Reducing the use of chemical crop protection products;
- Improving the efficiency of natural resource use; and
- Ensuring a responsible attitude towards worker health and safety

The record keeping system must be such that it is possible to trace back produce received on the market to its origins, meaning where it was produced in the orchard. All the production processes and actions, including labour, utilised to produce the fruit must be open to scrutiny.

It is important that all employees are aware of the importance of recording all the necessary actions and observations during the production process, as well as why the information is necessary.

Such actions and observations to be recorded will include the following:

- Plant growth events (blossoms, etc.)
- Weather data
- Irrigation scheduling
- Details of fertiliser applications
- Details of pest and disease control application.

Dates of plant growth events

These dates vary from year to year and influences phonological development of fruit up to the time of harvest. Comparing the date with those of previous years is an indication of the harvest date relative to the previous year's and can be utilised in planning the harvesting process.

Weather Data

Weather data includes:

- Rainfall
- Daily maximum and minimum temperatures
- Humidity
- Evaporation

Analysis of trends in weather data are used to determine fruit growth patterns which indicates the size spectrum of produce at harvest. This information is used in crop prediction and plays an important role in marketing, as the markets vary in their fruit size preferences.

Irrigation Scheduling

The prescribed irrigation scheduling is documented by the irrigation manager, and the actual implementation of the planned scheduling must be recorded to ensure compliance. Irrigation reports also include details of problems that may have been encountered with the irrigation system.

Fertiliser Applications

This information is utilised in combination with production statistics to formulate the fertiliser recommendations for each year. It must also be available for inspection for qualification under the Eurepgap system.

All instructions to employees indicating time of application and quantities must be given in writing and the actual application per planting area recorded as one of the requirements for trace ability.

Pest and Disease Control Application

All details of the pest and disease control program must be recorded for Eurepgap qualification. This should include verification that the person recommending the programme is qualified, all instructions to employees, safety precautions, and training records.

Below is a table that can be used to identify and list the various production cycles of an enterprise. In small groups, you must identify, list and analyse the production cycles that are relevant for your farming enterprise. In the 'stage of production' columns, identify the key stage, and create shaded

areas to show when these processes take place. You will have to access some of this information from other staff members on the farm.

PLANT PRODUCTION CYCLES

Month	***Stage of production***	***Stage of production***	***Production Processes***					
			Fertilisation	Pest and Disease Control	Irrigation	Pruning/or other process	Harvesting	Packing
January								
February								
March								
April								
May								
June								
July								
August								
September								
October								
November								
December								

HARVEST PRACTICES

BASIC PREPARATION REQUIREMENTS

The harvesting of produce is the final process in the production cycle, and one of the most important. If the harvest is not well-planned and well-managed, it may lead to damage to produce that has been produced at high cost, especially in the case of fresh produce such as fruit and vegetables. Other produce, such as grains and seeds, are less easily damaged. In the case of livestock, the animals can become stressed and/or damaged during the harvesting/transporting process.

The basic requirements for preparing of the harvesting process are:

Crop estimates
Management
Equipment
Work force

- **Crop Estimates**

The basis for calculating equipment and labour needed to harvest the crop within the normal harvesting/picking period of each cultivar is an accurate crop estimate.

The estimate must, apart from crop volume, also indicate projected size spread per cultivar, external quality and time of ripening.

Internal quality development towards harvest must be monitored from about six to eight weeks before estimated harvesting date to confirm or adjust earlier predictions.

- **Management**

✓ Training

All supervisors and workers must be trained before harvesting to ensure that the correct methods are used during the picking process.

It is important that both the supervisors and workers are at the same level of understanding of why the picking process must be done in a certain manner and what the negative effects of deviation would be.

- ✓ Quality Management

  Systems must be devised to monitor that the produce is harvested with the correct internal and external quality standards. This dictates that samples must be taken and analysed from well before harvesting, and the quality standards must be monitored up to harvesting.

- ✓ Monitoring Systems for All Actions

  The actual harvesting process must be done as prescribed and must be carefully monitored. It is important that the Eurepgap requirements for information regarding all aspects involved in picking are met.

These would include training before and during harvesting, produce quality monitoring, rate of harvesting and transport.

Equipment

All the equipment needed for the harvesting process must be examined beforehand to ensure that it is in good condition and that it is sufficient. Equipment may include:

- Tractors
- Trailers
- Bins, Ladders, Clippers, picking bags and Picking gloves for the fruit and vegetable grower,
- Mechanised harvesting equipment

Sufficient ablution facilities must be available for the additional workers that are employed during the harvesting period.

Work Force

The number of harvest workers and supervisors required is calculated on the basis of the crop estimate, taking into account the period in which the harvesting must be completed for each cultivar.

Harvesting Systems

The harvesting system of the enterprise depends on what is being grown what should happen to the produce during harvesting process. For example, there is a vast difference between how fresh apples are dealt with, compared with grains and seeds.

Pre-Harvest Actions:

The pre-harvest actions may (depending in the enterprise) include the following:

- Final estimation of total crop
- Comparing internal and external quality with marketing standards
- Sourcing and training of supervisors and harvesters
- Medical examination of all workers to be involved in the picking operation
- Issuing new overalls to all pickers
- Preparing and cleaning picking equipment
- Harvesting / Picking Process

The harvest / picking process may (depending in the enterprise) include the following:

- Decide which picking method to use, i.e. clippers or snap-picking
- Daily inspection of cleanliness and condition of ladders, clippers and picking bags
- Inspection of fingernails of pickers, which must be short to prevent injuries to fruit
- Ensuring that enough drinking water is available
- Monitoring hygiene standards, e.g. washing of hands after visiting toilet
- Ensuring that turgid (wet from dew, rain or high humidity) fruit are not picked to prevent pressure bruising (oleocellosis)
- Monitoring by supervisors of general picking and handling of fruit from tree to bin
- Inspection of fruit as picking bags are emptied when picking out on colour

- Ensuring that picking bags are emptied carefully so as not to cause injuries to the fruit
- Ensuring that fruit do not have long stems after picking
- Ensuring that bins or trailers are not overfilled before transport
- Monitoring the removal of all fallen and/or decayed fruit from orchards after picking
- Transport to Accumulation Point or Pack house

In the case of produce that can be easily damaged, harvested produce must be transported from the growing area to a pack house at a moderate speed to prevent injuries or bruising. If this is the case, then the roads that will be used should be graded to prevent unnecessary wear and tear on transport vehicles and equipment and can lead to injuries and bruising to the produce.

Transport at high speeds on gravel roads causes dust to settle on the produce which leads to injuries and small injuries can lead to infection by pathogens and resultant in decay.

HEALTH AND HYGIENE PRINCIPLES

Health and Safety

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

✓ Employers

According to the Act, 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;
- Taking steps to eliminate or mitigate any hazard or potential hazard to the safety or health of employees;
- Making arrangements for ensuring the safety and absence of risks to health in the production and harvesting process;

- 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;
- Enforcing such measures as may be necessary in the interest of health and safety;
- 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.

✓ Employees

Every employee shall at work:

- Take reasonable care for the health and safety of himself and of other persons who may be affected by his acts of omissions;
- Co-operate with his supervisor to comply with any such imposed measures;
- Carry out any lawful order given to him in the interest of health and safety;
- If any unsafe or unhealthy situation comes to his attention, report it as soon as possible to his supervisor and/or employer;
- If he is involved in any accident which may affect his health or has caused injury to himself, report the incident as soon as possible;
- Co-operate with and in safety committees whenever required.

Hygiene

A hygiene risk analysis encompassing, amongst others, harvesting procedures, should be carried out prior to harvesting and processing at all production units.

All actions identified should be communicated to all persons involved in the 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;
- 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 produce, including personal cleanliness including hand washing, wearing of jewellery, fingernail-length and cleaning, and personal behaviour;
- Wearing and care 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.

QUALITY STANDARDS RELEVANT TO THE PRODUCT

Internal Quality Standards

Harvesting produce at optimum maturity is an important factor, especially with regards to perishable produce, as it determines the shelf life of the final product.

In the case of fruit, a number of parameters, including puffiness, rind-colour, and acid and sugar levels, are used to measure fruit maturity. The parameters are monitored from about four to six weeks before the anticipated date of harvest to confirm that the predicted fruit maturity coincides with the packing period indicated on the crop estimate. It is important to know how maturity is measured for the product that is to be harvested.

It is essential that the internal produce quality complies in all respects with the export requirements before harvesting.

External Quality Standards

A thorough understanding of external standards must be known for the specific commodity; these will vary.

External standards at the time of harvest refer, in the case of fruit, to rind colour, blemishes, deformed fruit and insect damage and diseases. Injuries sustained during picking and transport is also monitored at the pack house as a culling factor.

Rind colour develops further after picking and can be enhanced through de-greening or delaying the fruit before processing at a higher temperature. Practices like these will however detract from shelf life and marketing potential. It is therefore best practice to only harvest fruit with fully developed rind colour.

Blemishes are caused by wind, hail and insects, as well as by implements at an early stage of fruit development. A certain level of blemishes is allowed in export and local market fruit, but obviously non-conforming fruit must be graded out in the orchard. This also holds for deformed fruit.

Pests and Diseases

Pests and diseases usually affect produce long before harvest. Numerous post-harvest diseases result from pre-harvest infections; these should be controlled as per the commodity being produced. The level of post-harvest decay is also influenced by picking, transport and other practices. Correct management of these practices is therefore of primary importance to deliver a highly marketable product to the pack house for processing.

POST- HARVEST PRACTICES

In agriculture, **postharvest handling** is the stage of crop production immediately following harvest, including cooling, cleaning, sorting and packing. The instant a crop is removed from the ground, or separated from its parent plant, it begins to deteriorate. Post-harvest treatment largely determines final quality, whether a crop is sold for fresh consumption, or used as an ingredient in a processed food product. Effective handling decreases postharvest losses.

The most important goals of post-harvest handling are keeping the product cool, to avoid moisture loss and slow down undesirable chemical changes, and avoiding physical damage such as bruising, to delay spoilage. Sanitation is also an important factor, to reduce the possibility of pathogens that could be carried by fresh produce, for example, as residue from contaminated washing water.

After the field, post-harvest processing is usually continued in a packing house. This can be a simple shed, providing shade and running water, or a large-scale, sophisticated, mechanized facility, with conveyor belts, automated sorting and packing stations, walk-in coolers and the like. In mechanized harvesting, processing may also begin as part of the actual harvest process, with initial cleaning and sorting performed by the harvesting machinery.

Initial post-harvest storage conditions are critical to maintaining quality. Each crop has an optimum range for storage temperature and humidity. Also, certain crops cannot be effectively stored together, as unwanted chemical interactions can result. Various methods of high-speed cooling, and sophisticated refrigerated and atmosphere-controlled environments, are employed to prolong freshness, particularly in large-scale operations.

Regardless of the scale of harvest, from home garden to industrialized farm, the basic principles of post-harvest handling for most crops are the same:

- **handle with care** to avoid damage (cutting, crushing, bruising)
- **cool** immediately and maintain in cool conditions
- **cull** (remove damaged items)

Losses of horticultural produce are a major problem in the post-harvest chain. They can be caused by a wide variety of factors, ranging from growing conditions to handling at retail level. Not only are losses clearly a waste of food, but they also represent a similar waste of human effort, farm inputs, livelihoods, investments and scarce resources such as water.[2] Post-harvest losses for horticultural produce are, however, difficult to measure. In some cases, everything harvested by a farmer may end up being sold to consumers. In others, losses or waste may be considerable. Occasionally, losses may be 100%, for example when there is a price collapse and it would cost the farmer more to harvest and market the produce than to plough it back into the ground. Use of average loss figures is thus often misleading. There can be losses in quality, as measured both by the price obtained and the nutritional value, as well as in quantity.

There are numerous factors affecting post-harvest losses, from the soil in which the crop is grown to the handling of produce when it reaches the shop. Pre-harvest production practices may seriously affect post-harvest returns. Plants need a continuous supply of water for photosynthesis and transpiration. Damage can be caused by too much rain or irrigation, which can lead to decay; by too little water; and by irregular water supply, which can, for example, lead to growth cracks. Lack of plant food can affect the quality of fresh produce, causing stunted growth or discoloration of leaves, abnormal ripening and a range of other factors. Too much fertilizer can harm the development and

post-harvest condition of produce. Good crop husbandry is important for reducing losses. Weeds compete with crops for nutrients and soil moisture. Decaying plant residues in the field are also a major loss factor.

HEALTH AND HYGIENE PRINCIPLES FOR POST HARVEST PRACTICES

The general health, safety and hygiene principles discussed previously are also applicable for all post-harvest activities.

Transport of produce to and from the fields should not expose any person to possible injury. The tractors, vehicles and forklifts must all be in good condition and the drivers and operators must be well trained and licensed.

PLANT HEALTH

NUTRIENT ANALYSES

Soil is made up of minerals. The colour, structure and texture of specific soil is determined by the minerals that it contains.

All plants need the following to grow and produce food, and to successfully complete their lifecycles:

Sunlight;
Water;
Oxygen;
Carbon dioxide; and
Nutrients (food), also called *mineral nutrient elements* or *essential nutrient elements.*

Different plants require different quantities of specific nutrients. Plants source nutrients from the soil and irrigation water. The nutrients that are not supplied naturally are supplied as fertilisers.

If the soil that a plant grows in is managed well, it the plant will grow well and produce optimally. To manage soil, we need to know:

- What nutrients the crop requires and in what quantities;
- The characteristics of the soil that will allow this plant to take up water and air optimally;
- The soil type that will allow the plant to anchor and grow optimally.

Once we know what the ideal soil is for the crop, we also need to determine what we could do to optimise the soil we have available.

NUTRIENT ANALYSES

Nutrient deficiencies develop because certain physiological processes cannot be completed without a certain minimum supply of the specific nutrients. This results in a reasonably specific and identifiable symptom for each element.

Once the symptoms of a possible nutrient deficiency have been observed, the deficiency must be confirmed through leaf- or soil analysis. Not all abnormalities observed are necessarily due to nutrient deficiency. Pests and diseases may cause symptoms similar to those of nutrient deficits.

While it is important to have a good understanding of nutrient deficiency symptoms, it cannot be used in developing a fertilisation program. By the time nutrient deficiency symptoms appear, the deficiency has already impacted on the growth and production of the crop. It is essential to have a proactive approach to plant nutrition.

In order to take necessary interventions, we need to diagnose the nutritional status of the crop. This is especially true for perennial crops. Leaf and soil analysis are diagnostic tools that are used to monitor the nutritional status of the crop. Crop information is added to the data gathered from the analyses, and a refined diagnostics system is developed in this manner.

In order for an analysis to be conducted, representative samples must be collected and processed;

The first principle of any sampling action is that the sample must be **representative** of the bulk of the medium that is being sampled. A sample should not be viewed as a section of the whole, but rather the whole reduced to a manageable volume.

It is important that all sampling equipment, including cups, spatulas, buckets, and mixing equipment, must be thoroughly cleaned before sampling. This will avoid contamination of samples.

Sampling procedures

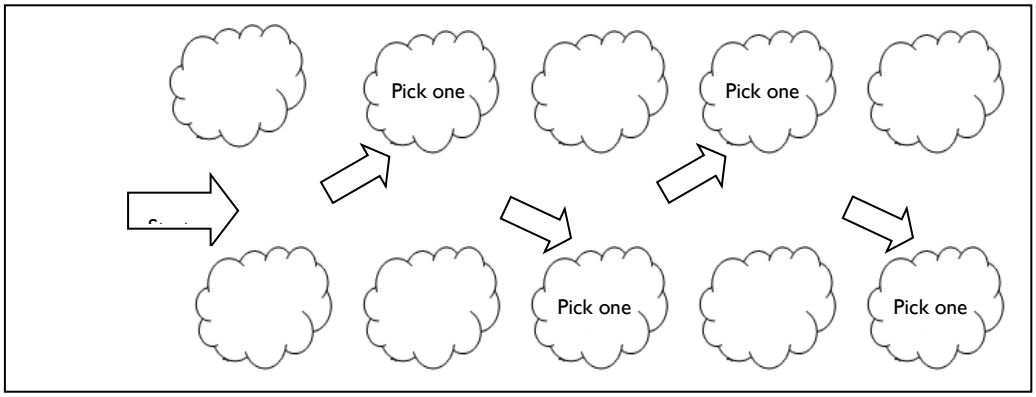
Leaves, In the case of tree crops soil and leaf samples are taken at and from the same set of trees every year. This is to comply with the first principle of sampling, and to minimise the effects of other factors on the nutritional status of the trees. Two to four rows that represent the orchard in all

respects are selected for sampling and are referred to as the **index blocks** or **rows**. The rows are marked, and samples for that orchard are always taken from those trees.

❖ **Leaf Sampling procedure**

Leaf sampling must be done at the appropriate time of the season. In the case of citrus orchards sampling occurs between February and May. Sampling of a specific orchard – or the whole farm – should be done at the same time every year, for instance the second week of March. Leaves are picked from **behind fruit** and sampling should therefore be done before harvesting.

- Enter the path between two of the rows in the index block and pick leaves from every second tree on the left and right.



- Pick 50 to 100 leaves per sample;
- Pick only healthy undamaged leaves;
- Pick leaves that are between 1 and 2 metres from the orchard floor, i.e. between about the waist and head of a person of average height;
- Pick leaves from **fruit bearing** twigs.
- Place the leaves in a new, clean plastics bag;
- Squeeze the air out of the bag and close it tightly;
- Label the sample as is prescribed by the laboratory that will be conducting your analysis. **Never put a label inside the sample bag with leaves, as the moisture will damage your label. The ideal way of labelling is to place the**

sample in the plastics bag into a second bag. The label in then sandwiched between the two bags.

- Keep the samples until they are dispatched to the laboratory in the shade or in a cool area, but do not freeze the samples.

Specific sampling procedures are available for other tree and field crops and vegetables. Depending on the specific crop you are working with, the learner should get hold of these procedures and collect plant samples accordingly.

❖ **Soil Sampling Procedure**

- Take soil samples from the same index block where the leaf sample was taken;
- Identify areas under every second to fourth tree for collecting sub-samples;
- A soil sample is made up of a number of sub-samples, that are mixed together to form the sample.
- A total of between 15 and 20 sub-samples should be taken per index row;
- Remove any visible plant debris from the surface of the soil, but take care not to remove the topsoil;
- Take the sub-sample from the surface down to a depth of 30cm depth using a spade or soil auger;
- Collect all sub-samples in a plastics bucket;
- Mix the soil in the bucket and place about 500g in a plastics bag;
- Seal the bag tightly;
- Label the sample as is prescribed by the laboratory. **Never put a label in the sample bag with the soil.**

❖ **Sample Granular or powdered Fertilisers**

- Select at least 1% of the bags that are to be tested and take a sub-sample of 200g from each bag;

- Take the 200g to represent the top, middle and bottom of the bag;
- Put all these sub-samples in a plastics bucket and mix it thoroughly;
- Remove 500g of the mixed sample and place into a suitable clean plastic bag;
- Seal the bag properly;
- Label the sample as is prescribed by the laboratory to be used for analyses. **Never put a label in the sample bag with the fertiliser**.

A spatula used for taking grain samples can also be used. In this case press the spatula into the top, middle and bottom of the bags and collect these sub-samples in a bucket.

When sampling is done for a legal dispute, the Registrar of Fertilisers prescribes specific procedures and samples must be taken in the presence of both parties to the dispute.

❖ **Sampling Liquid Fertilisers or Fertiliser Solutions**

- Select at least 1% of the containers to be tested and take a sub-sample of 200ml from each container;
- Put all the sub-samples in a plastic bucket and mix it thoroughly;
- Remove and place 500ml of the mixed sample into a suitable, clean plastics bottle;
- Seal properly;
- Stick or tie a label to the bottle, as prescribed by the laboratory to be used for analyses.

❖ **Labelling Samples**

- Attach a label to the plastic bag or bottle, by either sticking it on, or tying it securely with string;
- Do not write the information directly onto the bag or bottle, as even permanent marker ink rubs off during transport;
- Never place a label inside the bag with the sample;

- If more than one sample is sent, at least one of the labels should contain all the details of the sender, including:
    - Name;
    - Address;
    - Telephone number;
    - Fax number;
    - Contact person
    - Details of analysis required in case of fertiliser samples and special instructions, where required;
    - Order number, where used;
    - Type of sample;
    - Sample reference, i.e. orchard number, store number. Remember that the sample reference (name or number) must mean something to the sender. The laboratory report will contain this reference and the sender must be able to connect the results with the relevant fertiliser batch. Keep the reference simple, however. A reference such as "Orchard 27 near dam" is unnecessary, if there is only one orchard 27. The word "orchard" can even be left out in the case of leaf, soil and fruit samples, as these samples are always taken from orchards. Be consistent in the manner in which references are used, so that all farm employees that handle the samples will understand it. These simple rules make the whole process of recording, reporting and record keeping much easier.
- The labels on the remainder of the samples can reflect only the name, sample reference and type of sample.

SAMPLE PREPARATION AND PACKAGING

- Keep samples of all types in a cool, dry area away from direct sunlight until ready for dispatch. Ensure that the samples are kept away from possible sources of contamination;

- Before packing the samples, ensure that all the samples are labelled correctly, and that the labels are legible;

    - Check the samples against a Samples Dispatched list as they are being packed;

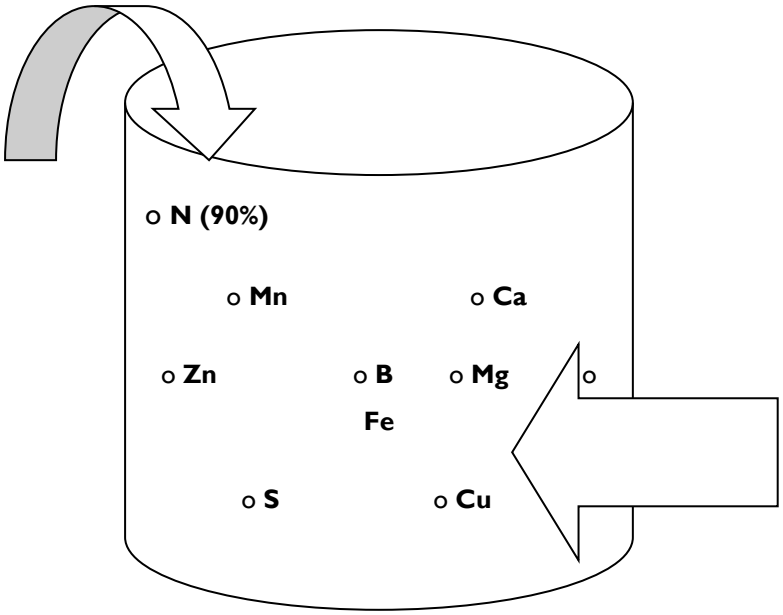
    - Pack the samples in a sturdy box and fill the box with packing material such as bubble wrap and/or newspaper, to steady the samples.

BASIC SYMPTOMS OF NUTRITIONAL DEFICIENCIES

INTRODUCTION

Plant nutrient elements are divided into two groups called Macro- and Micro-elements. The effect of the most limiting nutrient element can be illustrated by trying to fill a drum or barrel with holes at various levels in its side. Each hole represents the relative optimal concentration of a nutrient element. In the sketch below, nitrogen (N) is present at 90% and potassium (K) at 30% of their respective optimal concentrations. To fill the drum, one has to first of all block the hole representing K. Thereafter, you can fill the drum to the level where phosphorus (P) becomes the most limiting nutrient element.

If you first block the nitrogen (N) hole before blocking the K hole you still will not be able to fill the drum more than 30%. Therefore, to fill the drum all nutrient elements must be present at their respective optimal concentration (100% level) but getting the N level to 100% and not the K level will not enable the plant to produce at 100% capacity. Although molybdenum is required in very small quantities compared to nitrogen, the shortage of this element will still cause the plant to produce at only 40% of its capacity in the example below.



❖ **Macro Elements**

Soil fertility is a collective term used to describe the status of the soil in terms of phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and to some extent, nitrogen (N). Fertile soil contains these nutrient elements in adequate quantities to sustain plant growth.

❖ **The symptoms of nutrient deficiencies**

Nutrient Element	Plant Part (first to display symptoms)	Mild Expression	Severe Expression
Nitrogen (N)	Old leaves	Yellowing of all the old leaves, to a light-yellow colour.	Yellowing of all leaves just before or during a new leaf flush which will result in leaf drop.
Phosphorus (P)	Fruit	Open centre resembling over-matured fruit.	Thick skins and puffy fruit with high acid level.

Nutrient Element	Plant Part (first to display symptoms)	Mild Expression	Severe Expression
Potassium (K)	Fruit	Small fruit	Small fruit with thin skins combined with a low yield. On young trees the leaves may turn bronze.
Calcium (Ca)	Fruit	Increase incidence of creasing, (a physiological disorder) although not yet confirmed.	Chlorosis (yellowing) of very young leaves and dieback of growth tips.
Magnesium (Mg)	Old leaves	Chlorosis of the front part of the leaf from the tip and sides of the leaf. An inverted green V with the open end of the V at the petiole side appears as the symptom develops.	Leaf drop and decrease in fruit set.
Sulphur (S)	New leaves	Yellowing to the colour of butter of emerging leaves on a green twig.	Extremely reduced fruit set.
Copper (Cu)	New leaves	Extra-large leaves on strong new growth.	Gum pockets in the albedo (white part of the peel) of the fruit. Fruit is small, thin skinned and hard.
Iron (Fe)	New leaves	Yellowing of the lamina (leaf blade) of young leaves leaving a well-defined network of small veins.	Reduced fruit set.

Nutrient Element	Plant Part (first to display symptoms)	Mild Expression	Severe Expression
Manganese (Mn)	New leaves	Inter-veinal yellowing of a normal-sized leaf, almost over the entire leaf. Broad green areas around the veins and Chlorotic areas between veins are the most obvious symptoms.	Increase in the number of leaves affected.
Zinc (Zn)	New leaves	Interveinal yellowing of a small-sized leaf, starting at the tip of the leaf. Resembles manganese deficiency but appears on small leaves and the chlorosis starts at the tip of the leaf.	Increase in the number of leaves affected and reduction in fruit size.
Boron (B)	New leaves	Corking of the midrib vein on the underside of the leaves. This resembles cold damage of leaves.	Gum pockets around the centre of the fruit. Fruit size is reduced.

IDENTIFYING NUTRIENT DEFICIENCIES IN PLANTS

The most important features of nutrient element deficiencies are:

- The leaf should display the same symptom on both the left-hand and right-hand side of the midrib. This is important in distinguishing between nutrient deficiencies and leaf symptoms caused by other factors.
- Nutrient deficiency symptoms appear first on either new or old leaves. From there the symptom can spread to the entire plant.
- Certain nutrient deficiency symptoms appear first or are more noticeably on fruit.
- Nutrient deficiency starts with mild symptoms and develops into severe symptoms.

CORRECTING NUTRIENT DEFICIENCIES

The first response to detecting nutrient deficiency symptoms is to report it to the supervisor or manager.

The presence of nutrient deficiency symptoms is a sign of an unsuccessful fertilisation program. Deficiency symptoms generally appear after the shortage has had an impact on the plant and/or production. The fertilisation program should provide for methods to identify and correct short supplies of any essential nutrient element before it impacts on the crop.

Rectifying nutrient deficiencies is seldom a simple matter of applying the nutrient. Very often the deficiency is the result of factors other than an absolute short supply. A deficiency can be induced by other factors that convert the specific nutrient into an unavailable form. It could also be the nutrient has been converted to a less active form. To improve the supply of the specific nutrient, one needs to determine why its supply is not optimal (the best it can be) and try to correct that.

Once it has been applied to the plant, there is no guarantee that the active form will last long enough to result in the required physiological reactions. To maintain optimal concentrations of the available nutrient elements in the trees, enough of the nutrient in the available form must be present to be utilised by the plant.

The table below lists that most common causes of and factors associated with nutrient deficiencies, and the corrective measure that can be taken.

Symptoms of Nutrient Deficiencies in crops and potential corrective actions:

Nutrient Element	Causes of Deficiency and Factors that Can Induce a Deficiency	Corrective Actions
Nitrogen (N)	Too little applied	Increase the application.
	Too much lost due to leaching	Split the application and control the irrigation better.
	Phytophthora (root rot)	Treat the disease with foliar sprays.
Phosphorus (P)	Too little applied	Increase the application.
	Soil pH too high	Not much to be done.
	Soil pH too low	Apply lime to soil.

Nutrient Element	Causes of Deficiency and Factors that Can Induce a Deficiency	Corrective Actions
Potassium (K)	Too little applied	Increase the application.
	Mg supply too high	Apply K through foliar sprays.
	Trees old	Not much to be done.
	Nematodes	Treat the pest.
Calcium (Ca)	Too little applied	Increase the application.
	Climatic conditions	Increase the application during critical periods.
	Soil pH too low	Apply lime to soil.
Magnesium (Mg)	Too little applied	Increase the application.
	K supply too high	Apply Mg through foliar sprays.
	Soil pH too low	Apply lime to soil.
Sulphur (S)	Too little applied	Increase the application.
Copper (Cu)	Too little applied	Increase the application.
	Soil pH too high	Apply Cu though foliar sprays.
Iron (Fe)	Too little applied	Increase the application.
	Soil pH too high	Use soil application of a chelate that is stable at a high pH.
	Over-irrigation	Reschedule the irrigation.
Manganese (Mn)	Too little applied	Increase the application.
	Soil pH too high	Apply Mn through foliar sprays.
	Recent application of lime	Apply Mn through foliar sprays.
Zinc (Zn)	Too little applied	Increase the application.
	Soil pH too high	Apply Zn through foliar sprays.
	Too much P applied	Apply Zn through foliar sprays.

Nutrient Element	Causes of Deficiency and Factors that Can Induce a Deficiency	Corrective Actions
Boron (B)	Too little applied	Increase the application.
	Too low pH in the soil	Apply lime to soil.

PROCEDURE FOR THE APPLICATION OF NUTRIENTS

INTRODUCTION

Fertilisers are applied in one of the following manners:

- **Manual Application** – The application of granular and powdered forms of fertiliser to the surface of the soil by hand.

- **Mechanical Application** – The application of granular and powdered fertilisers, and slurries, - which are suspended fertilisers, by way of mechanical equipment.

- **Fertigation** – The application fertilisers in liquid and water-soluble powdered form by adding it to the irrigation water.

- **Foliar Application** – The application of fertilisers in liquid and water-soluble powdered form by adding it to water and spraying it onto the trees.

CALCULATING THE TOTAL FERTILISER REQUIREMENT

In an orchard situation a fertilisation program normally indicates the amount of fertiliser that has to be applied per tree. To calculate the total amount of fertiliser required for a specific orchard, the following formula is used:

Total Amount of Fertiliser Required = Fertiliser per Tree (g or ml) x Number of Trees in Orchard:

For field crops the amount of fertiliser required will be given as a dosage rate per hectare.

Example:

Calculating the Total Fertiliser Requirement for an orchard.

The table below represents a typical fertilisation program for a citrus orchard:

Fertilisation Program - Citrus			
Orchard identity:	**Orchard 10**	**Size:**	**3.0ha**
Cultivar/Variety:	**Delta Valencias**	**No of Trees per ha:**	**316**
Fertiliser		**Quantity**	**Time of Application**
Soil Applications		**g per tree**	
Limestone Ammonium Nitrate (LAN)		500g	July
LAN		250g	August
LAN		250g	September
Potassium Chloride (KCL)		500g	September
Dolomitic Lime		4000g	October
Foliar Sprays		**g per 100l water**	
Low Biuret Urea		1000g	July
Manganese Sulphate		200g	October
Solubor®		150g	October
Remarks:			

The total amount of LAN needed for the July application is calculated as:

Number of Trees in Orchard = Orchard Size in Hectare (ha) x Number of Trees per Ha

= 3.0ha x 316

= 948 trees in the orchard

Total Amount of Fertiliser Required = Fertiliser per Tree g or ml) x Number of Trees in Orchard

= 500g x 948 trees

= 474,000g (/1,000 to convert to kg)

=474kg

This means that 474 kg of LAN is required for the July application of LAN to orchard 10.

Once the total amount of fertiliser required for the orchard has been calculated, the fertiliser can be collected from the store and prepared for application.

In a field crop situation, the fertiliser will be based on leaf and soil analyses. The recommendations will indicate the amount of fertiliser to be applied per m^2 or per ha. Before planting, fertiliser containing N, P and K will be broadcasted, while N will be applied as a top dressed later during the season. The required nitrogen is usually split into smaller amounts, which are then applied at intervals during the growing season.

COLLECTING FERTILISER FROM STORAGE

In line with the standards of **good agricultural practises (GAP)** fertilisers must be stored according to their type and packaging. Fertilisers have a fairly long shelf life, provided it is stored in the manner prescribed by the suppliers. However, contamination can occur and bags might lose their labels. If in doubt of the contents or concentration of any fertiliser, take samples and send it for analysis.

THE DESCRIPTION ON THE BAGS OR CONTAINERS

To ensure that the correct fertilisers are selected, double-check the following before loading:

The **concentration of the active ingredient** specified on the bag or container, because some fertilisers are supplied in more than one concentration. Zinc nitrate are supplied in formulations with an active ingredient (Zn) concentration ranging from 5.5% to 16%;

Granular and powdered fertilisers are supplied in 25kg or 50kg bags. LAN is mostly supplied in 50kg bags. In the case such as the example above, ten 50 kg bags, i.e. 500 kg of fertiliser will be collected from the store. Half a bag should be left after the application, and this should be returned to the store and sealed properly for future use. When collecting fertiliser from the store, check that there are no half-used bags that should be used first.

Once the correct fertiliser and its concentration are confirmed, the instruction to load the required number of bags or containers can be executed.

PREPARING FERTILISERS

Granular and powdered fertilisers seldom need preparation before application. For manual application, fertiliser bags or containers are transported to the orchards and the required number of bags is off-loaded at each orchard.

For fertigation and foliar applications, the fertiliser is merely mixed with the amount of water prescribed in the fertilisation program.

When applied to field crops the fertiliser is either applied through the irrigation system (fertigation) for vegetables and pivot systems, or in granular form by hand or using spreaders.

MEASURING FERTILISERS

It is important to apply the correct amount of fertiliser, because, apart from the cost implication, over-application can be as harmful to the tree as under-application.

In the case of manual application, the amount of powdered or granular fertiliser that is to be applied is normally stated on the fertilisation program in g/tree. This prescribed mass per tree cannot be weighed for every tree, as this would take a long time and be unproductive. Follow the steps below:

- Carefully weigh the prescribed mass of fertiliser;
- Determine the volume of the mass of fertiliser;
- Make scoops to hold the exact volume of fertiliser that is required, by for instance cutting used oil or canned fruit tins to the correct size. Apply one or two scoops of the specified fertiliser.

In the case of fertigation and foliar applications, the liquid or powdered fertilisers are measured or weighed carefully and added to the prescribed amount of water.

APPLYING FERTILISERS

The feeder-roots of a orchard trees are concentrated in the area around the trunk of the tree. This is normally the area, which is wetted during irrigation.

Fertilisers are applied manually in the following manner:

- Irrigate the orchard for about 30minutes before application to demarcate the area in which the feeder-roots grow;
- Scoop the required amount of fertiliser from the bag;
- Spread the fertiliser evenly on the wetted area, with little or no fertiliser against the trunk of the tree.

INDIVIDUAL ACTIVITY: CALCULATION, IDENTIFY AND RESEARCH

The returned nutrient analysis suggests that the land require 185 kg of nitrogen, 37 kg of phosphate and 185 kg of potassium per hectare. Now draw up the ratios and decide between the two lots of fertiliser (2:3:2 (22) and 5:1:5 (25)) which one would best suit your need. And how many 50 kg bags you would require.

Show all calculations and make short notes on what was done.

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Chapter 2

Monitor the establishment of a crop

In this session we explore the following concepts:

- Select tools and equipment for planting a specific crop
- Machinery and implements for establishing crops
- Care of tools and machinery
- Crop planting equipment
- Handle planting material
- Hygiene standards
- Impact of environmental conditions on crops
- Spacing requirements for planting of crops

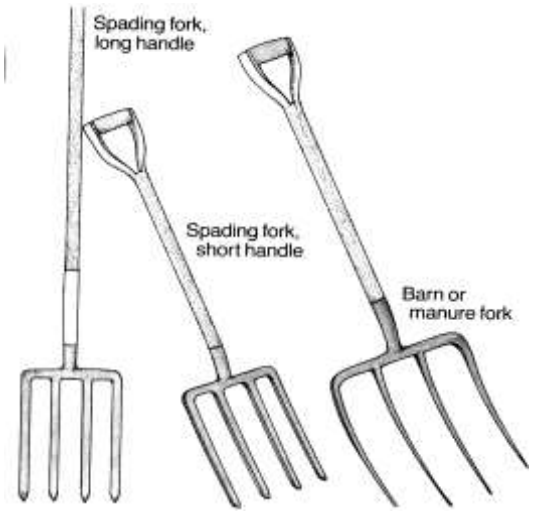
SELECT TOOLS AND EQUIPMENT FOR PLANTING A SPECIFIC CROP

HAND TOOLS

Hand tools used in crop establishment are generally the same as garden tools.

- **Forks:**

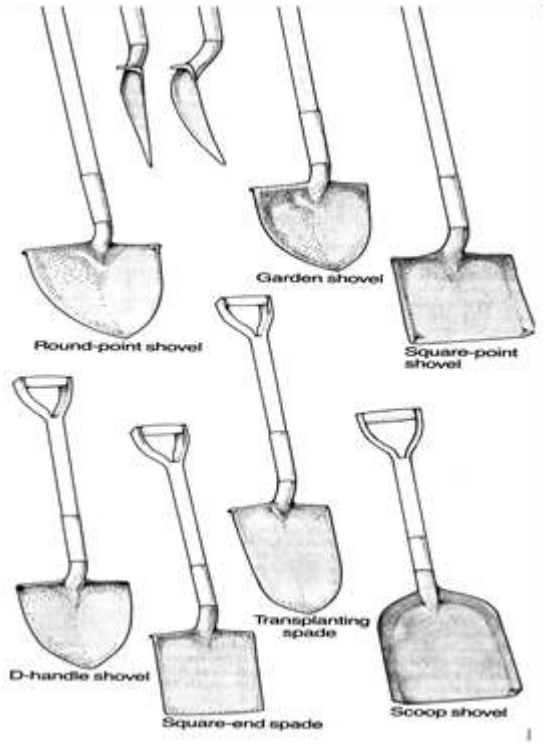
Forks come in different sizes, small, medium and large. A large fork is similar in size to a large spade and is essentially used to loosen soil and break up clods. A medium fork is used for digging up bulbs and root crops such as potatoes.



Hay or compost forks are used for turning or moving hay and compost. A small hand fork can be used to plant seedlings and bulbs.

- **Spades and shovels:**

Spades and shovels are used for digging holes and trenches, for transplanting trees and shrubs and for scooping, compost, manure and fertiliser. Many styles are available, each designed for a particular purpose.



- **Rakes**

Rakes are used to level off freshly ploughed soil before planting or sowing of a crop. A rake has a handle like a broom and a cross piece made out of iron or heavy-duty plastic teeth.

- **Hoes**

A hoe is a long-handled tool which is used to cultivate between cropping rows and cut through weeds while tilling the soil. A hoe has a sharp blade, which comes in two widths, either narrow or broad.

- **Wheelbarrows**

A wheelbarrow is essential for carrying important tools, seed and seedlings into the field.

MACHINERY AND IMPLEMENTS FOR ESTABLISHING CROPS

There are a great number of different types of implements and machinery used by commercial farmers to establish crops.

- **Row units**

Row units are used for planting seeds in rows at the correct spacing and depth. The discs make a shallow furrow und covers it up again after the seeds have been planted. Some types have the function of placing fertilizers with the seeds.

- **Box Drills:**

Box drills are used for drilling holes and planting seeds in a no tillage production system.

Large fields:

In dry-land systems the use of planters that can plant a wide area is popular.

CARE OF TOOLS AND MACHINERY

Good quality crop planting tools can last for 10 years or more if well looked after. All tools should be collected at the end of each working day, cleaned and stored under shelter. All mud must be removed from implements so that they will be clean and ready for use.

Implements must be regularly cleaned and all seed and fertilizer must be removed and stored after use.

Wheelbarrows should be washed out with a hose and left upside down to prevent remaining water from creating rust in the barrow. It is recommended that tools such as spades and shovels be occasionally wiped down with an oily cloth to assist in preserving the finish on the blade and to perform more efficiently.

CROP PLANTING EQUIPMENT

Crop planting equipment is used in establishing crops.

- **Planting string**

A planting string consists of string with wooden pegs. The pegs are inserted into the soil, and the string tightened. This provides a straight line on which planting is done. It is used when establishing seeds, bulbs or seedlings, and allows straight line planting, making later maintenance such as weeding, fertilising and harvesting easy.

- **Sprinklers, pipes and hoses**

Once planted, all seeds, bulbs or plants will require watering. Generally, this will be done using an irrigation system. Take care to ensure that the hoses and pipes are not damaged by implements when preparing the soil for planting, and that vehicles do not run over and damage irrigation systems.

HANDLE PLANTING MATERIAL

Planting material differs for different crops. Crops are propagated through seeds, seedlings, bulbs, tubers, plant cuttings, grafting or budding and plating of nursery reared grafted trees. There are a number of handling requirements that are necessary to ensure maximum survival and optimal growth of the established crop.

- **Seeds and bulbs**

  Seeds and bulbs must be are stored in a cool, dark and dry area until such time that they are to be sown or planted. The same principal applies to propagation materials such as potato tubers. Other seeds such as tobacco, cabbage and tomatoes are established in seed beds from which they are transplanted into the open soil. More expensive or very small seeds like some vegetable and flower seeds are planted in seed trays kept in a controlled environment where the seed germinate, and seedlings are kept until they are strong enough to be transplanted.

  Irrespective of the kind or type of planting material used in propagation, the preparation of the soil or seed bed prior to establishment is critical. Planting material, especially seeds, must be in close contact with the soil to enable them to absorb water for germination.

  The soil should therefore be well prepared before planting. Soil can be prepared using a shovel or a fork, and in the case of larger scale plantings, a tractor, plough, disc plough or other mechanical equipment can be used. Soil preparation generally includes the application of the appropriate amounts of fertiliser. Seedling and cuttings should be irrigated directly after planting.

- **Remember:**

- Use certified seed of recommended cultivars for your area.
- Obtain planting material from reputable companies.
- Follow planting recommendations regarding planting time, planting depth and plant spacing
- Consider weather conditions before planting.
- Plant in straight rows.

- Fertilise according to fertilisation recommendations from soil fertility analysis.
- The main reasons for germination failure are poor quality planting material, sowing too deeply, too dry or too wet seed bed and temperatures outside the norm.

✦ **When establishing seedlings or cuttings, the following should be noted:**

- Seedlings are grown from seed. A week before transplanting, seedlings should be 'hardened off' by exposing them to full sunlight for a few hours per day. This will assist in the seedlings adjusting to field conditions where no shade will be available.
- Before planting, remove any dead or dying seedlings.
- Water the seedlings before planting.
- Pre-prepare the planting area
- Try to plant on an overcast day, and never plant in the heat of the day. Aim at planting late afternoons allowing seedlings and cuttings a night to recover. Seedlings will not tolerate full sunshine before or after planting. Poor pre-planting care will lead to seedling losses.
- Once planted, seedlings and cuttings should be watered immediately. A fine mist spray is most effective. This should not be done during the heat of the day.
- Watering must be conducted carefully ensuring that the water does not wash away the freshly prepared soil and expose the roots of the seedling.
- Ensure that the seedlings or cuttings that have not been planted are protected from direct sunlight and have adequate water, as they will dry out and die very quickly if poorly treated.
- All newly planted crops should be monitored by for overall survival rate, weak and diseased plants. If dead or damaged seedlings are removed, they should be replaced with fresh seedlings. It would be useful to carry a wheelbarrow full of replacement seedlings to replace those that have died in the crop as you do the inspection. Don't forget to water the seedlings before and after planting.

HYGIENE STANDARDS

All equipment and tools should be clean and properly sterilized before starting with the propagation. Disinfectants on the market are, household 'Jik', chlorine used for swimming pools, 'Sporekill' and 'Prasin'. Apart from personal hygiene, workers must wash their hands and preferably wear sterilized rubber gloves when working with growing media and propagation material. The reason for this is that the equipment and propagation material can be infected with fungi, bacteria or viruses that can cause diseases and eventually affect the production of the crop.

When using seed as propagation material, the seed can be sterilized or treated with fungicides.

IMPACTS OF ENVIRONMENTAL CONDITIONS ON CROPS

ENVIRONMENTAL CONDITIONS

Different crops require different environmental conditions for optimal growth. An example of this is beans and onions are sown between autumn and early winter (cool to cold period) whereas tomatoes and cucumbers are sown in spring after the last frosts of winter (warmer months).

It is therefore important to select the correct crop and cultivar for the particular time of year, and also the one best suited to your environment. You can consult with an extension officer or crop specialist or read about the crops and its various cultivars before you decide on the planting stock you buy. Planting the wrong crops or during the wrong time of the year is a common cause of crop failure. In addition, also consider the market you intend for the specific crop.

Excessive humidity can cause the development of a fungal disease known as 'damping off'. Similarly, cold conditions may lead to germination failure or cold damage to seedlings.

Mixtures of fertiliser can also be used to provide different nutrients for specific crops. The farmer will be aware of the requirements for such plants. The planting site for the crop should be watered once or twice before planting to allow the fertiliser and soil to settle. Seedlings should be transplanted with as much soil as possible from the original site surrounding the roots. Remember that in a natural situation plant roots are never exposed to the wind, so it is important that as much of the original soil is kept with the seedling. This exposure is commonly called root shock and will kill young seedlings very quickly.

The planting area should be watered thoroughly a day before transplanting seedlings into the soil and the soil should be moist and not wet.

Avoid planting seedlings on windy days, as the wind will dry out young seedling plants, exacerbating the effects of wind shock. You should also avoid planting seedlings before heavy rainfall. Heavy rain not only increases the likelihood of damping off fungus developing, but also causes erosion of freshly prepared soils. Heavy rain can destroy the seedling habitat and wash away the newly planted seeds or plants.

Long term crops such fruit trees and vines are established towards the end of winter. These are planted in holes at least one meter wide 60 cm deep.

The bottom of the hole is layered with manure and well decomposed compost. The tree should be planted, carefully and no deeper than it was at the nursery, with the hole forming a small dam for the collection of water. Each plant will require 15 - 20 litres of water immediately upon planting.

TRANSPLANT OR ROOT SHOCK

Definition:

Shock or trauma experienced by a plant when transplanted.

Minimizing Transplant Shock

Transplant shock can be minimized by carefully considering the weather conditions and the plant's growth cycle before moving; as well as having the planting hole ready to avoid having the plant's roots exposed longer than necessary. Also ensure the new transplant receives adequate moisture after it is settled in its new home.

Transplanting on cool, cloudy days can help a plant recover quickly; if that's not possible, shade cloth or some protection may be placed loosely over the plant for a few days. Certain plants should be transplanted when dormant to reduce the effects of being moved.

Some gardeners add Vitamin B1 to the water used to moisten newly transplanted seedlings; they say it helps reduce transplant shock and gets the plant off to a good start.

Examples of root shock:

HOW TO READ AND ANALYSE DOCUMENTS

Reading text:

When reading text in order to understand what you are reading, it is often required that you demonstrate understanding and the ability to analyse text by answering questions about the text.

We can use a variety of techniques to read text in order to become familiarised with the text and the content thereof.

Scanning:

Scanning is used to find specific information in a text quickly while ignoring its broader meaning.

Skimming:

Skimming is a high-speed reading process and involves visually searching the sentences of a page for **clues to meaning**. It is conducted at a higher rate than normal reading for comprehension.

Pre-reading:

Pre-reading is the initial relatively fast reading of a piece of information to form a general idea or get an overall impression of the content, nature and content covered in the material without identifying or addressing specific aspects from the text for purposes of analysis or the answering of specific questions relating to the content of the text.

Re-reading:

Re-reading is the focused reading for purposes of gaining a clear and detailed understanding from the text for purposes of comprehension or analysis.

Sifting:

Sifting is used to distinguish between the important and other information contained in the text that may not be completely relevant to the main message of the text.

Summarizing techniques:

The following technique is followed to successfully interact with text in order to summarise:

- **Finding the topic sentence in a paragraph**

Text consists of a heading and usually combination of paragraphs including an opening paragraph or introduction, the main body of the text and a closing paragraph.

The paragraph is the unit of thought in a piece of writing. Each paragraph is separated from the rest of the passage by means of a blank line above and below it. The sentences in a paragraph have one thing in common - they are all based on the central idea in that paragraph.

Shorten it

When we write, we usually tend to use too many words rather than too few. Many of the things that we say or write are lengthy and sometimes even repeats itself.

When you summarize information, you take the unnecessary words away and only write the important information.

Rules for summarizing

The following procedure outlines the steps required for successful summarising of text:

- Scan the text quickly in order to gain an overall impression of its contents.
- Read through the text and underline the important sentences.
- Number the topic sentences in order of their importance to your summary.
- Evaluate the information gathered and ensure that there are no repetitions, unnecessary words, examples or illustrations in any of the topic sentences and key words.
- The summary should be given a title that captures the essence of the passage.
- The summary must be written in your own words. You can refer back to the original passage, but never copy whole phrases or sentences from it.
- The summary should be written in the past tense even if the original is written in the present tense.
- The summary must contain no repetition and no examples.

Check the summary

- Make sure that you have not introduced meanings and comments of your own that lie outside of the original text.
- Check that your sentences are short, to the point and written in your own words.
- Ensure that your summary is logical and accurate. Have you succeeded in getting across the

essence of the original text?

- Check whether your summary reads easily and flows logically.

SPACING REQUIREMENTS FOR PLANTING OF CROPS

SPACING BETWEEN ROWS AND INDIVIDUAL PLANTS

Plant spacing between rows and between individual plants is critical when establishing crops. Before ploughing the soil and planting, the farmer must plan for the particular crop being sown or planted. Plants that grow too close together will be stunted, whilst plants that grow too far apart will decrease crop productivity. Therefore, spacing needs to be calculated between rows, and between individual plants. A planting line is a useful guide to spacing, as are the instructions on seed packets and advice from the nursery or grower of the seedlings.

The depth of planting can vary and should be a little deeper when conditions are dry and hot, or if only rainfall is depended on. If water is freely available and the ground can be kept moist after sowing, then a slightly shallower seed planting can take place. Seeds should be planted no deeper than 2-3 times their size into the soil. Each crop will have its own specific requirements for depth of planting, it is important to research and consult with commodity experts over the ideal depth for your particular crop.

When planting a vineyard or fruit orchard it is very important to carefully plan to space between trees in a row and spacing between different rows to provide access to tractors and other implements. Remember that there is a break-even point between the number of trees in a row and to allow adequate growing space for each tree. E.g. it is not better to plant a hundred trees in a row if there is only space for fifty trees.

Example:

Cucumbers - 12 inches apart, 18-24 inches between rows, and seeds a half inch deep.

Muskmelon - 6 to 12 inches apart, 12 to 18 inches between rows, and seeds one eighth inch deep.

Pumpkin - 12 to 18 inches apart, 36 to 48 inches between rows, and seeds three to five inches deep.

Summer Squash - 24 to 36 apart, 18 to 48 inches between rows, and seeds one inch deep.

Winter Squash - 24 to 48 inches apart, 24 to 100 between rows, and one inch deep.

Watermelon - 24 to 72 inches apart, 60 to 100 between rows, and one inch deep.

Chapter 3

Crop Protection Through the Management of Pest Disease and Weed

In this session we explore the following concepts:

- The damage pests cause to plants
- Encourage natural enemies of pests
- Pests of crop plants
- Insect pest management
- Symptoms of disease
- Plant viruses
- Disease management strategies
- Weed descriptions and Weed control
- Old and new damage
- Monitoring methods
- Monitoring and interpretation of pests
- Implement a pre-application plan
- Plant protection products
- Application methods and equipment
- Protective gear and safety equipment
- Mixing pesticides
- Pesticide application
- Health and safety during application
- Post application procedures
- Reporting problems and dealing with emergencies

PEST MANAGEMENT

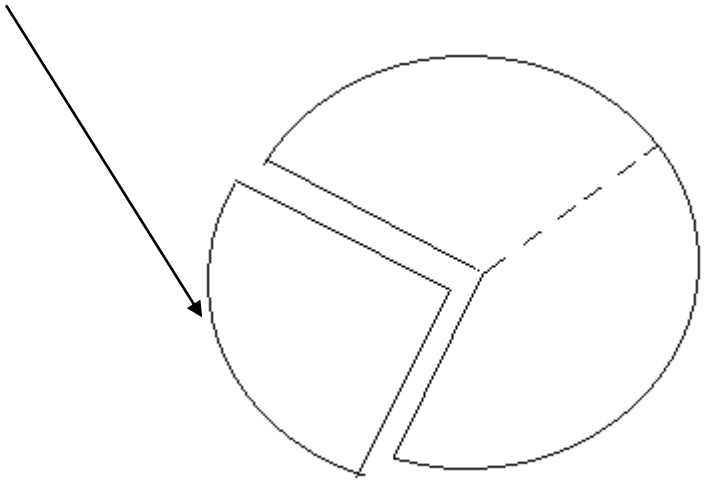
CONTROLLING PESTS AND DISEASES

Knowing about pests is important because pests cab damage large numbers of your plants.

Plants can be damage at any stage of their growth and when they are being stored. Pests cause the loss of one-third of all the food produced in the world.

The circle shows all the food produced in the world in one year.

This amount of food is destroyed by plant pests.



WHAT PESTS ARE

All pests are divided into 6 categories:

1. Arthropods (spiders, mites, insects)
2. Nematodes (earthworms)
3. Molluscs (snails, slugs)
4. Vertebrates (rats, snakes, etc)
5. Pathogens (viruses, fungi, etc)
6. Weeds (invasive plants, grasses, etc)

Plant pests are animals that feed on plants. Most pests are insects but other animals such as snails, birds, rats and monkeys also damage plants. You can easily see insect pests such as grasshoppers, beetles, aphids and caterpillars. Other pests, such as red spiders, are very small and look like specks

of red soil on the back of leaves. Nematodes, which are tiny worms that attack the roots and some types of mites are so small that you only see them with a microscope.

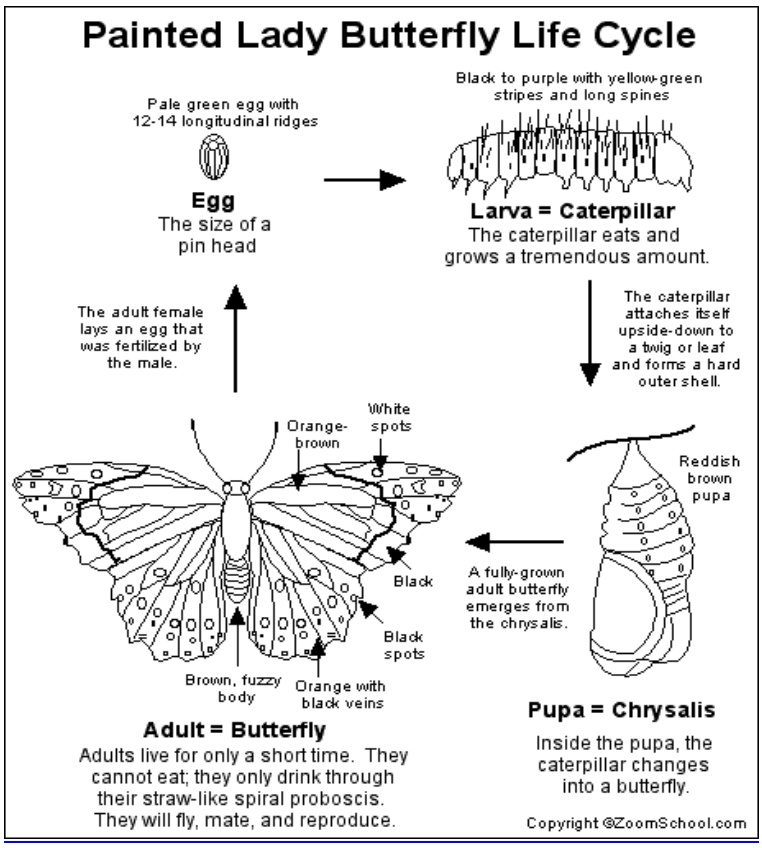
Grasshopper

Nematode

Red Spider Mite

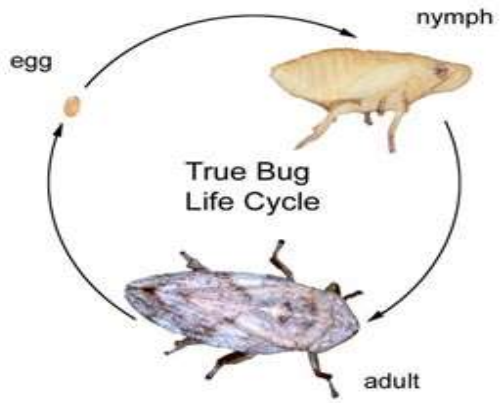
Insects multiply by laying eggs. They can have three or four stages in their life cycles. A life cycle is the time from when an egg hatches until the next eggs are laid. Knowing about the life cycle of a pest can help you to control it.

The four-stage life cycle:



In the four-stage life-cycle, larvae come out of the eggs. The larvae do not look like the adult insects. Once full grown, the larvae produce pupae in which they change into adults. Examples of insects with four-stage life-cycles are moths, butterflies, flies, beetles and bees. It is usually the larvae, not the adults, that damage the crop.

The three-stage life-cycle:



In the three-stage life-cycle, nymphs come out of the eggs. The nymphs are the same form as the adults but are smaller and softer and may be a different colour. Examples of insects with three-stage life-cycles are grasshoppers, termites, scales and bugs. By knowing the life-cycle of pests you can find out how to control them.

THE DAMAGE PESTS CAUSE TO PLANTS

Insects damage plants when they feed. Some pests feed on only one type of plant. For example, the larvae or caterpillars of the citrus swallowtail butterfly feed only on citrus such as oranges, lemons and naartjies. Other pests feed on many different types of plants. For example, the larvae of the Mediterranean fruitfly feed on citrus, mangoes, coffee, litchis, guavas, peaches, grapes, granadillas and may other types of fruit. When you see small worms in a fruit, they are usually fruitfly larvae.

The damage that plant pests do to plants depends on the way that they feed. Insects feed in one of two ways - either they chew, or they suck.

The types of damage that chewing or sucking insects cause are given below. You can use this information when you see that damage has been done to some of your plants and you want to find out what is causing the damage.

Chewing insects:

Insects that chew damage plants in the following ways:

- Chew large holes in the leaves. For example, many different types of beetles, grasshoppers and caterpillars.
- Some types of insects lay their eggs into fruit. The larvae which come out of the eggs then chew on the fruit. For example, fruit flies and codling moths.
- Chew along the surface or into the fruit. For example, bollworms and leaf roller caterpillars.
- Chew or bore into the wood of stems or roots. For example, termites and woodborers.
- Chew through the stems of seedlings. For example, cutworms.
- Chew holes in seeds. For example, weevils.
- Chew the flowers so that few fruit forms. For example, CMR beetles.

Bollworms

Weevil

Sucking insects:

Some insects suck the liquid out of leaves, buds, fruit, shoots, roots or branches. This liquid is called sap. Removing sap damages plants in the following ways:

- Leaves curl. Caused by, for example, aphids.
- Leaves or fruit are malformed or have strange shapes. This is often caused by sucking insects feeding on the leaf or flower buds. For example, mites or stinkbugs.
- Leaves are mottled or covered in small yellow marks. Caused by, for example, thrips and red spider mites.
- Shoots and branches die. Caused by, for example, scale insects.
- Brown, soft areas on fruit. Caused by, for example, fruit-piercing moths.
- Marks on the skins of fruit. Caused by, for example, scale insects, red spider mites and thrips.

Mites

Thrip

ENCOURAGE THE NATURAL ENEMIES OF PESTS

Plant pests are all parts of their own food chains and food webs. There are many animals that eat the pest animals which eat crop plants. These pest-eating animals, which we call predators or natural enemies, help t keep pest numbers down. Spraying with chemical pesticides kills the natural enemies as well as the pest insects. Examples of natural enemies of plant pests are lizards, chameleons, insect-eating birds including chickens and ducks, ladybird beetles and larvae, praying mantises, spiders, wasps and some fly larvae. Some wasps lay their eggs into the larvae of pest insects.

A wasp carrying a caterpillar to its nest

A ladybird beetle eating scale insect

PESTS OF CROP PLANTS

The process of managing problem insect populations is not always an easy task. It requires an understanding of the behaviour and life cycles of insects, as well as planning of a management strategy.

The section below provides a short summary of the characteristics of selected insects.

Ants – disturb plant beds and carry aphids to different plants.

Woodlice and slaters – feed at night on new plant shoots and surface roots

Gall wasps – commonly found on fruit trees causes swelling of stems and death of branches.

Identification and management of insect pests in crops is a specialized and difficult process. Those mentioned above are but a few of the thousands of potential pests associated with crops. As such, it is important to seek advice from a knowledgeable farmer or pest management expert to help you in planning a pest management strategy.

OTHER CROP PESTS

Other pests that damage crops are nematodes that damage the roots of plants. Slugs and snails damage plant leaves

Rats, moles and uncontrolled farm animals can damage crops. Suitable management strategies must be developed for such problems.

INSECT PEST MANAGEMENT

Insect pest Management can be done through various methods. A system, by which the different methods are integrated, is known as integrated Pest Management (IPM). Insect management methods are discussed below.

- Natural control – is concentrated around the environmental factor, which prevent increases in pest numbers and their distribution. It also includes the presence of natural pest enemies in the environment.

- Physical control – occurs when physical or mechanical action is taken to control a pest. It includes physical changes in the environment that will lead to control of the pest. Physical control methods include

- Physical removal of the pest by hand, [which is impossible in a crop situation]

- Mechanical exclusion of the pest such as fly screens on windows

- Mechanical traps i.e. those that are non-toxic, such as sticky traps and electric traps

- Manipulation of the environment has limited application but can be used with success in processes such as dehydration, low relative humidity and regulating temperature.

- Control through agricultural practices. Pest control through agricultural practices or cultural control is used in the large-scale cultivation of crops. It is relatively cheap and environmentally friendly. Such practices include:
    - Ploughing in of host plants for pests
    - Sanitation practices
    - Destroying of remnants of pest infested crops
    - Crop rotation
    - Mixed cultivation
    - Strip cropping
    - Establishment of trap crops
    - Cultivation of pest resistant crops

Biological control

Biological control is the manipulation of pest enemies such as parasites, predators and pathogens in such a way that pest numbers are reduced. Biological control agents for pests are specific to a pest species, and once established, can increase and spread independently, making the control self-perpetuating. The control is however expensive, slow and the pest cannot be eliminated even for short periods of time.

- **Genetic manipulation**

  Genetic manipulation of the pest or the crop plant can be employed as a pest control strategy. The release of sterile male pest insect into a normal population has been shown effective in parasitic fly pests in Central America. Sterilisation can be achieved through radiation of chemicals. The process is however expensive.

  Manipulation of the genetics of crop plants can produce pest resident crops. This can be achieved by producing a plant that will repel the pest, or the production of a crop that produces toxic compounds. An alternative is a crop plant where growth is stimulated through insect attack, the crop thus compensates for the losses due to the pest.

- **Chemical pest control**

Chemical pest control is done by using pesticides. The term pesticides refer to the wide spectrum of agrochemicals used in plant protection. Pesticides include herbicides (plant or weed killers), insecticides, rodenticides (rodent killers), avicides (bird killers), molluscicides (snail killers) and acaracides (mite killers). Insecticides are classified in three major groups according to their mode of action, (a) the contact insecticides, (b) systemic insecticides and (c) those with stomach action. Contact insecticides enter the insect primarily through the exoskeleton and do not penetrate the leaves and are not translocated through the plant, whereas systemic insecticides must be taken in through feeding. The compounds are taken up by the plant and translocated throughout the plant. Insects with sucking feeding habits are the primary targets of systemic compounds. Stomach poisons must be ingested and is absorbed in the stomach of the insect. Fumigants are pesticides in a gas form and enter the insect through the respiratory system. Pesticides with trans-laminar action, penetrate the leaves of plants, but are not translocated through the plant.

- **Pesticide formulations**

The first step in the production of a pesticide is the production of the chemical compound, which has insecticide activity. This compound is known as the active ingredient (a.i.). For the compound to be effective it has to be applied to a crop field. Even older compounds are applied at relatively low rates, e.g. 1 kg spread over one hectare (10 000 m2). It is impractical to apply a pesticide as technical material, and an easier way of distributing a pesticide is diluted in water or in a powder. Often the active ingredient is not soluble in water but the compound is formulated in such a way that it can be diluted in water and then applied. A pesticide formulation is made up of the active ingredient, solvents that aids in water solubility or water miscibility, inert additives and adjuvant (compounds that aim uptake of an active ingredient). The relative amount of a.i. in the formulation is indicated on the label as a percentage (g a.i. per 100g or 100 ml).

Pesticides are available either as dry– or liquid formulations.

Dry formulations are sold as dusts (applied as is), granules (applied as is), baits (used as is), wettable powders (to be made up in water) and soluble powders (to be made up in water).

Liquid formulations are sold as emulsion concentrates (turn milky when diluted with water), soluble concentrates (used in dilution in water), Oils (used as is), Ultra low volume formulations (used as is), encapsulated formulations (used in dilution with water).

RECOGNIZING COMMON SYMPTOMS OF DISEASE

A plant disease is a disturbance brought about by a factor, which interferes with the manufacture, transport and utilization of energy sources or mineral nutrients and water in such a way that plant growth is negatively affected. Plant diseases are caused by pathogens and environmental factors. A plant pathogen is an organism which grows on a plant which provides growth factors. These organisms are generally not capable of producing their own food sources. The pathogenic organisms that cause disease are funguses, bacteria, mycoplasms, viruses and nematodes. Environmental factors which can cause plant diseases include temperature extremes, soil moisture extremes, and light extremes, lack of oxygen, pollutants and nutrient stress. This section deals with the pathogenic origins of plant diseases.

FUNGAL DISEASES

- ✓ Fungi cause fungal diseases.
- ✓ Fungi are plants that do not contain chlorophyll and thus they are not green and cannot convert sunlight energy to chemical energy.
- ✓ Fungi cannot produce carbohydrates for own usage.
- ✓ The vegetative parts of fungi consist of thin filaments known as hyphae, which masses together form a body, or a mass known as a mycelium.

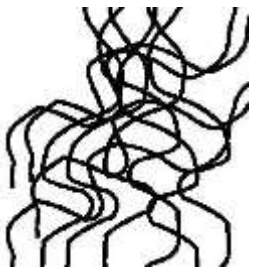


Figure 3.7 Diagrammatic representation of the fungal filaments, known as hyphae (left) and a hyphal mass known as mycelium (right)

- ✓ Fungi reproduce vegetative through the filamentous hyphae and sexually through spores.
- ✓ Fungi as a group is divided into two sub-groups, the slime moulds (lower fungi) and the true fungi (higher fungi).
- ✓ Disease- causing fungi are found in both these groups.
- ✓ **The lower fungi** – diseases are caused by three distinct groups of lower fungi. These diseases are discussed below:

    - ❖ Diseases caused by lower fungi without hyphae - are soil borne diseases that have a limited host range. The fungi rest and survive as resting spores in soil or in infected plants. They spread through movement of infected plant material, soil and water. Diseases of this nature are clubfoots in crucifers, powdery scab and wart disease in potato and maize brown leaf spot
    - ❖ Diseases caused by lower fungi with hyphae and zoospores – these fungi produce mycelium, form resting spores, produce living swimming spores (zoospores) which infect plants and spread through infected soil, infected plant material and through airborne sporangia. Examples of these types of fungal diseases are downy mildew and late blight.
    - ❖ Fungal diseases caused by lower fungi with hyphae but without zoospores - produce mycelium, produce air-borne thin walled spores and are generally weak parasites which grow on dead plant material. These fungi will attack live plant tissue only if the plant is under stress. Examples of these diseases are pumpkin fruit rot, vegetable soft rot, and bread mould and fruit rot.

- ✓ **The higher fungi**

    - Sooty moulds - causes a flat black coloured film on leaf surfaces which can be rubbed off, leaving a clean surface. It is common in warm, humid areas and is found on all crops. The organisms are not parasitic but use sugary excretions from aphids as food source. The primary damage caused is lowered photosynthetic rates.

- Leaf curl – causes leaf blistering and swelling that lead to leaf curl. Blisters are hollow and are found mainly on stone fruits. The disease leads to leaf drop which could weaken trees. The fungus survives in the buds of trees.

- Powdery mildew – A common disease, white to grey in colour, covering either the entire leave or part of it and usually on both sides of the leaf. It is found on young tissues and only grows on the plant surface. They are parasites and infestations are most severe under warm, dry weather conditions.

- Foliar diseases – generally leaf-spots and blights but may also affect other plant parts. May survive in soil or on plant debris.

Figure 3.8 Illustration of potato leaf infected with late blight.

This disease also causes lesions on stems, and brown patched on the skins of tubers rendering tubers unmarketable.

- **Alternaria** – a disease in annual crops causing leaf-spots and blights may also cause damping off, collar-, fruit- and tuber rot. Common on older plant tissues under nutrient stress. Numerous dark leaf-spots usually occur on affected plants. Survive on debris and seed.

- **Cercospora** – small, separate leaf-spots, circular to triangular in shape. Found on broadleaf and grass species. Under humid conditions grey mould lesions are visible. Spores are airborne with the disease in most severe under warmer conditions.

- **Septoria** – small leaf-spots that may join to form blights. Leaves become chlorotic. The infection starts on the lower, older parts and gradually progresses upwards.

- **Helminthosporium** – major disease in grass crops, causing leaf-spots and blight as well as crown and root rot.

- **Stem and twig canker** – start where the branch or twig is injured, or at the joint of a dead branch or twig. Cankers can kill branches and twigs; the infection is counter acted by the callus formation.

- **Anthracnose** – dark spots or sunken lesions on the leaves, stems, shoots and fruit. Survive on plant debris.

- **Ergot** – common on grass species, produce honey dew in infected florets, which is replaced by hard purple black fungal masses called sclerotia. These are toxic to animals and humans.

- **Botrytis** – common in glasshouse grown crops, causing blossom blight and fruit rot. Grey to brown mould surviving on debris.

- **Vascular wilt** – fungi grow in the vascular systems of the plant, blocking the water transportation, leads to wilting of plant tissues. Fusarium and Verticulum are soil borne fungi, which are difficult to control.

- **Post-harvest decay of fruit and vegetable products** occurs after harvest. Wounding of produce and high temperatures and humidity increases decay.

- **Post-harvest decay of stored grain** – is often initiated in the field and causes decay and discoloration of grains decreasing marketability. Some species produce mycotoxins.

- **Rust** – attack many hosts but causes the highest losses in staple crops damaging mainly leaves and stems. Rust to yellow coloured pustules form with gall formation. Rusts are parasitic and generally not systemic.

- **Smut** – mostly affect the ovaries of grain crops, but also attack leaves and stems. May become systemic that can cause stunting. Survive on debris and seed.

- **Rhizoctonia** – root and stem disease, which is soil borne and difficult to control. Survives in soil or in plant material. Symptoms include damping-off, wire-stem, cankers, root lesions, rot and potato black scurf.

- **Sclerotonium** – common in wet areas, causes damping-off, stem canker, crown blight and rot, fruit rot and wilt.

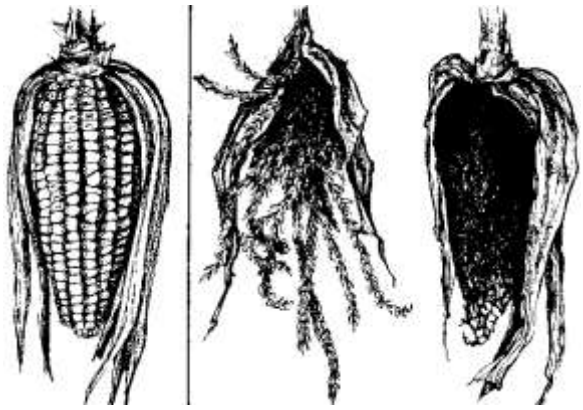


Figure 3.9 Cob and tassel smut in maize plants (right). The cob on the left is healthy.

BACTERIAL DISEASE

Bacteria are small, simple unicellular living organisms. There are four main shapes of bacteria namely spherical, rod-shaped, helix and comma shaped. All plant disease-forming bacteria are rod-shaped, with the exception of Streptomyces, which are filamentous. The reproduction of bacteria is simple, through cell division. Some bacteria are mobile through flagella, but mobility is limited to short distances. Bacteria multiply quickly if food sources are available and may reach a million within hours. They occur in almost all plants.

Disease forming bacteria may survive in soil, without the presence of the host plant, whilst others disappear as infected plants are removed. The main dispersion mechanism for bacteria is rain and water, but they can also be spread through the transport of infected plant material, insects or animals.

Bacterial diseases are classified according to the symptoms they produce.

- **Spots, steaks and blights** – these bacteria cause stripes and spots on the leaves, stems and fruit of crop plants. The bacterial blights and the leaf spots can flow into each other. Symptoms are necrotic spots, circular spots with a halo around it. When limited by leaf veins, the spots may be angular. On grass crops the symptoms are streaks and stripes rather than spots. Shot hole effects are visible when the infected tissues fall out.

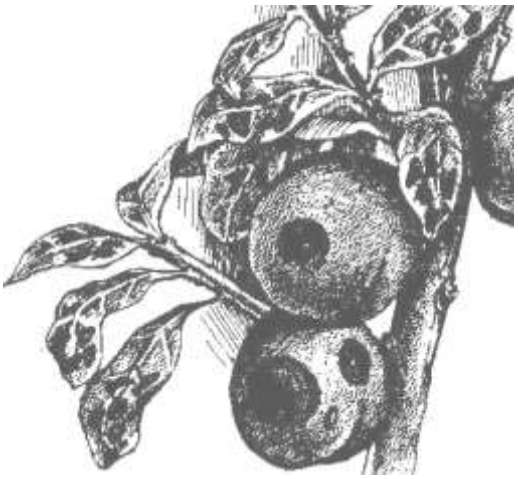


Figure 3.10 Bacterial Black Spot on plum fruit and leaves.

Vascular wilt – found mainly on herbaceous crops where the bacteria multiply in the vascular tissue, eventually blocking the transport system. The end results are wilting of the plant and eventual die-back. Discoloration of vascular tissues is not uncommon.

- **Soft rot** – enters plant tissues mainly through wounds and could spread through storage. Leads to separation of plant tissue cells and tissue collapse.

- **Galls** – crown gall in woody species is caused by a bacterium.

- **Cankers** – causes splits and cankers in woody tissues. Spot formation on leaves and fruit and die-back of buds and blossoms.

- **Scab –** the bacterium enters the plant tissue, causing the plant cells around the point of entry to divide, forming layers of corky cells, pushing the infected tissue out and forming of scabs.

➢ PLANT VIRUSES

Viruses are smaller than a cell and can only multiply within a cell. A large number of viruses are known, and a plant can be infected by more than one at the same time.

The major symptoms of virus infections are; reduced growth, colour mosaics, ring-spots, stem pitting, chlorosis and leaf roll.

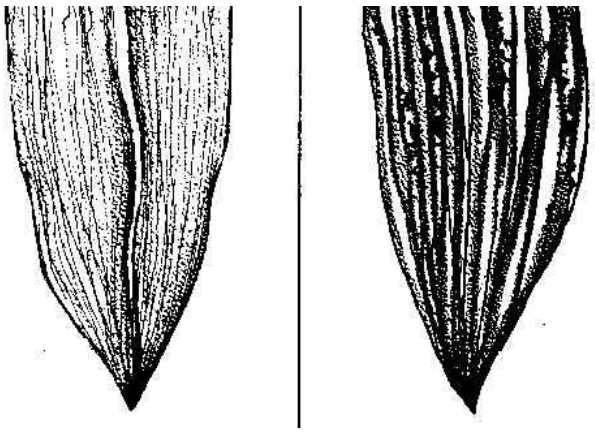


Figure 3.11 Chlorosis caused by maize streak virus. (Streaks on maize leaves)

Viruses are classed in one of five major groups according to their morphology.

- **Rigid rod-shaped viruses** – they are rod shaped in the range of 300 nm by 15 nm with the RNA in the centre. Tobacco Mosaic Virus is an example of this type of virus.
- **Flexible rod-shaped viruses** –they are longer and thinner than rods. An example is beetroot yellow disease virus.
- **Icosahedric shaped viruses** – the surface consists of 20 identical flat planes, with the RNA is in the centre. (e.g. Cucumber mosaic virus)
- **Bacillus-shaped viruses** – these are the bullet-shaped viruses, such as the Lucerne mosaic virus.
- **Viruses with double string RNA** – some viruses such as the rice dwarf virus have a double string of RNA.
- **Large membrane viruses** – these are almost spherical structures and are surrounded by a membrane

    - Viruses are not transmitted through rain or wind.
    - Virus transmission requires a vector.

- Viruses can be transmitted through movement of plant sap from infected to uninfected plants, such as in grafting.
- Viruses are transmitted through infected seed stocks, pollen, fungi and especially insects.

The most virulent plant diseases are transmitted through insect vectors.

DISEASE MANAGEMENT STRATEGIES

The control of plants diseases rests on five basic principles; exclusion, eradication, protection, resistance breeding and certification.

- Exclusion of a disease is based on excluding a disease from an area where the disease in not yet present. Total exclusion is not practical, but it can be achieved to some extent through using pathogen free propagation material. For this to be implemented fully, a well-managed certification scheme is required.
- Eradication – eradication of a pathogen is targeted at the survival of the pathogen and is aimed at eliminating of the pathogen-forming area.
- Protection – focuses on the protection of the plant against the pathogen. Protection places a barrier between the crop plant and the pathogen by the implementation of a chemical spray programme for a crop.
- Resistance breeding – is the process where the genetic composition of the crop is manipulated so that the crop resists the attack from a pathogen.
- Certification – includes introducing quarantine measures, as well as certifying propagation materials as disease free. (Limiting the transportation of potentially infected material from a high risk to a low risk area is also included in the certification system.) The success of a certification system relies on good management and the introduction of an inspection system.

CHEMICAL CONTROL OF FUNGAL DISEASES

Chemicals used in the control of fungi are called fungicides. Chemical measures are introduced to aid in eradication of diseases, protecting the crop against diseases and curing the crop from an existing disease.

- Eradication of plant diseases involves the control of the target pathogen while the pathogen is still on the outside of the crop plant. This is being done through seed treatments and soil fumigation before planting.

- Protective measures are measures taken to place a chemical barrier to the outside of the plant or a systemic compound within the plant. The chemical is applied before the pathogen is present in the plant.

- Curative measures are steps taken once the pathogen has already penetrated the crop. For this type of control, the chemical must be taken up by the plant, and must therefore have either a trans-laminar action or a systemic action.

- Eradicating or curative fungicides kill the disease on or inside the plant once the disease has developed. Protective fungicides form a protective layer around the seed or crop, killing fungal spores during their germination.

Fungicides are divided into three major groupings:

- Systemic fungicides are taken up by the plant and are trans-located within the plant throughout the plant

- Trans laminar fungicides are taken up by the leaves, but are not trans-located through the plant

- Broad-spectrum fungicides refer to fungicides that are effective against different funguses.

WEED MANAGEMENT

WEED DESCRIPTIONS

There are approximately 200 plant species that make up the world's most important crop weeds.

These species are spread over approximately 12 plant families. These 200 odd species have some common characteristics, which make them important weed species. These characteristics include high seed viability, rapid seed emergence, rapid initial plant growth, strong competitors and the production of large numbers of seed.

Weeds do not fall outside the classification of plants. The major groupings important in weed management, are broad-leaved weeds and grass species. Approximately two thirds of the important weeds are broad-leaved weeds, the rest are grasses, sedges or ferns.

Weeds can be further classified according to the time it takes for the plant to complete its life cycle. There are three groups of weeds classified according to the time for completion of the lifecycle as Annual weeds, Biennial weeds and Perennial weeds. Approximately two-thirds of this important weed species are annuals, with the rest predominantly perennials with only a small proportion being biennial plants. The lifecycle of a plant is defined as the time from seed emerging to the time of seed production i.e. from seed to seed.

- **Annual weeds**

Annual weeds complete their life cycle in one growing season, thus in less than one year. Due to their short lifecycle annuals produce large numbers of seed and grow very rapidly. These plants are sensitive to weed control practices.

Annual weeds can further be divided into two groups. Summer annuals, which germinate in the spring or early summer, grow in the summer, mature and form seed in the autumn. Summer Annuals complete the cycle seed to seed across two calendar years but in one growing season. Winter annuals germinate in autumn or early winter and mature and form seed in spring or early summer. So winter annuals complete the cycle in one calendar year and in one growing season. Annuals do not live for time periods exceeding 12 months and reproduce primarily through seed.

- **Biennial weeds**

Biennial weeds live longer than one year but not longer than two years. Biennial weeds usually have a fleshy tap root system for the storage of food sources. Biennials are not abundant in South Africa.

- **Perennial weeds**

Perennial weeds reproduce every year through vegetative organs such as rhizomes and stolons, bulbs and tubers, root and stem cuttings and can generally also form seed. Perennials can be sub-divided into two groups; namely simple perennials and creeping perennials. Simple perennials reproduce only by means of seed. Should the shoot of a simple perennial be damaged, new buds can form. Creeping perennials reproduce through seed and vegetative parts. Vegetative reproduction usually occurs through creeping surface roots or stolons, underground stems or rhizomes, tubers and bulbs.

Weeds are generally known by common names that may be unique to regions of the country. There are approximately 5 species of weeds that are all known as the “Khakie-bos”. Within the scientific community this problem of confusing species is overcome by specific scientific, Latin names.

It is useful to learn the Latin names of weeds rather than common name, in order to avoid the potential confusion of species.

WEED CONTROL

Weed management can be done by applying various methods:

- **Preventative weed management**

Most weeds produce large amounts of seeds per growing season that build up as a 'seed bank' in the soil. The seed of many weed species also have complicated dormancy behaviour with the result that all the seed do not germinate when conditions are favourable. Weed seed produced in the same season can therefore germinate over an extended period of several years. It is therefore important to prevent weeds from producing seed. Suitable cultivation techniques should be applied to ensure weeds are controlled early, before they become competitive. The use of mulch is effective in preventing seed germination and weed growth. Pruned leaves and branches, straw, bark mulch, or black plastic will control weed growth considerably. However, you should ensure that especially pruned leaves and branches are well composted before applying as mulch, as these could carry diseases that could infect the crop.

- **Biological control**

Some insects and animals can be used in certain crops to keep weeds under control.

- Mechanical weed control

  In fruit orchards weeds between rows are slashed by means of hand- lashers or machine lashers pulled by tractors. In agronomic crops weeds between rows can be removed using specialised machinery. Weed slashing involves walking along the rows of the crop, slashing the weeds with a hoe, leaving the weeds on the ground as mulch.

- Chemical control

  A very effective way of controlling weeds is by using chemicals known as herbicides. An herbicide is a chemical specifically designed to control killing plants. Herbicides are developed with specific modes of action. In broad terms there are two main groups of weeds, the broad-leaved weeds and grasses. An herbicide like 'Roundup' will kill both narrow as well as broad leaf weeds, including annual crops.

When using herbicides to kill weeds, care must be taken not to accidentally use a broad leaf herbicide on a broad leaf crop or visa versa. Herbicides can be highly poisonous and must be used very carefully, and only with competent handlers and equipment.

Remember:

It is impossible to remove all weeds from a crop as new infestations occur regularly. It is best to keep a weed problem under control, trying to remove weeds before they get the chance to form seed.

OLD AND NEW DAMAGE IN CROPS

INTRODUCTION

It is important to observe a growing crop closely. Insect and disease damage can occur literally overnight. Farmers must be aware of the condition of the crop at all times. Crop rows may be hundreds of metres long or consist of thousands of individual plants; therefore, one cannot monitor all the plants all the time. It is thus wise that the farmer selects a number of control plants or groups of plants that represent the condition of the plants on a crop field as a whole. These plants should be marked and individually numbered, enabling them to be repeatedly visited and their conditions checked. This process is known as monitoring.

The plants are monitored on a regular basis for the following reasons:

- Leaf condition (whether there are spots, chew marks from insects etc)
- Growth rate – measured with a ruler and recorded over a period of time
- Plant condition – poor, average, good or excellent
- Any pest or disease infection visible and the stage of infection
- Weed status and stage of development

Upon regular inspection, the farmer can visit each of the monitored plants and monitors their condition for the above features. These results of monitoring must be recorded, even if it is only recorded that plants are healthy. If the condition of the plants changes over time, any problem that develops can be managed as soon as it develops.

Regular monitoring of crops is important as it allows the farmer to distinguish between old damage on leaves and fruits that has already been treated, and new damage that might need treatment. For

example, grape vines may suffer from mildew in late spring when humidity is high. The farmer will treat the crop with a fungicide to destroy the mildew. On revisiting the crop in late summer, damage on the leaves of the grape plant will remain, even though the disease has been treated. Regular monitoring of crops makes it possible to differentiate between old and new damage and infection. Monitoring should also include environmental conditions like wind, rain hail and temperature readings.

There are approximately 200 plant species that make up the world's most important crop weeds.

MONITORING METHODS

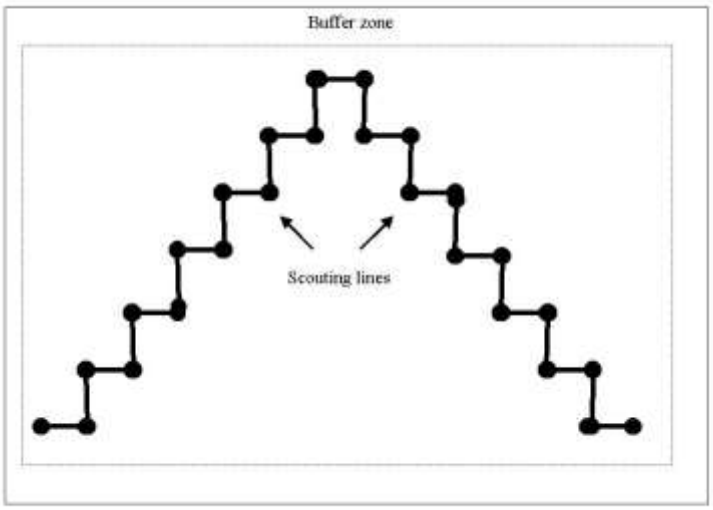
In order to prevent crop damage from insects and diseases it is essential that crops be inspected regularly. These inspections should be done regularly and could be done in conjunction with inspections for weed densities and crop nutrient and water status.

Crop monitoring indicates the pest's status and extent of the crop diseased. In this way the crop producer remains informed of the health status of his crop. Information on the crop disease and pest status enables the farmer to make decisions on whether control actions need to be taken and select a suitable control action. In this way the farmer can e.g. treat crops chemically as and when required instead of according to a strict spraying programme. In this way the amount of pesticide applied, and labour inputs can be reduced, also reducing the crop production costs.

The monitoring process is generally known as scouting. Scouting is used to identify pest species present as well as the extent of infestation of the pest. This can also be applied to crop diseases. In the case of crop diseases, it is not always possible to identify a disease or revere it to an expert in diseases. Thus, when monitoring for crop disease, the scouting process is aimed at identifying symptoms of disease, rather than collecting, identifying and counting individual pests. Plant samples can be collected for identification by experts.

Pest control programmes are based on infestation thresholds as well as economic thresholds for pest control. This programme must also take into account the growth stages of the crop plant and relate this to pest infestation rates. This aids in evaluating the vulnerability of the crop and the potential for damage that exists. The occurrence of natural pest enemies and pathogens must also be taken into account in the monitoring process.

The monitoring process starts with surveys. Monitoring techniques exist to aid in crop survey.



The two most useful survey techniques: the trans-ect and stepwise method, scouting or placement of traps. Both techniques require the investigator to walk through a field and at set intervals he stops, sampling, scouting or counting the area. Where scouting is done for diseases, the monitor should collect leaf, shoot, bud and fruit samples for identification by experts. Where the presence of diseases is suspected, samples must be collected and sent for analysis and identification by an expert.

The transect method involves scouting along a line across a field. The line can be diagonally across the field or parallel to the side of the field.

Using the transect method; a minimum of five sampling points per hectare should be selected.

When using the stepwise scouting method, the scout starts in the middle of one side of the field.

The scout moves forward and to his right stopping at pre-determined distances. Once he has crossed the whole field, the scout moves to the point of origin and repeats the exercise, but now moving forward and to his left. A maximum distance of 5 m should be used as a pre-set distance.

Once samples of insects or diseased plant parts have been collected the insects and diseases are identified. Counts of the number of pests are done to determine infestation rates. Based on the identity of the pest and degree of infestations, taking in account the crop- and environmental information, a management strategy can be implemented.

At the pre-determined intervals, using any of the scouting methods, sampling techniques for insect collection can be used. Sampling techniques generally used in pest monitoring are explained below:

- Shake and beat method: place plastic sheeting under the plants, then either shake or beat the plants with a stick and collect the insects which falls on the sheeting.

- Knock- down sampling: an insecticide is applied to a small area within the target area, which kills all insects present. Similarly, to the shake and beat method, insects are collected on a pre-set plastic sheet.

- Baits containing insecticides: can be used to attract and sample insects. Insecticide in laced molasses is an example.

- Mites can be sampled by brushing the crop leaves onto a glass sheet. Alternatively, the mites can be brushed onto paper, the paper flattened and the stains on the paper counted.

- Sweep nets are used to sample flying insects such as leaf-miners. The nets, made from suitable material, are swept across the plants, collecting the insects.

- Malaise traps are used for active insects and consists of a net with an opening on one side. (Looks like a tent) A container for trapping the insects is placed at the highest end.

- Sticky traps are made from strips covered with sticky substances on the surface. The sticky trap can be baited to attract certain species. The trapping efficacy of these types of traps is influenced by environmental conditions and the positioning of the trap.

- Water traps are suitable containers, containing water to which a soapy substance and a preservative is added, erected 1 m above soil level. The traps are suitable especially for trapping aphids.

- Sucking traps are basically modified vacuum apparatus, which sucks the insects into a net.

- A light trap is a lamp, usually ultraviolet, surrounded by a vertical baffle at the top of a funnel–shaped container, and a sampling container at the bottom.

- Pheromone traps are used for moths and butterflies. Pheromones (sexual hormones) of the targeted species are placed in a suitable container. The traps are set up over a large area and are suitable for monitoring of populations and also for pesticide application timing.

- Pit fall traps are containers, with a small volume of preservative, which are placed into the soil so that the open end is level with the soil surface. These traps are effective for insects that live on the soil surface.

SOIL SAMPLING

Soil sampling for soil dwelling insects can be done by using and auger soil coring device or a blade sampler. It is important that the volume of soil is known, so that the infestation per volume can be calculated.

MONITORING AND INTERPRETATION OF PEST

- **SCOUTING**

Monitoring for pests is commonly known as scouting. Scouting is aimed at identifying any pests, such as insects or signs of disease, present and assess the potential of the insect or disease becoming a problem and estimate the extent of damage. Because different pests occur throughout the life of the crop (some pests destroy seeds, other destroys leaves and other destroys fruit), weekly inspections are recommended.

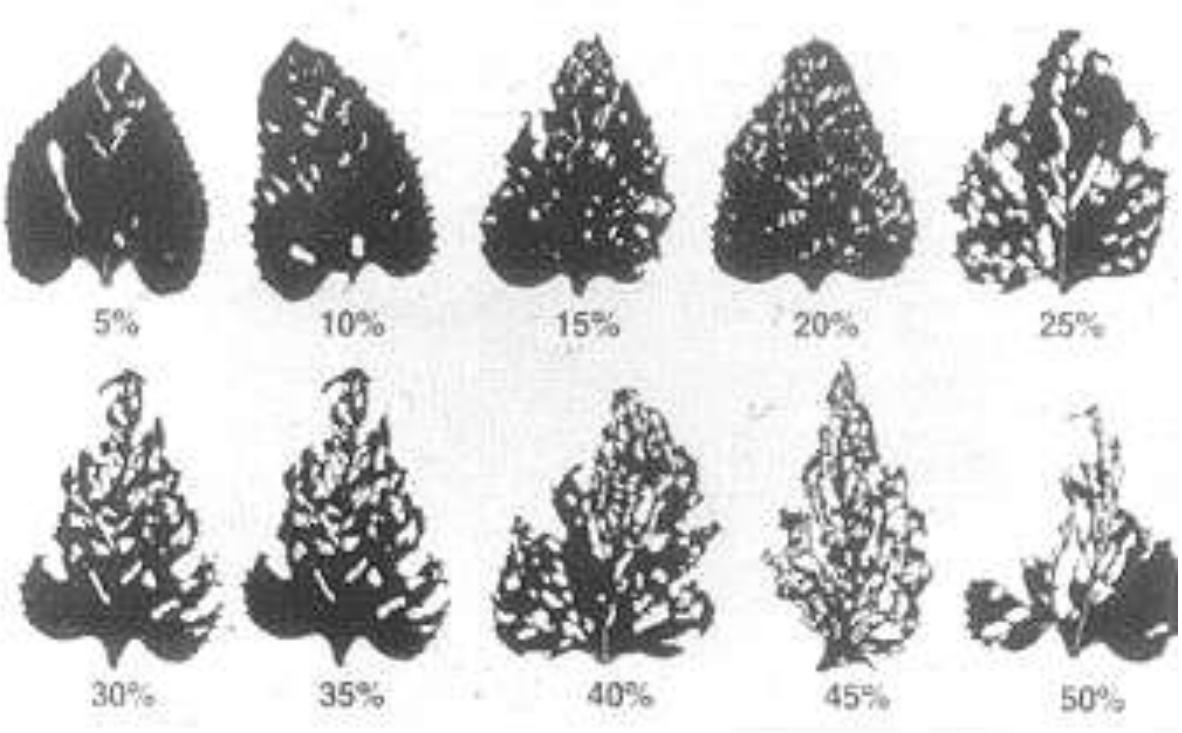
Scouting should occur before any control treatment is applied and again after treatment. This will indicate the impact of the treatment on the problem.

Pests such as grasshoppers can be observed, and their population size estimated by walking slowly through the field and making careful observations. Others, like fungal infections, or small insect like trips may require the use of a hand lens for observation. Monitoring for certain pests may require the use of specialized equipment or techniques such as nets or traps.

A large round net with a long handle can be used to sample flying insects on a crop. Walking along crop rows and swinging the net above the top of the crop will allow the capturing of flying crop-damaging insects. Insects can be collected in the bottom of the net for study and identification purposes.

- **ESTIMATING PERCENT LEAF DAMAGE**

Impacts on crops are calculated by estimating the percent leaf damage of the affected plants. Although the figure below is for sunflower leaves, the system can be used as a guide to estimate the percentage insect damage or percentage fungal infestation. If the picture of a leaf is used as the outline of a tree or crop plant, the system can be applied to score the extent of damage induced on a plant or tree.



Source: University of Missouri

The farmer will have a reasonable idea as to the extent of leaf or plant damage that the crop can tolerate. Different crops respond to different levels of damage. Therefore, it is important to have an accurate understanding of potential damage. Likewise, a certain number of insects on a crop is inevitable; an insecticide will not kill all problem insects. There will be a certain number of insects that can live on the crop that the farmer would consider an acceptable level.

- **RECORD KEEPING**

It is critical that all information gathered during scouting is accurately recorded. Information must be recorded before the application of the pesticide, and again after the treatment. These notes will be vital for you to be able to determine whether the crop treatment (such as pesticide application) was successful or not. Make sure that enough time is allowed for the treatment to become effective before the post treatment monitoring is conducted.

- **HYGIENE**

The spreading of weeds, disease and insect pests can be encouraged through poor hygiene practices on the farm. The aspects that are important include:

- Cleaning equipment such as shoes, tools, tyres and vehicles between sites or infestations.

- Close examination of nursery plants, seed, and imported soil or media to be used on the crop.
- Screening of irrigation water where weed seed contaminates surface water transported in canals and rivers or stored in lakes or ponds.
- Control of weeds and seed sources around the field or site.

IMPLEMENT A PRE-APPLICATION PLAN

INTRODUCTION

Crops attract a great variety of pests and diseases that cause external and internal damage to the crop and plant.

Although some pests and diseases in a field or orchard are controlled manually, the greater majority are controlled through the use of chemicals. The crop protection application methods covered in this unit standard refer to the chemical control of pests and diseases.

The term *Crop Protection Manager* is used in this learning material when referring to the person responsible for the implementation of the crop protection program. In practice, this function may be fulfilled by the farmer or the general manager of the farming operation.

Proper planning for protecting crops from pests and diseases is critically important. Poor planning could result in financial losses due to a reduced crop or a poor-quality crop, and possible damage to the health of trees. Time and money will also be lost if incorrect or unnecessary applications are made.

Planning entails two steps. Firstly, a crop protection program is compiled to control the pests and diseases commonly found in the area where the farm is located. The crop protection manager decides which chemicals to use, in what concentration to apply the chemicals, and the schedule of application. This information is incorporated in a crop protection program, which is normally compiled before the start of the season and strictly adhered to as the season progresses. There may be minor changes made during the season if circumstances in the field change.

Pre-application planning is done before each stipulated application on the crop protection program and may be best accomplished by using a simple checklist. We will look at the checklist at the end of this session, after considering the various components of this planning process.

A proper plan for the application of plant protection products, a thorough understanding of the following components is required:

- Plant protection products
- Application methods
- Application equipment
- Health and safety

PLANT PROTECTION PRODUCTS

The first step in the pre-application planning is to identify the product indicated in the crop protection program. Plant protection products are generally classified as insecticides, fungicides or herbicides.

Definitions:	
Pesticide	The overall term used for all classified Crop protection products (CPP's) or agro-chemicals.
Insecticides	Insecticides are plant protection products (PPP's) that are used to control insects.
Fungicides	Fungicides are plant protection products (PPP's) that are used to control fungi.
Herbicides	Herbicides are plant protection products (PPP's) that are used to control weeds.

✦ **Plant protection product registration**

Only chemicals that have been registered with the National Department of Agriculture in accordance with Act 36 of 1947 are permitted for use in South Africa. These products are listed in the following Government publications, which are updated from time to time:

- Guide for the Control of Plant Pests
- Guide for the Control of Plant Diseases

There is a section in these publications covering citrus pests and diseases where remedies for specific problems are listed. If these books are not available, the crop protection manager may need to consult a representative of one of the agrochemical companies.

✦ Plant protection product identification

The first step in identifying a product is to consult the chemical label. All chemicals must, by law, have a label on the container when it is supplied to the end-user.

The following information appears on the product label:

- Full instructions on how to use the chemical are indicated, together with detailed information on the uses for which the product is registered. The instructions must be read carefully and adhered to strictly. This will ensure that the best results are attained, that the safety of the user and others is not at risk, and that the environment is not excessively harmed. It is an offence to use a chemical in a manner for which it was not registered.

- A physical description of the product is supplied, including its colour and whether it is in fluid, powder or granular form. The crop protection manager should inspect the chemical in the container to ensure that it answers to this physical description. If not, the container and its contents should be discarded in the prescribed manner.

- The chemical composition of the product is indicated on the label.

- The toxicity of the product is indicated, along with instructions for its safe handling.

- The pre-harvest interval (PHI) of the product is indicated. The PHI, also known as the Withholding Period, refers to the period after application of a chemical treatment during which time the fruit may not be harvested. PHI's vary considerably from chemical to chemical and need to be checked by the crop protection manager when he compiles the crop protection program. It must also be checked as part of the pre-application planning.

- The product expiry date is stated, being the date on or before which the chemical should be used. Chemicals should be used before the expiry date to make sure that the chemical is still effective.

Please Note: All chemicals leave a residue on the fruit. There are very specific regulations regarding the chemical residue levels that are allowed, especially if they are exported. Minimum residue levels (MRL's) are prescribed for all plant protection products registered with the Department of Agriculture. The PHI indicates the period of time during which the chemical residue will be too high and beyond the regulatory limits. During this time the fruit must not be harvested.

- **Plant protection product availability**

The crop protection program indicates the concentration at which the product must be used, and the quantity required per tree or hectare. It may also indicate the total quantity of a chemical required for the application, but if not, the crop protection manager can calculate this by using the information provided.

The crop protection manager must ensure that a sufficient quantity of the chemical is available before application commences. In this regard, he needs to consult with the person in charge of procurement (buying) and the inventory manager.

APPLICATION METHODS

Plant protection products can be applied in various ways. The manner of application should be stated on the crop protection program.

Application methods include:

- Foliar spray application
- Trunk application
- Soil drench

There are many variations of application methods. The decision on which method to use depends on the specific requirements and purpose.

- **Foliar spray application**

The most common method of applying insecticides and fungicides to plants (trees on an orchard farm) is by applying a foliar spray. This means that the spray material is applied to the leaves of the trees. There are three main types of foliar spray applications, being:

- Light cover spray
- Medium cover spray
- Full cover spray

Light Cover Spray

As the name suggests, these sprays are applied at low volume and with a light covering of the tree canopy. The droplet size is small; therefore, the spray is applied in a fine mist. The application of chemical bait is usually done by aerial spraying at low volume.

The volume of spray material applied per tree during a light covering spray varies, depending on tree size and shape, but ranges from half a litre to three litres per tree.

Medium Cover Spray

Medium covering sprays are the most commonly form of application. It wets the foliage of the tree to the point of run-off. (Run-off means to the point where water starts dripping from the leaves.)

The tree canopy is not necessarily penetrated, but some of the branches may be slightly wet.

The volume of spraying material applied per tree during a medium cover spray varies, depending on the size and shape of the tree, but ranges from 10 to 20 litres per tree.

Full Cover Spray

Full covering sprays are designed to thoroughly wet the tree canopy and to penetrate the inside of the canopy, drenching the branches and framework of the tree as well.

The volume of spraying material applied per tree during a full cover spray varies, depending on the tree size and shape, but ranges from 20 to 50 litres per tree.

- **Trunk application**

Some chemicals can be applied directly to the trunk of the citrus tree. These chemicals are systemic, meaning that they are absorbed through the bark and being translocated within the tree to the area where they are required.

- **Soil drench**

  This method implies the diluting of a chemical in water and pouring it onto the soil around the trunk of the tree where it is absorbed by the roots and translocated within the tree. These chemicals are also systemic. Certain chemicals can also be applied through a drip irrigation system which allows its uptake by the roots.

APPLICATION EQUIPMENT

Once the method of application has been determined, the equipment required for the application is identified and checked. Application equipment and measuring equipment is required during most applications. The crop protection manager determines the equipment requirements by taking into account:

- The area or number of trees to which the chemical must be applied.
- The time period in which the application must be completed.
- The number of farm workers available.

Once the equipment requirements have been determined, the crop protection manager must consult with: 1) the person responsible for mechanical equipment to ensure that sufficient equipment (tractors and spraying machines) will be available. 2) The person responsible for the stores to ensure that sufficient measuring equipment and chemicals are available.

The crop protection manager must also ensure that all equipment is in a good working order, as breakdowns during application can cause delays that may result in ineffective pest and disease control. Spraying machines and tractors are normally serviced before the start of a season but must be checked regularly. The crop protection manager must consult with the person responsible for mechanical maintenance in this regard.

The application equipment that is required is specific to the application method.

Foliar Applications

Foliar applications can be applied in a number of ways, being:

Knapsacks

Handguns

Mist blowers
Crop sprayer aircraft

- **Knapsacks**

  Newly planted trees, up to the age of one year, may be sprayed with a knapsack as they require very little spray volumes.

  Be careful not to use a knapsack for the application of insecticides after it was used for the application of herbicides due to possible damage to trees.

- **Handguns**

  Trees between the age of two and four years old, depending on the cultivar planted and the area in which it is situated, are too big to be sprayed with knapsacks, therefore one will use handguns.

  A handgun implies a spaying cart with a hosepipe and spray gun held by an operator when applying an insecticide. With handguns, as opposed to knapsacks, a much higher volume of spraying material can be applied in less consuming times.

- **Mist blowers**

  The most popular automatic spraying machines are called mist blowers. These machines work on the principle of air displacement. The air within the tree is "blown out" by the high-speed fan on the spraying machine and replaced with chemical-filled air. There are many different types of mist blowers. They can be broadly classified into low, medium and high-profile machines. The choice of machine depends on the type of spray required. For example, low- and medium profile machines would not be suitable to apply a full cover spray to large mature trees.

  - *Low Profile Machines* are double-sided mist blowers without any tower or deflector.
  - *Medium Profile Machines* are raised, double-sided machines with or without a single-sided deflector or a raised machine with a short tower.
  - *High Profile Machines* are single or double-sided mist blowers that have tall towers and cover the tree canopy from top to bottom.

Tractors are used to pull spraying machines. Power from the tractor is transferred to the spraying machine by means of a power take-off (PTO) enabling the pump, fan and spray tank agitator to operate. The PTO is a short sprocket at the back of the tractor which is connected to the spraying machine by means of a PTO shaft.

Figure 1.1: PTO Shaft

Photograph from the Wikipedia Encyclopaedia, Wikipedia Foundation Inc

- **Crop Spraying Aircraft**

  Where large areas have to be covered in a short period of time, aerial applications (very expensive) is often used. Aerial applications can however only deliver light covering sprays and are therefore generally only used for bait sprays.

Trunk Applications

The quantity of chemicals, when applied in a trunk-application-form, must be measured very accurately. Specialised equipment, which is calibrated very accurately, is used for this purpose. The most common applicator is called a Calibra.

Some farmers use a paint brush for trunk applications. The quantity of product required is calculated according to the diameter of the tree trunk. There are tables available that indicate how much chemical to apply to trees of different sizes.

Soil Drench

The chemical solution is applied to the soil by using measuring cups or jugs which ensure with relative accuracy that the correct quantity is applied.

Health and Safety

All chemicals should be considered hazardous until indicated otherwise. Plant protection products can be hazardous to humans, animals and to the environment. When PPP's are being applied, health and safety regulations must be strictly obeyed.

In terms of planning the PPP applications, the requirements for protective gear and safety equipment for that particular chemical must be known to all who will take part in the application. The contact numbers for emergency services must be displayed prominently in a place where all workers have access to. It could be the Changing room.)

PROTECTIVE GEAR AND SAFETY EQUIPMENT

It is of utmost importance that the user is adequately protected when using plant protection products. Pictograms are displayed on product labels advising on the protective gear and safety equipment that are necessary when handling a particular chemical.

Advice Pictograms			
 Wear gloves	 Wear protection over nose and mouth	 Wear eye protection	 Wear respirator
 Wear boots	 Wear overalls	 Wear apron	 Wash after use

The biggest risk to the person that handles and applies PPP's is poisoning! The chemical can enter a person's body in the following three manners:

- By way of the mouth (orally)

- Through contact with the skin (dermal contact)
- By breathing (inhalation)

The most common manner of poisoning is through dermal contact. The following protective clothing must be available to those who use PPP's to eliminate the risk of poisoning.

Cotton Overalls – Cotton, in comparison with lightweight synthetic alternatives, has shown to be superior in durability, protectiveness and comfort. A two-piece overall is preferable.

Apron – An apron is used when mixing chemicals in case of spillage.

Raincoat and Hat – This protecting gear is used when foliar spraying is applied with mist blowers to protect the tractor driver against skin contact.

Goggles – Eye protection when working with chemicals is essential.

Unlined Rubber Gloves – Wearing rubber gloves decreases the possibility of skin contact.

Rubber Boots – Rubber boots or gumboots are worn to further decrease the chance of dermal exposure.

Facemask – A facemask is used as protection against inhalation.

Respirator – A respirator protects the user more effectively against inhalation, as it provides a separate supply of oxygen. Respirators are used if specified on the product label.

✦ **Contact details of emergency services**

Contact details of emergency services must be readily available to all persons who use PPP's. Display emergency telephone numbers close to the telephone so that they are easily noticeable and easy to find.

The following is a list of helpful numbers that should be available:

- Bateleur (a call centre that provides emergency advice)

- Poisons Information Centre (University of the Free State)
- Poisons Information Centre (Red Cross WMC Hospital)
- Tygerberg Pharmaceutical and Toxicology Consultation Centre
- Local doctor
- Local hospital
- Ambulance service

✦ **Pre-application checklist**

A pre-application checklist can now be compiled from the above information. The format of the pre-application checklist is not standard, and different farms may use different methods or formats for this purpose.

It is however essential that this type of information is recorded in a format that is easy to use for the persons responsible for the application. The checklist must contain all the necessary information to avoid confusion and the need to consult various records.

A pre-application is prepared for every application that has to be done according to the crop protection program. The pre-application checklists can then be used during the application to verify that the application is done correctly.

After the application has been completed, the pre-application checklist is filed with the application reports as part of the records kept for the farm.

Below is an example of a pre-application checklist.

Pre-Application Checklist		
Crop Protection Program Instructions:		
Application Date	From:	To:
Target Pest(s)/Disease(s)		

Chemical or CPPs						
PHI's						
CPP Concentration	*CPP*		*Concentration*		*Per*	
Application Method	Stem Application		Soil Drench		Spray	
Spray Type	Light Cover		Medium Cover		Full Cover	
Other Instructions						

CPP Requirements:

CPP	*Quantity*	*Unit*	*Unit Quantity*	*Check*	
				Available	*Expiry*

Equipment Requirements:

Description	*Quantity*	*Check*	
		Available	*Condition*

Worker Requirements:

Description	*Number*	*From*	*To*
Other Requirements:			
Notes:			
Signed:		**Date:**	

IMPORTANT NOTES:

- To protect a crop against pests and diseases one need a compilation of a crop protection program and pre-application planning.
- The most important components of pre-application planning are the plant protection products, application methods, application equipment and health and safety requirements.
- Plant protection products are classified as pesticides, fungicides and herbicides.
- Plant protection products must be registered with the Department of Agriculture for specific uses and may only be used for the purpose for which they are registered.
- The information displayed on the product label is full usage instructions, a physical description, the chemical composition, the toxicity, the pre-harvest interval and the expiry date of the product.
- The crop protection manager must ensure that the required products are available in sufficient quantities.
- Application methods mostly used are foliar sprays, trunk applications and soil drenching.

- The three main types of foliar applications are light covering, medium covering and full covering spraying.

- The equipment requirements are calculated based on the area of application, the period available for the application and the number of workers available.

- Knapsacks, handguns, mist blowers (spraying machines) and crop spraying aircraft are commonly used for foliar applications, depending on the size of the trees and the spraying requirements.

- Calibra applicators or paintbrushes are mostly used for trunk applications.

- Measuring cups and jugs are used for soil drenching.

- The health and safety requirements include the use of protective gear and safety equipment and displaying emergency contact details in an accessible place.

- The protective gear and safety equipment that are required is indicated on the label of each product with pictograms.

The pre-application checklist must include all the information required to complete the application.

MIXING PESTICIDES

INTRODUCTION

Mixing CPPs for crop protection applications correctly and accurately is essential. If a too low concentration of CPP is used, the crop will not be protected effectively. On the other hand, if the concentration is too high, it can result in overdosing animals and damaging the crop. A financial loss is unavoidable!

Mixing CPPs does not only involve measuring correct quantities and combining the ingredients. The person responsible for the mixing must be aware of the nature of the CPPs that is being handled, the safety requirements for working with such CPPs, the appropriate equipment that is required, and the correct mixing procedure.

Mixtures are normally mixed immediately before application and should not be stored in mixed form. It is therefore essential that the person responsible for mixing the CPPs has all the required CPPs, equipment and information available to complete the task without delay.

SAFE-HANDLING OF CHEMICALS

It is essential that the person responsible for mixing chemicals has a thorough understanding of the nature of the chemicals that will be handled, especially with regard to the toxicity of the chemicals, to ensure that the correct safety precautions are taken.

Colour codes, symbols and pictograms are used on the product labels of all chemicals to indicate its toxicity and the manner in which it should be handled.

- **Colour codes**

  Colour codes are used to indicate the hazard classification of the chemical. All agricultural chemicals are classified in terms of their toxicity. This information is displayed on the product's label and informs the user of the potential hazard I if not used in the correct manner.

Group	***Group Description***	***Hazard Statement***	***Colour Band***
Ia	Extremely Hazardous	Very Toxic	**Red**
Ib	Highly Hazardous	Toxic	
II	Moderately Hazardous	Harmful	**Yellow**
III	Slightly Hazardous	Caution	**Blue**
IV	Acute hazard unlikely in normal use		**Green**

The above table indicates the terminology used in classifying chemicals according to their potential hazards. This means that chemicals in Group Ia and Ib will be lethal when a very small quantity is swallowed. A much larger quantity of the substance in Group IV is necessary to be lethal.

- **Symbols**

Group	**Hazard**	**Symbol**	**Symbol**

	Statement	Description	
Ia – Extremely Hazardous	Very Toxic	Skull and Crossbones	
Ib – Highly Hazardous	Toxic		
II – Moderately Hazardous	Harmful	St. Andrew's Cross	

❖ **Pictograms**

Pictograms are used to indicate the storage requirements for the product, the type of product, the requirements for protective gear and clothing, and the danger that the product holds for animals.

Storage Pictograms		
 Keep locked away and out of reach of children		
Activity Pictograms		
 Application	 Handling dry concentrate	 Handling liquid concentrate
Advice Pictograms		
		
		

Wear gloves	Wear protection over nose and mouth	Wear eye protection	Wear respirator
 Wear boots	 Wear overalls	 Wear apron	 Wash after use
Warning Pictograms			
 Dangerous / harmful to livestock and poultry	 Dangerous / harmful to livestock	 Dangerous / harmful to poultry	 Dangerous / harmful to wildlife and birds
 Dangerous / harmful to wildlife	 Dangerous / harmful to birds	 Not for aerial application	 Dangerous / harmful to fish and water bodies

MIXING REQUIREMENTS

Apart from the chemicals, the following items are required during the mixing process:

- Protective clothing.
- Measuring equipment.
- Mixing equipment.

Clean water and a bar of soap must also be readily available in case a person's skin is contaminated with chemical spillage. A person must also wash up after handling the chemicals.

Protective Clothing

The following protective clothing is always worn when handling and mixing chemicals:

- Rubber gloves.
- Cotton overall.
- Rubber boots (gumboots).
- Plastic apron.
- Eye protection (goggles).

If it is indicated on the product label, a facemask or respirator must be used.

Measuring Equipment

To measure the correct quantity of a liquid chemical, an assize-measuring container is required. To measure wettable powders or granules, a scale weighing accurately, is needed

Electronic scales generally allow for more accurate measurements, but hand-scales can also be used. It is however essential that scales are serviced and calibrated regularly. Scales must be zeroed carefully before the chemicals are weighed.

Calculating the quantity of Chemicals or CPPs Required

The example provided for calculating the quantity of pesticide required, is based on a tree crop. The standard practice for tree crops is that recommendations for the concentration of crop protection CPPs to be made in **milliliters** (ml) or **grams** (g) per **100ℓ** of **water**. This is also the manner in which it is shown on the crop protection program.

The person responsible for mixing the spraying material needs to have a thorough understanding of this notation. Below are a few examples of notations:

Example:

arget Pest(s) / Disease(s)	***CPP***	***Notation***	***Explanation***
Red scale	Methomyl	100g / 100ℓ + mineral oil at 1.75ℓ	100g Methomyl plus 1.75ℓ of mineral oil per 100ℓ clean water
Thrips, b llworm, aphids & mealybug	Tokuthion	50ml / 100ℓ + wetter/buffer at 50ml	50ml Tokuthion plus 50ml wetter/buffer per 100ℓ clean water
Red scale, thrips, blackspot	Agrimec	15ml / 100ℓ	15ml Agrimec plus 200g Dithane plus 300ml mineral oil per 100ℓ clean water

To mix the above spraying materials, one has to calculate the quantities of the various ingredients depending on the total quantity of spraying material required. The amount of water is normally used as a basis, i.e. if 500ℓ of spraying material is required, 500ℓ of clean water will form the basis of the calculation. Using the examples above, calculating will be as follow:

Notation	*Spray Material Required*	*Calculation*	*Requirements*
100g/100ℓ + mineral oil at 1.75ℓ	500ℓ	(100g/100ℓ + mineral oil at 1.75ℓ) x 5 = 500g/500ℓ + 8.75ℓ mineral oil	500g CPP 500ℓ clean water 8.75ℓ mineral oil
50ml/100ℓ + wetter/buffer at 50ml	2,000ℓ	(50ml/100ℓ + wetter/buffer at 50ml) x 20 = 1,000ml(1ℓ)/2,000ℓ + 1,000ml(1ℓ) wetter/buffer	1ℓ CPP 2,000ℓ clean water 1ℓ wetter/buffer
15ml/100ℓ + 200g/100ℓ + mineral oil at 300ml	1,000ℓ	((15ml + 200g)/100ℓ + mineral oil at 300ml) x 10 = (150ml + 2,000g(2kg))/1,000ℓ + 3,000ml (3ℓ) mineral oil	150ml CPP 1 2kg CPP 2 1,000ℓ clean water 3ℓ mineral oil

- **Mixing procedure**

The mixing procedures for different pesticides differ. In some cases, it may be required that the compounds are pre-mixed in a separate container. In general, the procedure is to fill the spray tank halfway. The measured pesticide is added (the measuring equipment used can also be rinsed in the tank) and the tank is then filled to the correct level. Stir thoroughly. The pesticide label will specify the procedures to be followed. Read these carefully and apply these procedures. As example for a mist blower, the following steps are taken:

1. Measure the chemical ingredients accurately, using the appropriate equipment (assize measuring container for liquids and weighing scale for powders or granules).
2. Add the chemical ingredients to a 10ℓ bucket of clean water.
3. Mix thoroughly.

4. Fill the spray tank half with water.
5. Add the 10ℓ mixture to the spray tank on the mist blower and mix.
6. Add the remainder of the water to the spray tank, stirring the mixture continuously.

STORAGE OF CROP PROTECTION CHEMICALS

To ensure a safe working environment and to enable one to adequately deal with accidents such as fires and spillage, proper storage of CPP's is essential. The basic principles are as follows:

- Store CPPs in a secure, well-ventilated, cool and dry building that does not allow access to children, animals or unauthorised persons.
- There must be easy access to washing facilities with running water, soap and towels. It is important that an eye-flushing bottle is available in the event that eyes are contaminated.
- The storage facility should have a smooth, damp-resisting cement floor.
- The storage facility should have at least two 9 kg dry-powder fire extinguishers on hand. These must be located outside the storeroom.
- No food products, animal feed or seeds may be taken into the facility.
- Do not allow any eating, drinking or smoking in the storage facility.
- Separate pesticides, fungicides, herbicides and growth-regulators from each other within the storage area. Ensure that each storage area is well demarcated so that there can be no accidental mixing of products. It is recommended that herbicides are stored completely separately.
- Keep powders and granular products stored separately to avoid contamination in the event of spillage. Always store powders and granules on the upper shelves and liquids on lower shelves.
- Group stored CPPs according to their hazard potential, e.g. store red-band (group 1a and 1b) CPPs in the same part of the store.
- Products should be used on a first-in-first-out basis. This should ensure that CPPs are used before reaching their expiry date.

- Bags and containers that are not placed on shelves should be stacked on pallets to prevent a build-up of moisture.

- All containers and bags must be adequately marked. In the event that a label is destroyed or lost, the container must be marked with a marking pen, clearly stating the container's contents. The label should always be visible.

- An accurate stock movement recording system, indicating the quantities of each CPP purchased, issued and subsequently returned, must be in place. From the recording system, one should be able to determine the exact type and quantity of CPPs on hand at any given time.

- The containers of CPPs that have been opened and partly used should be resealed and returned to the store.

DISPOSAL OF EMPTY CONTAINERS

Empty CPP containers must under no circumstances be re-used for any purpose whatsoever. Even if the container has been washed thoroughly the risk of contamination remains high. Empty containers must be disposed of in the manner described below.

Empty containers must be rinsed by filling it to about a quarter with clean water, closing and shaking it well. Pour the rinse water into the spray tank. Repeat this process at least three times. Puncture the container after rinsing to ensure that it cannot be re-used.

Once containers have been punctured, they should be diminished (flattened) in bulk and buried at a disposal site in a pit. The disposal site must be:

- At least 50m from the nearest water source (dam, river and borehole);

- On relatively high ground or where the ground water is at least 2m deep;

- Not in sandy soils that leach easily; and

- Fenced in and a signpost.

Waste bags, paper and mildly contaminated items must be burned, while severely contaminated items and redundant CPPs must be disposed of using a high-temperature incinerator, which can also

be used for empty containers. A professional waste disposal company may be contacted in this regard.

GENERAL SANITATION

Ensure that a wash trough or large basin is available in or close to the CPP storage facility. This will allow the washing of contaminated clothing on site and prevent staff from wearing the clothing home where it may or may not be washed.

Equipment, such as scoops, buckets, measuring cups, etc. must be washed at the end of a working day. All protective clothing and equipment must be kept in good condition and cleaned regularly.

Have a spade, broom and a supply of dry sand on hand which can be used in case of CPP spillages. Sawdust must never be used for this purpose as it presents a fire hazard, and when mixed with certain CPPs, can result in explosion.

IMPORTANT NOTES:

- PPP used for foliar applications must be mixed correctly and accurately immediately before application.
- The person responsible for mixing the chemicals must take note of the safety requirements when handling the chemicals by checking the colour codes, symbols and pictograms that are used on the product labels.
- Colour codes are used to indicate the hazard classification of the chemical.
- Internationally recognised symbols are used to indicate the toxicity of chemicals that are extremely, highly and moderately hazardous.
- Pictograms are used to indicate other information about the product, including the required protective gear and clothing.
- Apart from the chemicals, protective clothing, measuring equipment and mixing equipment is required during the mixing process.
- The amount of chemicals that are required is calculated from the crop protection program. The same volume of water as the volume of spraying material that is required is used as a basis.

- Buffers are used to adjust the pH of water.
- Spraying oils often form part of spraying materials because they assist in controlling pest and diseases.
- The mixing procedure involves measuring the correct quantities of chemicals, mixing these in a bucket, adding the mixed chemicals to half the volume of water in the spray tank and adding the remainder of the water while stirring the mixture.
- Plant protection products must be stored in a safe, secure room that complies with GAP requirements.
- Empty chemical containers must not be re-used for any purpose. They must be rinsed, punctured and disposed of, either by being buried or by being incinerated.
- All protective clothing and equipment must be washed after use.

PESTICIDE APPLICATION

INTRODUCTION

This session focuses on the application of agro-chemicals or CPP's after the pre-application planning has been done and the CPPs have been mixed for application.

INFLUENCE OF CLIMATIC CONDITIONS

Climatic conditions play an important role when it comes to the application of CPP's, especially when the product is applied by way of spraying.

Wind

Foliar sprays should not be applied when wind speed exceeds 12 km/h. High wind speeds will negatively affect spray coverage of the tree, which could result in poor control of the target pest or disease. Excessive wind will also result in spray drift, which could damage other crops, pollute water supplies and harm the environment.

Rain and dew

Trees must be dry before foliar sprays are applied. If trees are wet, spraying material is diluted and less effective. One cannot spray at all while it is raining.

As a general rule, six hours of dry weather is required after an application. If more than 10 mm of rain falls before this time, the application should be re-applied.

Temperature

Most CPP's are applied during the summer months. Oil sprays must not be applied if temperatures are expected to exceed 30˚C. It is for this reason that oil sprays are often applied at night in warmer areas. It is very risky to apply oil under very hot conditions as fruit burn will occur. Some products are also sensitive to ultraviolet light (UV) and should also be applied after nightfall.

CALIBRATION

Definition:

Calibration Calibration in terms of pesticide application refers to the process of calculating and/or setting the delivery rate of the application using the application equipment. This may be done purely on the volume delivery per time interval or be based on an area volume rate.

Spray equipment calibration

In order to ensure that the targeted pest or disease is controlled adequately, it is essential that the spraying mixture is applied in a sufficient quantity to cover the crop or animal. In addition the coverage must be uniform. It is extremely important that spraying equipment must be calibrated correctly before it is used to apply spraying material, as the calibration of the equipment will determine the quantity of spraying material that will be applied to each tree, field or animal.

Spraying machines have a pump that pumps liquid from the spray tank through nozzles. These nozzles consist of spinners and discs. The spinner determines the droplet size, angle of the spray and a hollow or full cone. The discs have different size holes, which will determine the quantity of spraying material delivered. The quantity of spraying material delivered will also depend on the pressure of the pump (see table 3).

The following information is required to complete the calibration:

- Litres required per tree, animal or per hectare.
- Tree spacing in the row.
- Tractor speed.
- Number of nozzles to be used.
- Pump pressure.

The key is to work out how many litres per minute the spraying machine must deliver if it travels at a fixed speed, and how many trees or field (m^2) are passed at this speed.

Example of a mist blower for an orchard

Litres required per tree = 25ℓ

Tree spacing = 3.0m

Tractor speed = 33.3 meters per minute (2.0 km/hour)

Trees sprayed = 33.3 m/min divided by 3.0m tree spacing = 11.1 trees sprayed per minute

Total litres required per minute = 11.1 trees x 25ℓ/tree = 277.5 ℓ/min

This applies to a spraying machine that sprays both sides. For a machine that sprays on one side only, divide by 2: 277.5 ÷ 2 = 138.8 ℓ/min

Number of nozzles on spraying cart = 72

Litres required per nozzle = 277.5 ÷ 72 nozzles = 3.85 litres/nozzle

Pump pressure = 20 bar (2,000 kPa)

From the table, look under the 2000 kpa column and select a combination of spinners and discs to give 3.85 (or close to) litres per minute per nozzle. In this case, D4 disc + 45 spinner. It is important to select a combination of nozzles that will give the most efficient coverage. A popular combination for a good medium covering spray is to alternate 45 and 56 spinners with D3 discs to give good outside canopy coverage (45 spinners) and some degree of penetration (56 spinners).

Nozzle Delivery at Various Pressures in Litres/minute:

	700 kPa (100 psi)	1000 kPa (150 psi)	1400 kPa (200 psi)	2000 kPa (300psi)	2700 kPa (400psi)
23 spinner D1	0.405	0.470	0.526	0.620	0.697
D1.5	0.492	0.586	0.660	0.790	0.900
D2	0.606	0.720	0.800	0.950	1.060
D3	0.680	0.790	0.910	1.060	1.210
D4	0.870	1.060	1.210	1.440	1.660
D5	1.060	1.290	1.440	1.740	2.000
D6	1.210	1.480	1.700	2.050	2.340
25 spinner D1	0.590	0.700	0.795	0.966	1.100
D1.5	0.780	0.930	1.060	1.250	1.440
D2	0.950	1.100	1.290	1.550	1.740
D3	1.100	1.330	1.520	1.820	2.080
D4	1.710	2.050	2.350	2.840	3.250
D5	2.050	2.460	2.840	3.410	3.940
D6	2.065	3.220	3.680	4.500	5.190
45 spinner D1	0.720	0.850	0.970	1.170	1.320
D1.5	0.950	1.170	1.320	1.630	1.850
D2	1.210	1.440	1.660	2.010	2.310
D3	1.360	1.667	1.930	2.350	2.690
D4	2.120	2.570	2.950	3.600	4.200

D5	2.690	3.250	3.750	4.620	5.300
D6	3.520	4.350	5.090	6.210	7.200
56 spinner D1	0.870	1.060	1.250	1.510	1.740
D1.5	1.250	1.550	1.780	2.150	2.460
D2	1.480	1.780	2.080	2.540	2.910
D3	2.010	2.460	2.840	3.480	4.050
D4	3.300	4.010	4.660	5.720	6.580
D5	4.550	5.570	6.410	7.880	9.080
D6	6.600	7.720	9.320	11.450	13.170

Before the spraying machine starts with the application, the coverage must be checked in case a fine tuning is required. Possibly a few nozzles should be closed to avoid wastage or maybe the nozzle size towards the top of the spraying machine needs changing to ensure better coverage of the tree.

It is important to remember that the speed of the PTO should be 540 rpm. This aspect is often ignored and can lead to incorrect pressure being delivered by the pump and thus lower volumes of spraying material being applied.

The nozzles and spinners referred to above are made from metal, ceramic or plastic. The advantage of ceramic nozzles and spinners are the fact that they do not wear easily and can be used for many years. Conversely, nozzles and spinners manufactured from metal wear easily and must be replaced at the beginning of each season. Ceramic nozzles and spinners are not as versatile as the metal type as they lack in different sizes. Also, ceramic nozzles and spinners are relatively expensive and break easily if they are not handled with care.

PROTECTIVE GEAR

Before application commences, the person applying the CPP's must be adequately supplied with protective clothing and safety equipment. The degree of protection required will depend on the type of chemical; e.g. if a Group 1 chemical is applied with a mist blower, full protection for the tractor

driver is required, while minimum protection is required for a Group 4 chemical applied via the soil drench method.

Maximum protection includes:

- Cotton overall;
- Rain hat, raincoat and trousers;
- Gum boots and goggles;
- Respirator, with appropriate cartridge; and
- Rubber gloves

Minimum protection includes:

- Cotton overall;
- Gum boots; and
- Rubber gloves

APPLICATION OF CROP PROTECTION

Once all the necessary preparations for the application of the spraying material have been made, the following steps are taken:

Mist blowers

- The mist blower is attached to a tractor and the PTO is connected.
- The spraying machine is filled with water and the chosen discs and spinners are inserted into the nozzles.
- The pH of the water is checked to determine whether a buffering agent is required.
- The spraying machine is tested in the orchard/field with water to determine whether the theoretical calibration that was done initially gives the correct spray coverage to the tree/field, measured by observation.
- Minor adjustments are usually necessary to ensure good coverage and to prevent wastage of spraying material.
- The spraying material is mixed in the spray tank as prescribed.
- Before spraying starts, the protective clothing of the tractor driver is checked.

- Full instructions are given to the driver regarding the correct gear that the tractor should be in, the pump pressure required, and where the accelerator should be set in order to attain the correct PTO revolutions (540rpm).

Handguns and Knapsacks

The spraying material is prepared in the same way as described above. The manner in which it is applied depends on the type and model of the equipment used. Please follow the manufacturers' instructions.

Soil Drench

In soil drench applications, the chemical is prepared, and the correct quantity is measured in a container.

The chemical is then poured around the base of the tree, around the trunk in an even manner or as per labelled instructions.

Trunk Applications

Trunk applications vary somewhat depending on the product. Generally, the chemical is painted onto the trunk of the tree.

The instructions of the manufacturer must be followed carefully with trunk applications.

IMPORTANT NOTES:

- The climatic conditions that must be taken into account for foliar applications are wind, rain, dew and temperature.
- If the wind is too strong during application, it will result in spray-drift that may harm the environment and water sources. (Other people in the vicinity?)
- Trees must not be wet when they are sprayed, as this will dilute the spraying material and make the chemicals less effective.
- If the spraying material contains oil, it must not be applied when it is too hot, as is can burn the fruit. Certain chemicals are also sensitive to ultraviolet light.

- Spraying equipment must be calibrated before being used to ensure that the spraying material will be applied at the correct rate.

- The most important step in the calibration of mist blowers is selecting the correct combination of spinners and discs to deliver the correct volume of spray.

- The tractor driver, or any person that applies spraying material, must wear the appropriate protective gear and clothing for the chemicals that are being applied.

- For foliar applications, the mist blower is connected to the tractor, set up and tested, and then filled with spraying material. Full instructions must be given to the tractor driver.

- Applications with handguns and knapsacks are done according to the manufacturers' instructions.

- The methods used for trunk and soil applications depend on the product and are according to the manufacturers' instructions.

HEALTH AND SAFETY DURING PESTICIDE APPLICATION

Not all pesticides kill in the same way. Pesticides kill by disrupting or interfering with some vital function of the pest needed for it to survive. This is called the pesticide's mode of action. For, example, the mode of action of many insecticides is interfering with the insect's nervous system. It is important to know a pesticide's mode of action as this is the same way in which human 's could be harmed by pesticides. Therefore, pesticides can be very dangerous to humans.

Risks associated with exposure to pesticides

Pesticides can cause quick immediate (acute) or slow in the future (chronic) health effects. Some acute effects might be:

<u>Damage to the nerves:</u>

- Headache, dizziness and weakness

- Tremors

- A lot of spittle developing, sweating, tearing of eyes

- Blurred vision

- Nausea and vomiting
- Tingling fingers
- Numbness
- Convulsions

Damage to the lungs:

- Difficulty breathing
- Lungs fill up with fluid
- Failure to breathe leading to death

Damage to skin:

- Rashes

Damage to eyes:

- Eye irritations

Chronic pesticide exposure is linked to increased risks of developing cancer and disorders such as Parkinson's disease. Some chronic effects may be:

- Permanent eye damage
- Developing allergies and/or asthma
- Cancer 9e.g. leukemia, brain tumours)
- Effects on the immune system
- Birth defects
- Not able to have children
- Developmental problems in children
- Neurologocal diseases

- Lung, liver and kidney problems
- Parkinson's disease

Some factors make people more susceptible to developing pesticide related diseases

These include:

- Children who are still developing/growing are very vulnerable to long term effects
- Drinking alcohol
- If the person has a liver disease
- Being undernourished for a long time
- Pregnant women
- Occupation (e.g. farmers, pesticide applicators and mixers, green house workers)
- Women and men of child bearing age
- Elderly
- Individuals with allergies, asthma or other respiratory diseases
- Individuals who are HIV positive or have AIDS
- Individuals with TB
- Individuals who are chemically sensitive
- Individuals who are chronically ill
- Individuals with genetic variations that leads to increased susceptibility

HOW ARE FARMERS EXPOSED TO PESTICIDES?

There are many ways in which farmers can be exposed to pesticides and their harmful effects:

- Chemicals used in the home to control cockroaches, ants, flies, bed bugs, etc.
- Chemicals used in agriculture – producing crops

- Food that you eat may have pesticide residues
- Pesticides in the water you drink

The four main ways that pesticides enter farmer's bodies are through getting pesticides on the skin, drinking/swallowing pesticides; pesticide splashes getting in the eyes and breathing in pesticides in the air.

HOW DO PESTICIDES ENTER THE BODY?

- Through the skin (dermal)
- Through the mouth (oral)
- Through the lungs (respiratory)
- Through the eyes (ocular)

Some ways of being exposed are:

- Handling/mixing pesticides, especially if you are not using gloves, respirator, plastic coveralls and boots
- When applying pesticides to the field, etc
- Drinking contaminated water
- Eating food that has pesticides on or in them
- Dipping animals in pesticides
- Wearing a dust mask rather than a respirator (may breathe in pesticide if mask is wet)
- Wearing improper gloves (e.g. latex gloves do not provide protection)
- Breathing in pesticides fumes that we or others spray
- Touching crops, flowers or other surfaces that have been sprayed
- Drinking water that has pesticides in it
- Walking barefoot on surfaces that have been sprayed

- Walking bare legged in wet fields where the pesticides get onto the legs from the wet plants
- Eating food that has pesticide residues in them
- Chemicals used in our homes
- Reusing pesticides containers, especially for storing water

EXPOSURE REDUCTION

To avoid dangerous exposures to pesticides and potential health effects, learn and practice the following;

- First make sure that you have a pest problem tat requires treatment. A few pests are not always a problem. Learn to identify your pests and how many pests are okay without treatment. Contact the ARC (Agricultural Research Council) for advice on how to "scout' for pests.
- Remove pests by hand where possible.
- If you need to treat, first find out what alternatives to pesticides you can use such a product containing pyrethrum and rotenone. Contact the ARC, the Gaia Research Institute or Surplus people Project.
- Non-chemical pest control measures should always be used first. These include: sanitation, irrigation, manual weeding and pest removal.

If you do use pesticides, be sure to follow these tips:

LABEL:

- Read the label or get someone to treat it to you before using any pesticide.
- Make sure you understand the health risks and precautions you need to take.
- Identify the colour code. How hazardous is the product you want to use? Can you protect yourself and others? If not, don't use it.
- **Never** put pesticides in any other container than the one it came in and make sure the label is always on it.
- If you or someone else is poisoned, take the label with you and get medical help.

PESTICIDES:

- Only use the pesticide for what it says it will kill.
- Keep pesticides in their original containers with the label and tightly sealed.
- Do not mix pesticides or use more than one at a time.
- Do not mix different pesticides together.
- Do not use things to mix the pesticides with that come from your kitchen or home and make sure you mark the tool you use with a danger sign.
- Mix pesticides away from water sources, children, and not in any place people live in.
- Store pesticides away from children, animals and water sources.
- Do NOT transport pesticides next to the driver or passengers.

PPE:

- Use personal protection equipment (PPE) properly when pesticide use is considered necessary.
- Make sure you are using the right PPE for that particular pesticide. For example, a red colour code on a label will required a respirator, not a dust mask to prevent getting sick.

APPLICATION:

- Use the correct equipment for applying pesticides and make sure it does not leak on you or the soil.
- DO NOT spray pesticides on a windy day.
- Drop a leaf to find out the wind direction and make sure you spray so that wind is hitting your back.
- Make sure when spraying pesticides that house windows are closed, and no children, animals or water sources are nearby and can be contaminated.
- Only apply pesticides early in the morning or in the later afternoon – never during the day, especially when it is hot. The pesticide can become more dangerous.
- Do not enter a sprayed field until all the plants and soil is no longer wet from pesticides.
- When using a pesticide can for spraying (e.g. Doom), cover your hand with a glove or plastic bag (throw the bag out after spraying where it won't cause contamination) to avoid skin contact with poison. Use a mask to avoid breathing in the spray mist from the can.

AFTER USE:

- Wash body and equipment away from water sources and home every time after using pesticides.
- Wash pesticide clothes after each use.
- Do not wash pesticide contaminated clothes with non-pesticide clothes.
- NEVER pour pesticides or put empty containers down the drain or into the toilet or into storm water drains or into rivers, reservoirs or dams.
- Let everyone around you know when you are using pesticides, so they can protect themselves.
- DO NOT REUSE PESTICIDE CONTAINERS.
- IT IS AGAINST THE LAW TO BURN or BURY EMPTY PESTICIDE CONTAINERS. Burning can release toxic fumes and burying contaminates water sources.
- TAKE TRIPLE RINSED CONTAINERS BACK TO WHERE YOU BOUGHT IT

STORAGE:

- Store pesticides in a locked room that is not part of your home and make sure children or others cannot open the room or find the key.
- Do not leave pesticides, sprayers or containers lying around – lock these away.

POST APPLICATION PROCEDURES

INTRODUCTION

Once the CPP's have been applied in the prescribed manner, certain steps must be taken to clean, maintain and store the used equipment and to ensure that no further contamination can take place. In this session, we will look at these post-application procedures.

POST - APPLICATION PROCEDURES

The following procedures must be followed after completing the application, some of which are discussed in more detail in the remainder of this session:

- Clean all mixing and application equipment thoroughly and store in the prescribed manner.
- Clean all protective clothing and equipment thoroughly and store in the prescribed manner.

- Collect and dispose of empty containers and other waste products correctly, as discussed in section 6 of session 2, and ensure that no empty containers are reused.

- Apply personal hygiene and safety.

- Notify CPP manager of completion of work.

CLEANING OF EQUIPMENT

Once the spraying operation has been completed, all machinery must be washed with clean water and stored for future use.

If spraying equipment is not cleaned properly after use, the danger of contamination remains, and people, animals and the environment may be placed at risk. In addition, certain CPPs are corrosive and spraying equipment that is not properly washed may be damaged.

Spraying Equipment

Spraying machines must be washed in an area with adequate, safe drainage such as a filling point with a good French drain and at least 50m away from any water sources.

- Once parked at the filling point, remove the filter, normally situated near the pump.

- Rinse the filter with clean water so that all residues are removed.

- Fill the spraying tank with water while the agitator (mixing mechanism) is running. Water will pour through the open filter rinsing the tank. The tank is considered clean only once all pesticide residues have been removed.

- Wash the outside of the spraying machine with a cloth to remove all spray residues.

- Only now the spraying machine can be park in its designated area.

Other Equipment

All other equipment, such as brushes, knapsacks, mixing equipment, etc., must be washed with an appropriate liquid soap and well rinsed in a suitably well-drained area.

PERSONAL HYGIENE

On completing the spraying task, all persons involved should bath and dress in CLEAN clothing. **Do not** put on the clothes that were used for the spraying operation unless they have been laundered properly.

IMPORTANT NOTES:

After the application of a PPP has been completed, all the following steps must be followed:

1. Clean all mixing and application equipment thoroughly and store in the prescribed manner.
2. Clean all protective clothing and equipment thoroughly and store in the prescribed manner.
3. Collect and dispose of empty containers and other waste products correctly, as discussed in section 6 of session 2, and ensure that no empty containers are reused.
4. Apply personal hygiene and safety.
5. Notify the crop protection manager that the work has been completed.

REPORTING PROBLEMS

MONITORING THE APPLICATION PROCESS

Monitoring and managing spraying operations is critical in the control of pests and diseases. Timing of control measures to be taken is of major importance as certain pests, e.g. thrips or bollworm, or diseases, such as blackspot, can cause severe damage to the citrus crop within days if not controlled in time.

The following steps must be taken and monitored continuously:

- Ensure that all necessary information, such as fields to be sprayed, spray covering and CPP attributes (especially toxicity) are well communicated to tractor drivers and other personnel involved, as well as other workers that may be active in the area.
- Check that all personnel concerned are wearing suitable protective clothing. Take into account the toxicity of the CPP as indicated on the product label.

- Check that the correct CPPs are used and that each spraying tank is mixed with the correct concentration as recommended on the label.

- If applicable, check pH of the water and adjust with a buffer if necessary.

- You must check that the accelerator is set at the correct revolutions to obtain the desired PTO speed (require 540 rpm) are attained on the tractor.

- Check whether the pump on the spraying machine is operating at the correct pressure.

- Check that correct discs and spinners have been inserted into the nozzles.

- Check that the agitator of the spraying machine is functioning adequately and that the CPPs placed inside the spray tank are well mixed.

- Check spray coverage on the trees and ensure that the physical wetting is as desired.

- Ensure that all nozzles are spraying onto the tree. You may have to close or alter the direction of nozzles.

- Check that the quantity of litres being applied per tree is within an acceptable range of dosage required. This can be done by comparing the number of tanks used against the number of trees sprayed.

- Check that the number of tanks sprayed and the quantity of CPP used coincide.

- Observe climatic conditions and react accordingly. Stop spraying if it starts raining or is too windy or too hot.

- Finally, the effectiveness of the spray against the target pest must be determined. In the case of thrips or bollworm, results should be noticeable in 24 hours.

REPORTING PROBLEMS AND UNUSUAL OCCURRENCES

Many of the points referred to above are fairly simple. It is however very important to consult with the supervisor or crop protection manager if you are unsure about anything.

Management must prescribe reporting procedures to all employees to ensure that these procedures are obeyed. The procedures must be applied and enforced at all times. Do not wait, report problems or unusual occurrences immediately. Rather be safe than sorry.

IMPORTANT NOTES:

- The prescribed procedures for the preparation and application of plant protection products must be monitored carefully.
- Problems and unusual occur

DEALING WITH EMERGENCIES

Emergency situations occur even where every precaution has been taken to prevent it from happening. It is essential that all authorised personnel handling CPPs are aware of the steps that must be taken in case of an emergency.

Spills, leakages and poisoning are the most common emergency situations that occur where CPPs are handled.

PROCEDURES FOR MINOR SPILLS AND LEAKAGES

Equipment

The following equipment should be available and easily accessible at all times in areas where CPPs are stored and must be used when a CPP spill or leakage occurs:

- Two sets of protective clothing, including respirators and facemasks;
- Two brooms;
- Two shovels;
- 50kg powdered lime*; and

- A number of open-top drums in which to place spilled CPPs.

Personnel can react immediately in a case of emergency if the above-mentioned equipment is in place.

Lime is suitable as a general-purpose absorbent for liquid CPP's due to its alkaline nature. It assists the degradation of most toxic substances such as organophosphates.

Clean-up Procedures

All persons that regularly work within a CPP storage area must be able to cope if a spill or leakage occurs.

- Apply first aid to anyone affected by the CPP and obtain medical attention immediately
- Isolate the area; remove and keep all unauthorised people away from this area.
- Every person involved in the cleaning up operation must wear protective clothing;
- Attempt to enclose the spill or leakage as far as possible by constructing an absorbent barrier of sand or lime around the spilt material;
- Place leaking containers, if any, into open-top drums and label the drums clearly for future reference or disposal;
- Collect the spilt material and absorbent substance with shovels and brooms and place it into open-top drums for disposal;
- Ventilate the building as much as possible by opening all doors and windows;
- If the spillage is on soil or gravel, dig up the area and remove the contaminated soil;
- If the spillage is on concrete, neutralise the CPP with lime or a 10% solution of sodium carbonate (Na_2CO_3) or alternatively, with 5% sodium hydroxide (NaOH);
- Clean all equipment used during the clean-up operation thoroughly, including laundering protective clothing, and store for future use; and
- Dispose of the open-top drums and its contents

PROCEDURES IN CASE OF POISONING

The local doctor must be advised in advance which CPP's are going to be used during the season. Supply him with a copy of every CPP's label that will be used. This should enable him to have appropriate antidotes on hand.

Every person that works with CPPs or comes into contact with CPPs should be thoroughly aware of the symptoms of poisoning. A list of the symptoms should be displayed prominently within the work area. It can be similar to the figure below:

General Signs and Symptoms of Poisoning (AVCASA, 2001)

- Headache
- Dizziness
- Nausea
- Tremors of Tongue and Eyelids
- Salivation
- Cramps
- Vomiting
- Sweating
- Muscular Weakness
- Anxiety
- Blurred Vision

In the event of poisoning, arrange for medical attention as soon as possible, or arrange for transporting the affected person to a hospital or clinic. While this is being done, administer the following first aid procedures:

- Determine which CPP caused the poisoning.
- If the product is known, consult the label for the specific first aid procedures.
- Determine how the CPP was taken in, i.e. by mouth, through the skin or by inhalation.
- Make sure that the breathing tract is open.

- If the patient is unconscious, turn them onto their stomach.
- Start artificial respiration if the person is not breathing.
- If the patient absorbed the CPP via the skin, remove the patient from the contamination point, remove all contaminated clothing and wash affected areas with soap and water.
- If the eyes have been affected, wash with clean water for at least 15 minutes.
- If the CPPs have been swallowed do NOT induce vomiting unless it is specifically specified on the chemical's label.
- Keep the patient warm.

EMERGENCY PROCEDURES TO BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL

The following emergency procedures can be administered to a person that has been poisoned, but may ONLY be administered by qualified, authorised medical personnel:

Organophosphate poisoning – Atropine by injection.

Organochlorine poisoning – Treatment will depend on symptoms. Control convulsions and maintain tissue oxygenation.

Carbamate poisoning– Atropine by injection.

INCIDENT REPORTS

An incident normally refers to an accident or a near accident at the workplace where:

- Workers were or could have been injured or killed;
- Safety was compromised; or
- Property was damaged

In an effort to understand the causes of the accident, an incident report is written by the supervisor or manager responsible for the work being conducted. Incident reports are necessary as it compels

persons involved to explore every angle of the accident (or near accident) in an attempt to prevent any similar accidents in future. Serious accidents are to be reported to the Department of Labour who will conduct their own investigation, which may lead to the prosecution of the responsible person if negligence is found to be the cause.

An incident report should at least contain the following information:

1. Date of occurrence
2. Place of occurrence
3. Name of department manager
4. Name(s) of injured person(s)
5. Description of injuries, illness or damage to property
6. Full description of how the accident took place
7. Names of witnesses to the accident

IMPORTANT NOTES:

- Procedures for emergency situations must be in place and known to all personnel.
- The most common emergencies are poisoning and spillages.
- The symptoms of poisoning must be displayed prominently in the area where chemicals are stored and handled.
- When a person shows symptoms of poisoning, medical attention must be arranged as soon as possible, and first aid must be administered in the meantime.
- The equipment for containing and cleaning spillages must be on hand at all times.
- The procedures for containing and cleaning spillages must be followed carefully.
- Incident reports must be completed for any incident in which workers were or may have been injured or killed, during which safety was compromised, or in which property was damaged.

Chapter 4

How to Apply Plant Manipulation Methods

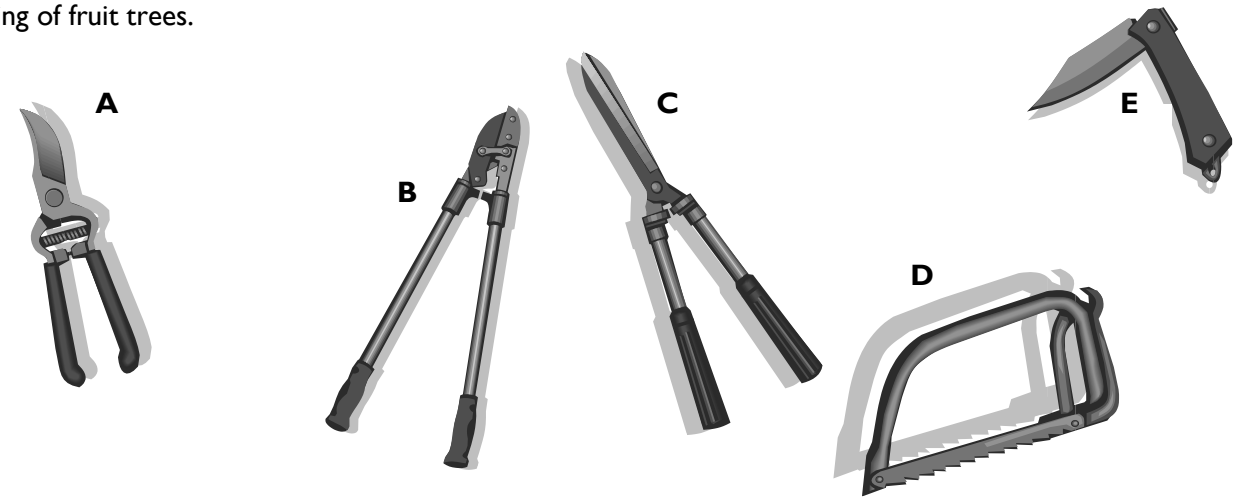
In this session we explore the following concepts:

- Tools used for manipulation
- Manipulation techniques
- Trellising and pruning
- Training tree crops
- Training vegetable crops
- Flower and fruit manipulation
- Chemical manipulation
- Physical manipulation

THE SELECTION AND USE OF TOOLS AND EQUIPMENT

TOOLS USED FOR PLANT MANIPULATION

It is important to establish at the beginning what are some of the basic tools used for pruning and training of fruit trees.



- **Secateurs (pruning shears A)**

  Good quality secateurs are essential; these are simply a pair of scissors that have been specifically designed for cutting plant material. A grower will always find a use for a pair of secateurs.

- **Lopping shears (B)**

  The lopping shears are used to prune branches that are too thick for ordinary secateurs. It has strong secateurs blades on extended handles about 40 cm in length.

- **Hedging shears (C)**

  Hedging shears are used for cutting/trimming hedges.

- **Pruning saw (D)**

  A carpenter's saw would not be used for pruning bushes or trees. There are many different sizes and shapes of pruning saws available. These normally have reversed teeth and are narrow enough to make a clean cut at the base of a branch without damaging the bark on the adjoining stem.

- **Pruning knife (E)**

  Pruning knifes are usually in the form of a pocket knife with a curved cutting edge. It is useful for cleaning a cut edge or shaping a torn wound.

- **Ladder**

  This is usually a wooden ladder with a folding tripod leg that allows a person to get close to the tree to perform the tricky top work.

  Anyone performing pruning or training work must wear the appropriate **safety clothing.**

  The operator must ensure that tools and equipment used are sterilised as required and cleaned thoroughly at the end of the day.

PLANT MANIPULATION TECHNIQUES

There are a number of different manipulation techniques that are applied to crop plants.

In this section different manipulation techniques relevant to different crops and crop growth stages are investigated.

Crop plants can be roughly divided into three main groups with regards to manipulation.

Fruit bearing vegetable crops

- Crops require a wide range of manipulation.

Leafy vegetable crops

- Require limited or no manipulation. Manipulation is normally limited to removal of mature leaves that may be ready for harvest or are diseased

Tree crops

- Require primarily training, pruning and in some cases chemical manipulation of fruit.

Plant manipulation in fruit bearing vegetable crops

- Suckering and trimming

  - A sucker is a small shoot, which forms between the petiole and the stem on crops such as tomatoes. Suckers drain plant nutrients, which would

normally be channeled into fruit production. Suckers are removed when they reach approximately 2 to 5 cm in length.

- The suckers are removed by simply snapping them off between the thumb and index finger. Alternatively, they can be removed using a knife, but this poses a potential of spreading disease.
- Trimming of side-shoots is done regularly using a knife or shears. Always disinfect after each plant has been trimmed. If the growth tip is damaged the side shoots will grow profusely, one of the side shoots and can then be selected as a new leading shoot

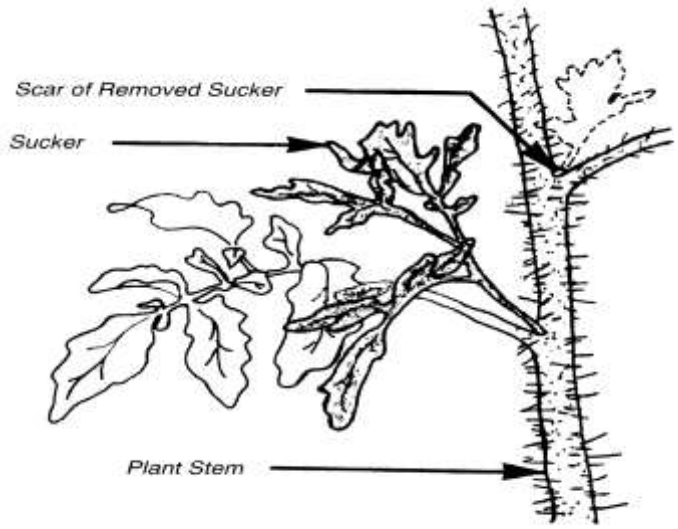


Figure 12.8. Removal of tomato suckers at an early stage.

Removal of leaves

- During growth the older, mature leaves die. These leaves are susceptible to diseases and should be removed. Removal of older leaves also improves the ventilation around the bottom of the plant. The number of leaves removed and depends on the grower and plant cultivated.

- Fruit Manipulation

- Fruit thinning is a process through which fruit that are malformed or poor colour developed are removed. Fruit are removed in areas where diseased leaves have been removed to allow for sufficient leaf development.

- Fruit ripening may be manipulated using specialised chemicals. A compound such as Ethephon can be used to induce even ripening in tree crops. Similarly, chemicals such as HCN are used to induce bud break in crops that are require low temperatures for bud break.

- Pollination

In most popular hydroponics crops pollination may be required. This is usually done by ventilation, insects or movement of workers through the glasshouse. By vibrating the stay wires on the trellising, the plants can be shaken, aiding pollination.

- Trellising of plants

Trellising is labour intensive and should be done taking care not to damage plants. It ensures that plants are kept upright and do not lie on the ground. Plants need to be manually twisted around the trellis system. Some trellises have removable supports which are removed to make the process easier.

Some plants are layered in order to keep the harvesting and handling height below 2.5m. Various trellising systems can be used on different species.

Creeping type plants require trellising. A trellis is a simple structure, which is used to support the plant. The simplest trellis is one in which wire is spun against a wall in a grid pattern. The plant is then threaded through the grid and allowed to grow.

This kind of trellis can be made to fit any shape that may be required. The wooden poles are secured in the ground by digging a suitable hole and inserting them into the hole. The poles are then laid against one another and fastened using string or wire.

Trellises can be manufactured from wood, which is nailed or screwed together in a square, or diamond shaped design.

The trellises are made in pre-determined width and height to suit its application.

A simple trellis is made by planting poles into the ground at pre-determined distances. A number of horizontal wires are now spun parallel to one another. The plant's main shoots are merely draped over the wires. In some cases, they need to be fastened to the wires.

In hydroponics systems trellising could be as simple as a wire that is spun from the roof to the floor of the tunnel. The primary shoots of a tomato; pepper or cucumber is then simply wound around the wire.

It is important that the shoot is fastened to the trellis, that the plant is not damaged with the binding being used. The binding could be specialised plant tape or thin wire.

Example of trellises:

Plant manipulation on tree crops

- Pruning

  Plants are pruned primarily to encourage growth of new flower bearing wood, to remove dead vegetation and to improve their appearance or to keep a tree at a manageable size, making harvesting more efficient. Pruning is only done on perennial scrubs and trees.

  In a natural environment pruning occurs through the action of wind, or through breakage due to excessive fruit loads, and animal browsing. Such natural pruning frequently leaves stubs or slowly healing wounds that are susceptible to decay and disease.

  Pruning in orchards prevents decay at broken areas and promotes quick healing of wounds.

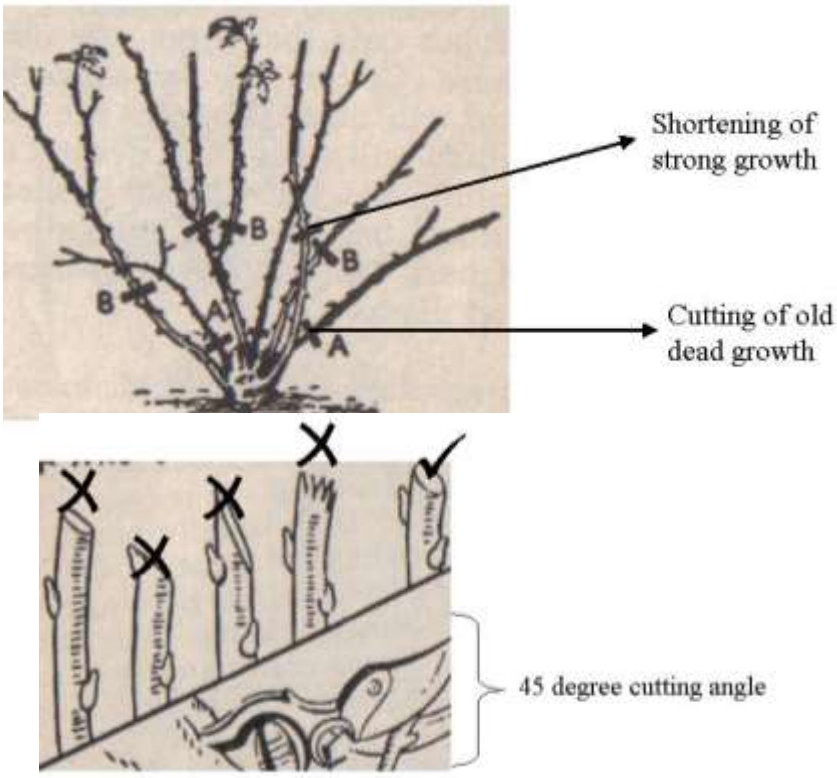
- Pruning tools

  The major pruning tools that are used in tree crops are pruning shears and a specialised saw called a lopper. In some cases, specialised motorised saws can also be used. Depending on the size of the trees a chain saw can also be used. The principals of pruning as described below are the same independent of the tools used.

It is important that the tools used are always kept clean and free of plant residues. They should also be sharpened regularly. This will ensure that the pruning cut is always clean and accurate.

- The basic rules for pruning are:

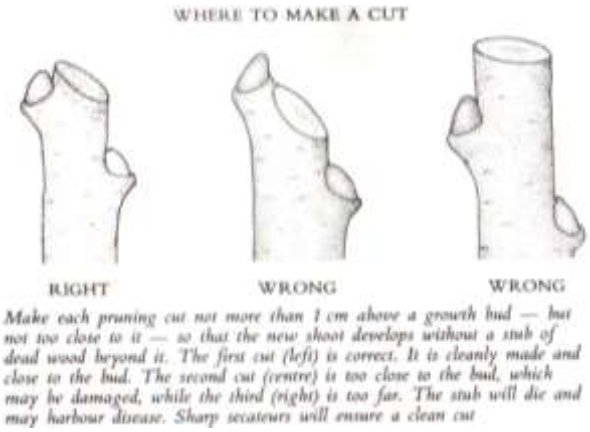
1. Remove all dead wood.
2. Remove damaged wood such as scales or sun scalded wood or wood covered in lesions.
3. Remove branches that cross the centre of the plant, or those that rub against other branches.
4. Remove suckers completely.
5. Remove branches that make the bush look lopsided.
6. Remove an old cane for each new cane that develops. This will renew the plant.
7. The cane should be cut back to an outside but eye about the fourth bud eye or so from the base.
8. The cuts should be clean and at a 45-degree angle to the stem. Ensure the pruning shears are sharp and clean before use.



- Pruning is mostly done during the dormant period (winter) although summer pruning can also be done.

- Training and trellising

  Training and trellising systems are not only used in vegetable crops, but also in some fruit tree crops. During the initial stages of plant development, the farmer is mainly concerned with the training of the tree. The aim is to develop a framework for the future that can carry heavy crops of good quality fruit.



FRAMEWORK DEVELOPMENT PRINCIPLES AS PART OF PLANT MANIPULATION METHODS

INTRODUCTION

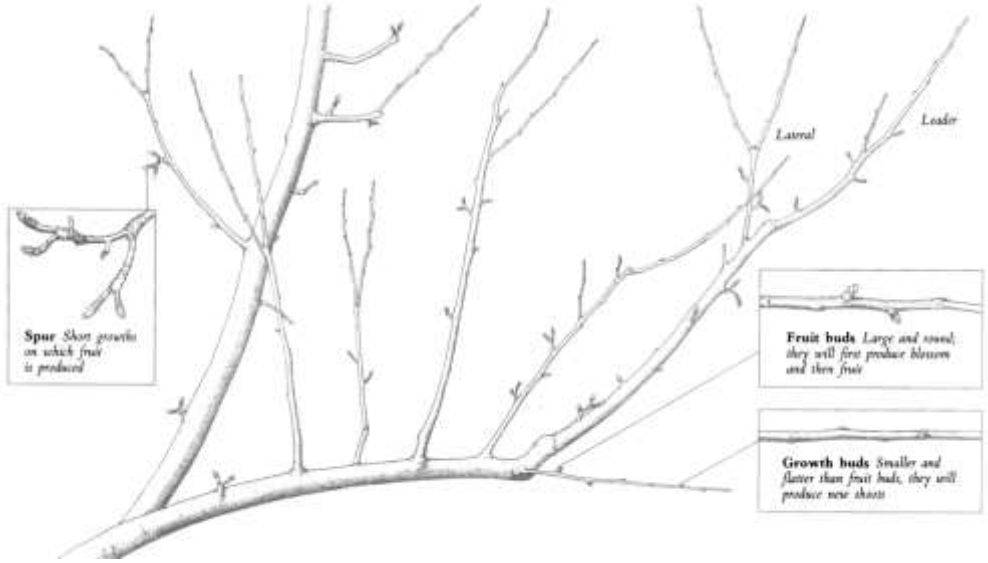
Trellising and pruning are used to:

- Maximise the ability of the plant to produce a crop.
- Create a shape that is ideal for harvesting.
- Allow the plant to be directed in a manner that maximises light and encourages fruiting.
- Make it easier to control diseases and pests.
- To produce better quality plant and to extend the life of a plant.
- Allow plants to fruit earlier.

TRAINING TREE CROPS

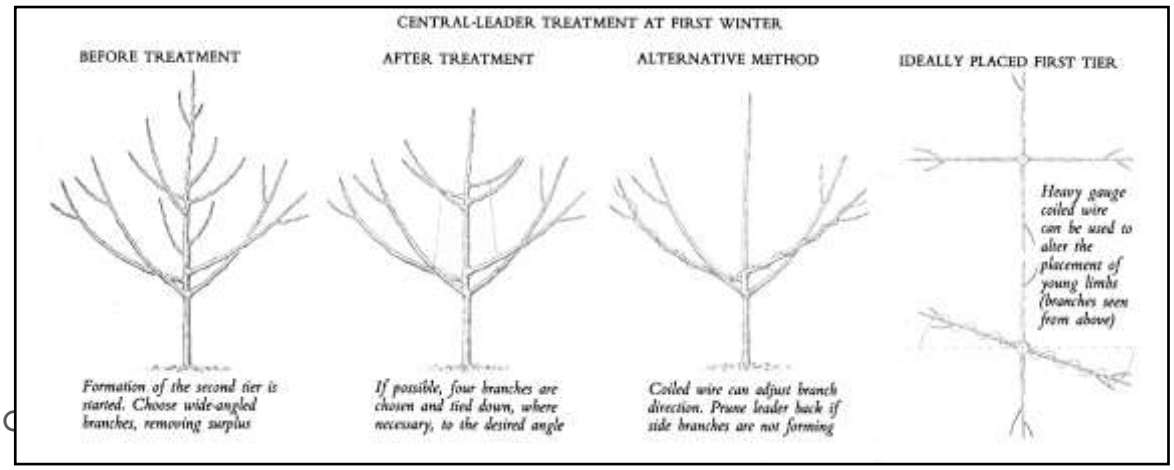
Training tree crops– Apple

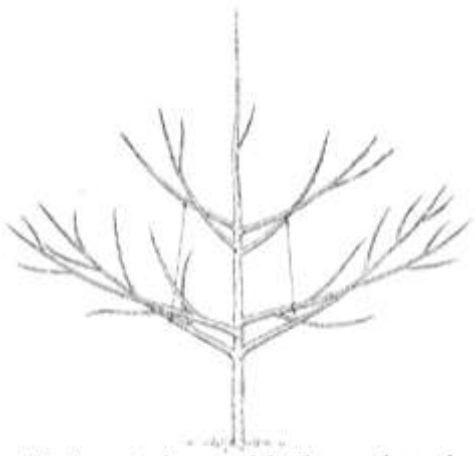
An example of the application of these techniques is training of apple trees. As an example, a commonly used training system used in apple orchards is discussed. The system is called the **central leader system**.



The first phase of frame development occurs at planting when the stem is pruned down to a height of 80 cm above ground and the side shoots are removed leaving only four selected branches that form an evenly spaced tier. This is normally done in winter. These remaining branches are then staked at an angle of 30-40 degrees from the horizontal.

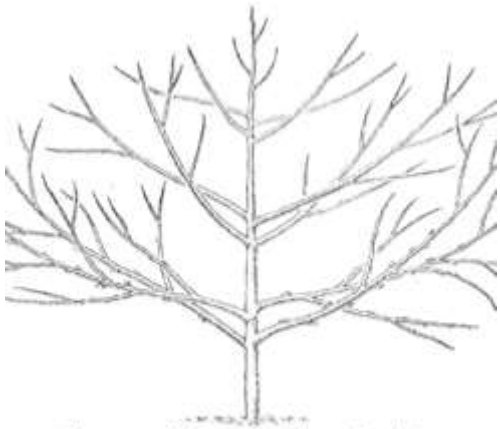
Summer pruning will have to be done to remove misplaced branches.





The lower tier has extended. The tree, shortened the previous year, has second tier growth

In the second year the first tier would have grown new shoots and the tree have developed a second tier that will be staked to the first tier. This second tier should be about 50 cm above the first tier. At this point it is advisable to shorten the leader if it is too vigorous. If the branches that make up the tier are not evenly spaced; lightly coiled wire can be used to correct this. This technique can also be used to adjust the angle of the growth of the side branches. Twine half the wire around the branch on one side of the central leader and extend it to twine around a branch on the other side. Leave the wire in place for only about six weeks so that it does not damage the wood and buds



The pyramid shape should now be obvious. Shorten the leader, if necessary

During the third winter the tree would have developed a pyramid shape and a third tier. The second tier will have produced laterals. Pruning should be kept to the absolute minimum. The leader should be shortened to stimulate growth into the framework.

Structural training is complete, or close to completion. Ideally there are four tiers

In the fourth winter the tree has developed four tiers and the leader is shortened again. By this time the tree produces fruit and it might be necessary to thin fruit from the branch terminals until they are stronger and able to withstand the weight of the fruit.

After the fourth-year light pruning is done. This promotes early and heavy first crop. Laterals should only be cut back in the young tree if they are out of place or diseased.

TRAINING VEGETABLE CROPS / HYDROPONICS TOMATO

As a second example of training techniques, tunnel grown tomatoes is discussed. Very few tools are used here.

Tunnel tomatoes are indeterminate growers. This means that they can grow and produce fruit continuously over an extended time period. Tomato follow a sympodial growth model, which means that after the juvenile growth phase has terminated, the apical meristem terminates in an inflorescence.

In order for the plant to continue growing, the axillary bud of the terminal leaf produces two to three leaves before it also terminates in an inflorescence. The next axillary will continue to grow in a similar manner.

This process of the sprouting bud, formation of two to three leaves and an inflorescence, will continue indefinitely as long as the plant remains healthy and protected from unfavourable conditions.

To prevent plants from becoming too dense, the lateral shoots are removed, using either pruning shares or pruning knives. The tools must be kept sterile during the process. In this way the single, remaining stem becomes very long and needs to be supported. Often two stems will be developed from a single plant. The simplest method used for support is using wire or specialised thread that is anchored in the ground. The loose end of the stay wire is spun around the stem being supported. Wires are spun at a suitable height inside the tunnel, onto which the stems are anchored. As the plants grow, the anchors are disengaged from the wires, and the stems layered just above soil levels, reducing the plant mass that is required to be kept up.

FLOWER AND FRUIT MANIPULATION

FRUIT MANIPULATION

Fruit manipulation in crops is usually limited to fruit thinning or synchronisation of fruit drop or fruit ripening.

Fruit thinning is done to remove fruit that are diseased, malformed or have poor colour development. Fruit are also removed from young tree crops to ensure that the tree is not damaged due to too high fruit loads. In some cases, reduced fruit loads will reduce the number of fruit borne per tree, but will lead to an increase in the quality of the remaining fruit.

Where diseased leaves have been removed in the case of crops such as hydroponics tomatoes, the fruit is removed, to ensure sufficient leaf development for the following crop. Fruit thinning can be done by hand, as in the case of tunnel produced vegetables, or may be done using chemicals in the case of tree crops.

The process of fruit ripening can be encouraged using chemicals. A compound for examples such as Ethephon can be used to induce even ripening in tree crops. In crops such as macadamia and walnuts, the compound is used to ensure even nut drop, making the harvest easier.

In some crops such as blue berries and cherries, bud break will only occur after the crops have experienced significant cold spells. Should insufficient cold be experiences, the crop will not bud and low yields will be experienced. To this end chemicals such as HCN are used to induce bud break.

Pollination is important for fruit set in all fruiting crops. In most cases bees are the preferred pollinators. Where natural bee populations are low, beekeepers are employed to supply hives to orchards. Where bees are important for pollination it must be ensured that spray programmes are developed to ensure the bees populations are not damaged through pesticide applications.

In the case of hydroponics crops, most pollination occurs through ventilation, insects or movement of workers through the glasshouses. In crops such as peppers, pollination is critical and manual pollination may be necessary. Vibrating the stay wires on the trellising shakes the plant which aids pollination.

CHEMICAL MANIPULATION OF FLOWERS AND FRUIT

Several chemicals are used to control flower and fruit development in fruiting plants. Through the use of chemicals, the energy of the plant can be directed to the purpose of producing a quality fruit of the required size at the required time.

Through the use of chemicals, you can avoid the period of bud dormancy and stimulate the plant into early production, thus gaining the lucrative early market for a crop.

Chemicals such as 'Paclobutrasol can control the height of the plant, terminal buds can be 'pinched', cold requirements substituted, and excessive long shoots can be chemically disbudded.

Ethylene is a chemical that is naturally produced in fruits, seeds, flowers, stems, leaves and roots and controls a multitude of processes.

Ethylene is used commercially to promote flower development and colour formation and speeds up fruit ripening. Ethylene is also used in the production of pineapples to stimulate even flowering.

In deciduous fruit production, the flowers often drop prematurely before pollination has taken place resulting in a loss of potential crop. If the plant is sprayed with the chemical **silver thiosulate**, which prolongs flower life and reduces floret abscission.

In apple trees where different shoots types tend to produce different plant parts. Lateral shoots tend to produce vegetative growth. If these are left unchecked the plant becomes very leafy and bears very little fruit. If laterals are pruned, they produce sprigs that carry fruit. Manual pruning of laterals is time consuming. Chemical pruning will kill terminal buds and produce side shoots that tend to become sprigs that will produce fruit.

PHYSICAL MANIPULATION OF FRUIT AND FLOWERS IN CROP PRODUCTION

Physical manipulation encompasses the manual activities that encourage the healthy development of the tree, ensuring that a tree produces regular, acceptable sized fruit when it is wanted. The

manipulation directs the plant's energy into the process of producing a quality fruit within a time period that is expected by the farmer or market.

Thinning

Thinning is a manipulation process by which a part of a too heavy crop is removed. This leads to improved fruit size and promotes regular cropping by alleviation of alternate bearing.

Thinning should be carried out early in the season, after the first natural fruit shed and as soon as it becomes obvious that the crop will be too heavy. After thinning make sure that mature fruit are not in contact with each other.

If fruit trees are allowed to produce a too heavy crop, the tree will produce a crop only every second year (alternate bearing). Thinning will ensure that the tree produces a crop every year.

Thinning can also be done during pruning by thinning out bearer shoots. In tomatoes and cucumbers grown under protection, thinning implies the removal of all lateral branches, leaving one bearing stem only.

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