Citrus Orchard Foreman Occupational Learning

citrus academy
P.O. Box 461, Hillcrest, 3650
(031) 765-3410

Study Guide

KM-05:

Basic Principles of Plant Nutrition

Qualification:	110667 – Occupational Certificate: Orchard and Vineyard Foreman		
Module No.:	611202001-KM-05		
Module Title:	Basic principles of plant nutrition		
NQF Level:	4	**Credits:**	4

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Contents

Qualification Information

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

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

Knowledge Module

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

Module Code	**Module Title**	**Level**	**Credits**
Knowledge Modules			
611202-001-00-KM-01	Plant Structure and Physiology	4	5
611202-001-00-KM-02	Vineyard or Orchard Establishment	3	2
611202-001-00-KM-03	Vineyard or Orchard Manipulation Processes	3	8
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611202-001-00-KM-10	Overseeing Farming Resource Utilisation	4	8
Practical Skill Modules			
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611202-001-00-PM-2a	Set Team and Individual Performance Goals to Enhancing Team Performance	4	10
611202-001-00-PM-2b	Control Vineyard or Orchard Practices	4	10
611202-001-00-PM-03	Supply Accurate Daily Orchard or Vineyard and Production Information	4	10

Knowledge Topics, Topic Elements, and IACs

The content of this study guide is aligned to the following knowledge topics, topic elements, and internal assessment criteria of the module above.

Knowledge Topics, Topic Elements, and IACs	
Code	**Title**
KM-05-KT01	**Crop Nutrition (13%, 0.52 credits)**
KT0101	Plant growth requirements
KT0102	Nutrient status (N, P, K)
KT0103	Principles of nutrient application
IAC0101	The role of essential nutrient elements in plant growth is explained
IAC0102	Plant growth requirements through various stages of production is outlined
IAC0103	Nutrient deficiencies are explained in terms of symptoms, causes and corrective actions
IAC0104	Nutrient sources (organic, compost, etc.) are listed and described
IAC0105	Commercial fertilisers and mixtures are listed and described
IAC0106	Nutrient application methods are described
KM-05-KT02	**Soil properties (13%, 0.52 credits)**
KT0201	Physical chemical and biological soil properties
KT0202	Growth requirements of plants
IAC0201	The texture, structure, water holding capacity and drainage capacity is discussed in terms of its effect on crop growth
IAC0202	The effects of pH, EC, CEC, etc. on crop growth is described
IAC0203	The role of micro-organisms and organic matter on crop growth is explained
IAC0204	The physical and chemical soil requirements of different crops are outlined
KM-05-KT03	**Sampling procedures (13%, 0.52 credits)**
KT0301	Leaf, soil and fruit sampling and analysis
IAC0301	Methods of measuring nutritional status of plant through analysis (leaf, soil and fruit) are outlined
IAC0302	Sampling methods (soil, leaf, and fruit) are discussed in terms of merits and appropriate application
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KM-05-KT04	**Principles of soil preparation and remediation (13%, 0.52 credits)**
KT0401	{Principles of soil preparation and remediation} Application of fertiliser
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IAC0402	The importance of soil preparation and remediation is explained
IAC0403	The practical application of physical and chemical corrective measures such as mechanical soil preparation, pre-planting soil improvement for fertility and soil conditions is outlined and motivated
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KM-05-KT05	**Irrigation (12%, 0.48 credits)**
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KT0503	Principles of irrigation scheduling and application
KT0504	Leaching and contamination
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IAC0502	Irrigation system components are given and the function of each is described
IAC0503	Installation and maintenances principles are outlined and motivated
IAC0504	The necessity of water supply (supplementation) through irrigation is explained
IAC0505	Water quality requirements for specific crops are given
IAC0506	Irrigation scheduling in different climatic and weather conditions and stages of fruit production is outlined and motivated
IAC0507	The impact of soil properties and conditions on irrigation scheduling are discussed
IAC0508	The use of irrigation scheduling equipment in measuring soil water status is described
IAC0509	The principles of using irrigation efficiency reports to determine the need for maintenance and repairs are explained
IAC0510	Irrigation system maintenance plans and emergency response procedures are outlined
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IAC0512	The prevention of contamination through sound fertilisation and irrigation practices is described
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KT0603	Contamination risks
KT0604	Recordkeeping
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IAC0605	Basic principles of recordkeeping (such as accuracy and currency) is motivated
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KT0803	Integrated pest management (IPM)
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IAC0802	The OHS and GAP for safe handling of chemicals is described

IAC0803	GAP for record-keeping of chemical applications is delineated and motivated
IAC0804	IPM reporting requirements and traceability is explained

KM-05-KT01
Crop Nutrition
(13%, 0.52 credits)

Topic Elements

The content of this chapter covers the following topic elements:

- KT0101: Plant growth requirements
- KT0102: Nutrient status (N, P, K)
- KT0103: Principles of nutrient application

1. KT0101: Plant Growth Requirements

IAC0101: The role of essential nutrient elements in plant growth is explained

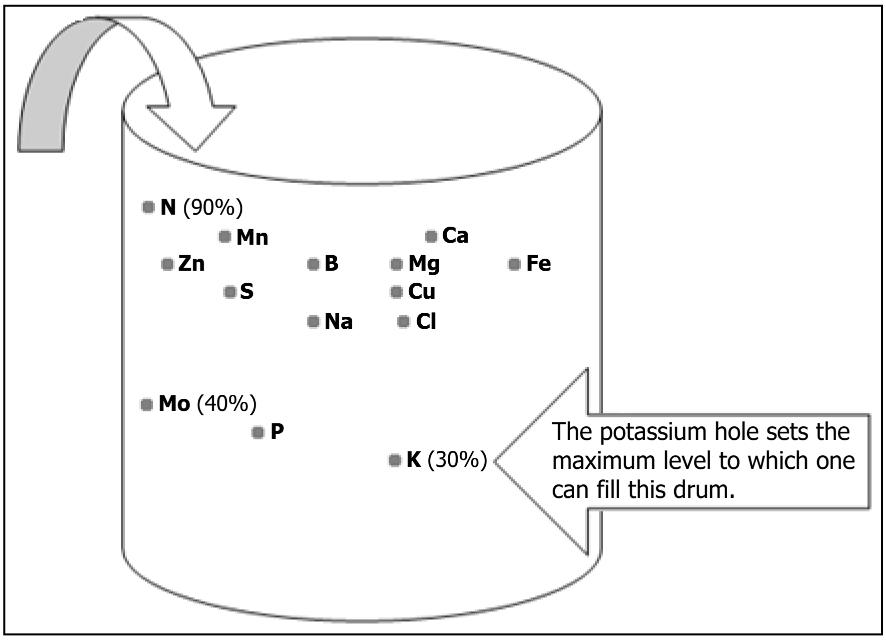
- Understanding essential nutrients is vital for running a productive farm.
- Nutrients influence growth, fruit development, and overall tree health.
- Each nutrient plays a specific, unique role in physiological processes including assisting with photosynthesis and increasing disease and pest resistance.
- Trees require a balanced nutrient supply to have long, productive lives.
- There are 14 essential nutrient elements that trees require to complete their lifecycles.
- Essential nutrients are classified into two groups, macronutrients and micronutrients.
- Macronutrients are nutrients needed in relatively large quantities.
- Micronutrients are nutrients needed in relatively small quantities.
- The table below describes the specific roles of each nutrient:

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

Essential Nutrient Element	Function
Sulphur (S)	Sulphur 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)	Sodium can replace potassium to some extent in certain plants.
Chloride (Cl)	Chloride is a micro-nutrient, with plants requiring about 20mmg per litre in their nutrient solution. Chloride is involved in the reactions where water molecules are split during photosynthesis.
Other micronutrient elements (Cu, Fe, Mn, Zn, B and Mo)	These micronutrients are involved in many physiological reactions as catalysts.

Table 1: Role and Function of Essential Nutrient Elements

- Each nutrient has an optimum level required for proper plant growth and development.
- The ability of a plant to grow, and thus produce fruit, depends on the most limiting nutrient element.
- The most limiting element is the element which the plant has lowest amount available of, relative to the optimum level of that nutrient.
- This means that the most limiting element is the element currently limiting growth and development.
- The concept is illustrated below by the "barrel or drum analogy", where each hole in the barrel represents a nutrient's percentage of optimum availability.



- The lowest hole (the most deficient nutrient) determines how full the barrel (plant growth) can get.
- To increase growth, the most limiting nutrient must be corrected first (Potassium (K) in the example).

- Once that element is sufficient, another element (Phosphorus (P) in the example) may become the new limiting factor.
- Blocking a hole in the barrel analogy means bringing that nutrient to its optimum concentration (100%).
- If nitrogen (N) is corrected but potassium (K) remains deficient, the drum cannot be filled beyond 30%, meaning growth remains limited.
- All nutrients must be at their optimal (100%) levels for the plant to reach maximum productivity.
- Even nutrients needed in very small amounts (e.g., molybdenum) can limit growth if deficient — in the example, production drops to 40% capacity.
- Effective nutrient management in commercial citrus production means maintaining all nutrients at optimal levels while minimizing costs.

IAC0102: Plant growth requirements through various stages of production is outlined

- Citrus trees, like all plants, require sunlight, water, air, and nutrients to survive and grow.
- Citrus trees typically require a minimum of 6 to 8 hours of direct sunlight daily.
- Citrus trees need a constant, well-distributed supply of water throughout the year, particularly during dry periods.
- Citrus trees require adequate air circulation within their canopy to prevent the proliferation of certain diseases and to ensure their overall well-being.
- Citrus trees require a balanced supply of multiple essential nutrients, including nitrogen, phosphorus, potassium, iron, zinc, and manganese, among others.
- These nutrients are essential for various processes such as photosynthesis, cell division, and the formation of essential plant structures like leaves, stems, and fruit.
- Citrus trees receive these nutrients by absorbing them from the soil through their root system.
- Photosynthesis is the biological process by which citrus trees convert light energy (usually sunlight) into chemical energy, stored in the form of glucose (sugar) and oxygen.
- Photosynthesis is vital for the tree's survival and forms the foundation for food production in the tree.
- Sunlight is absorbed by chlorophyll pigments in the leaves.
- Citrus trees absorb water through their root systems, transporting it to the leaves where it participates in the photosynthetic process.
- Water molecules are split in a process called photolysis, releasing oxygen as a by-product, and providing electrons essential for the formation of glucose.
- Air provides carbon dioxide (CO_2), which is another crucial ingredient in photosynthesis.
- Citrus trees draw in carbon dioxide from the surrounding air through tiny openings called stomata on their leaves.
- This absorbed carbon dioxide combines with the hydrogen ions generated from water during photolysis to create glucose molecules.
- Nutrients are not directly involved in the energy conversion steps of photosynthesis but are vital for the overall health and efficiency of citrus trees.

- Nutrients such as nitrogen (N), phosphorus (P), and potassium (K) support the formation of chlorophyll and other molecules involved in photosynthesis.

self-assessment

KT0101: Plant Growth Requirements

Can I?	Y/N
Can I describe the growth requirements of a citrus tree?	
Can I describe the function and absorption of nutrients in citrus trees?	
Can I describe the function and absorption of water in citrus trees?	
Can I describe the function and absorption of air in citrus trees?	
Can I describe the function and absorption of sunlight in citrus trees?	
Can I explain the process and purpose of photosynthesis?	

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0101	The role of essential nutrient elements in plant growth is explained	B7, D1, D2, D4, E2
IAC0102	Plant growth requirements through various stages of production is outlined	B3, B7, D1, D2, E2

2. KT0102: Nutrient Status (N, P, K)

IAC0103: Nutrient deficiencies are explained in terms of symptoms, causes and corrective actions

- Nutrient deficiencies are usually identified through visible symptoms which appear before sampling results are available.
- Deficiencies typically begin mildly and worsen over time if not corrected, making it important to recognise major deficiency symptoms early and take quick and effective action.
- Leaves are usually the first part of the tree to show deficiency symptoms.
- Healthy leaves should be symmetrical (both sides look the same).
- Sometimes, multiple deficiency symptoms can appear on the same leaf, making diagnosis more challenging.
- Non-nutritional factors can also sometimes mask or mimic nutrient deficiency symptoms, further complicating diagnoses.
- Symptoms generally appear first on either the newest or oldest leaves, depending on the nutrient involved.
- Some deficiency symptoms may be most noticeable in the fruit rather than the leaves.

Nutrient Element	First Plant Part to Display Symptoms	Mild Expression	Severe Expression
Nitrogen (N)	Old leaves	Yellowing of all old leaves, to a light yellow colour.	Yellowing of all leaves just before or during new leaf flush resulting in leaf drop.
Phosphorus (P)	Fruit	Open centre resembling over-matured fruit.	Thick skins and puffy fruit with high acid levels.
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	Increased creasing (physiological disorder).	Chlorosis (yellowing) of very young leaves and dieback of growth tips.
Magnesium (Mg)	Old leaves	Chlorosis of front of leaf from tip and sides of leaf. Inverted green V with open end of V at petiole side appears as symptom develops.	Leaf drop and decrease in fruit set.
Sulphur (S)	New leaves	Yellowing to butter-colour of new leaves on green twig.	Extremely reduced fruit set.
Copper (Cu)	New leaves	Extra-large leaves on strong new growth.	Gum pockets in albedo (white part of the peel)

Nutrient Element	First Plant Part to Display Symptoms	Mild Expression	Severe Expression
			of fruit. Fruit is small, thin-skinned and hard.
Iron (Fe)	New leaves	Yellowing of lamina (leaf blade) of young leaves leaving well-defined network of small veins.	Reduced fruit set.
Manganese (Mn)	New leaves	Inter-veinal yellowing of normal-sized leaf, almost over entire leaf. Broad green areas around veins and chlorotic areas between veins are most obvious symptoms.	Increase in number of leaves affected.
Zinc (Zn)	New leaves	Interveinal yellowing of small-sized leaf, starting at tip of leaf. Resembles manganese deficiency but appears on small leaves and chlorosis starts at tip of the leaf.	Increase in number of leaves affected and reduction in fruit size.
Boron (B)	New leaves	Corking of midrib vein on underside of leaf. Resembles symptoms of cold damage on leaves.	Gum pockets around centre of the fruit. Fruit size reduced.

Table 2: Symptoms of Nutrient Deficiencies in Citrus

- Any worker noticing any nutrient deficiency symptoms (even if they are unsure) must report them immediately to the orchard supervisor or manager.
- The appearance of deficiency symptoms usually indicates an ineffective or poorly designed fertilisation program.
- Unfortunately, symptoms emerge after the deficiency has already affected the plant and/or yield, meaning that corrective measures are focused on minimising the damage.
- A good fertilisation program should include protocols for detecting and correcting deficiencies early, before the entire orchard is impacted.
- Sometimes, it may make more sense to tolerate a mild deficiency for a short period, if the cost of correction would be more than the potential loss of yield.
- Correcting deficiencies is not always as simple as adding more of the missing nutrient, as deficiencies can be induced by other factors, not just an actual shortage of the nutrient.
- "Induced" deficiencies occur when a nutrient becomes unavailable or physiologically inactive, meaning that the nutrient is there, in the soil, but the plant cannot access it.
- Induced deficiencies usually occur due to soil or environmental factors.
- To fix a deficiency, growers must first identify and correct the underlying cause of poor nutrient availability.

- Even after application, nutrients may not remain active long enough to produce the desired physiological effects.
- Maintaining optimal nutrient concentrations requires growers to ensure that enough available forms of the nutrient are present for plant uptake.
- The table below outlines common causes of nutrient deficiencies and recommended corrective measures:

Nutrient Element	Causes of Deficiency and Deficiency-Inducing Factors	Corrective Actions
Nitrogen (N)	Too little applied.	Increase the application.
	Too much lost due to leaching.	Split application and control irrigation.
	Phytophthora (root rot) limiting the ability of plant to take up N from soil.	Treat the disease and apply nitrogen through foliar sprays in the meantime.
Phosphorus (P)	Too little applied.	Increase the application.
	Soil pH too high.	Apply treatment to decrease soil pH.
	Soil pH too low.	Apply treatment to increase soil pH.
Potassium (K)	Too little applied.	Increase the application.
	Mg supply too high.	Apply K through foliar sprays.
	Old trees.	N/a.
	Nematodes.	Treat the pest.
Calcium (Ca)	Too little applied.	Increase the application.
	Climatic conditions.	Increase 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 chelate that is stable at 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.

Nutrient Element	Causes of Deficiency and Deficiency-Inducing Factors	Corrective Actions
	Too much P applied.	Apply Zn through foliar sprays.
Boron (B)	Too little applied.	Increase the application.
	Soil pH too low.	Apply lime to soil.

Table 3: Causes and Corrective Actions for Nutrient Deficiencies

IAC0104: Nutrient sources (organic, compost, etc.) are listed and described

- Fertilisers are nutrient sources applied to plants to support growth and productivity.
- The three most common nutrient elements in fertilisers are nitrogen (N), phosphorus (P), and potassium (K).
- Fertilisers may contain one, two, or all three of these nutrients.
- Nitrogen is available in organic, inorganic, or mixed forms.
- Fertilisers for citrus trees are applied through soil applications or foliar applications.
- Soil applications involve applying nutrients directly into the soil.
- Soil applications can be performed manually, mechanically, or through fertigation.
- Manual soil applications involve spreading granular or powdered fertiliser by hand.
- Mechanical soil applications involve using equipment to apply granular, powdered, or slurry fertilisers.
- Fertigation involves adding liquid or water-soluble fertilisers to irrigation water.
- Foliar applications involve mixing nutrients with water and spraying them onto the trees' leaves.
- Fertilisers can be derived from organic or inorganic sources.
- Organic fertilisers are made of natural or synthetic organic materials.
- Inorganic fertilisers are chemically produced compounds.
- Some fertilisers are mixtures of both types.
- Compost (decomposed plant material) is an organic fertiliser, but it is not commonly used in commercial citrus production due to the large quantities required and the difficulty in controlling nutrient content.
- Other organic fertilisers include chicken droppings and cattle manure, though these are also not widely used in citrus farming.
- Citrus production mainly relies on inorganic fertilisers, in the form of commercially available (chemical) fertilisers.
- These fertilisers can be granular, powdered, or liquid.
- Granular fertilisers consist of coarse particles for soil application.
- Powdered fertilisers consist of fine material for soil, foliar, or fertigation use.
- Liquid fertilisers consist of liquids ready for dilution in water for foliar or fertigation application.

self-assessment

KT0102: Nutrient Status (N, P, K)

Can I?	Y/N
Can I identify nutrient deficiencies through visible symptoms?	
Can I explain the value of early recognition of deficiency?	
Can I describe a mild expression of deficiencies for each of the various essential nutrients?	
Can I describe a severe expression of deficiencies for each of the various essential nutrients?	
Can I explain what workers should do if they notice possible nutrient deficiency symptoms?	
Can I determine whether a deficiency should be tolerated or corrected?	
Can I describe the causes of deficiency for each of the various essential nutrients?	
Can I prescribe the appropriate corrective actions for deficiencies for each of the various essential nutrients?	
Can I describe the composition and forms of common fertilisers?	
Can I select the appropriate fertiliser for a corrective action?	
Can I describe and perform various application methods for fertilisers?	

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0103	Nutrient deficiencies are explained in terms of symptoms, causes and corrective actions	A5, B7, D1, D2, D3
IAC0104	Nutrient sources (organic, compost, etc.) are listed and described	A5, C1, C2, D2, E2

3. KT0103: Principles of Nutrient Application

IAC0105: Commercial fertilisers and mixtures are listed and described

- The table below lists common fertilisers in Southern Africa and the nutrient elements each provides.

Fertiliser	Nutrient Elements	Nutrient Content
Potassium Chloride	K and Cl	50% K*, 50% Cl*
Potassium Sulphate	K and S	% K*, % S*
Potassium Nitrate	K and N	38% K, 13% N
Mono Potassium Phosphate (MKP)	K and P	29% K, 24% P
Calcitic Lime	Ca	minimum 35% Ca
Dolomitic Lime	Mg	maximum 10% Ca and minimum 4,3% Mg
Gypsum	Ca and S	235 Ca, 19% S
Calcium Nitrate	Ca and N	17% Ca, 12% N
Magnesium Nitrate	Mg and N	10% Mg 10% N
Magnesium Sulphate	Mg and S	10% Mg, 13% S
Limestone Ammonium Nitrate (LAN)	N	28% N
Urea	N	46% N
Ammonium Sulphate	N	21% N, 23% S
Ammonium Nitrate	N	19-34% N
Ammonium Sulphate Nitrate	N	27% N, 12% S
Single Super Phosphate	P, Ca and S	10% P, 22% S, % Ca
Mono Ammonium Phosphate (MAP)	N and P	11-12% N and 22-26% P

Table 4: Fertilisers Commonly Available in South Africa

IAC0106: Nutrient application methods are described

- Some nutrients must be applied regularly each year to maintain tree health and productivity.
- The fertilisation manager must develop an annual fertilisation program to plan these applications.
- The fertilisation programme is designed based on tree age, the previous season's yield, reports of past deficiencies, and soil and leaf analyses.
- Continuous soil and leaf analyses are further used to guide and adjust the fertilisation program throughout the year.
- Once the fertilisation program is finalised, preparations for applying fertilisers at the scheduled times begin.
- The procedure of preparing for a fertiliser application is as follows:

1. Calculate the total amount of fertiliser required.
2. Collect the fertiliser from storage.
3. Collect the application equipment from storage.
4. Measure the fertiliser to match the required volume and weight.
5. Calibrate the application equipment.

- The amount of fertiliser required and applied must be carefully calculated to avoid over- and under-application.
- Over-application can damage trees or soil.
- Under-application can cause nutrient deficiencies and reduce yield.
- The total amount of fertiliser required is calculated from the fertilisation program.
- The formula is 'Total Fertiliser Required = Fertiliser per Tree (g or ml) × Number of Trees in Orchard'.
- If the number of trees isn't known, it can be calculated as 'Number of Trees in Orchard = Orchard Size (ha) × Number of Trees per ha'.
- After calculating the total fertiliser required, workers must collect the required amount from the storeroom.
- Before collection, workers need to verify that they are collecting the right chemicals.
- The process of checking the agrochemical before collection is as follows:

1. Use half-used bags first when applicable before opening new bags.
2. Check the active ingredient concentration on the bag or container (some fertilisers come in multiple concentrations).
3. Weigh the bag to confirm the weight of the bag matches the label (e.g., 25kg, 50kg).
4. Check that the product inside the bag matches the label (i.e. The label says granular and there are granules in the bag).
5. Assist the storeroom manager in filling out all appropriate records.

- Before application, fertilisers must be carefully measured to ensure that the right amount is applied.
- Before manual applications, the prescribed mass per tree must be converted to volume.
- This conversion is performed by weighing the required amount, measure its volume in ml, and then creating uniform scoops in this volume for workers.
- For fertigation and foliar applications, the liquid or powdered fertiliser must be weighed or measured before mixing with water.
- The process of soil applications of agrochemicals is as follows:

1. Pre-irrigate the orchard for about 30 minutes to wet the feeder-root zone.
2. Scoop and spread fertiliser evenly on the wetted area, avoiding the trunk.

- Fertigation involves adding measured fertiliser directly to irrigation water as per manufacturer instructions.
- Mechanical applications follow manufacturer and supplier instructions, with attention to PPE and safety requirements.

self-assessment

KT0103: Principles of Nutrient Application

Can I?	Y/N
Can I list common fertilisers in Southern Africa and the nutrient elements each provides?	
Can I assist in developing an annual fertilisation program?	
Can I perform ongoing soil and leaf analyses and adjust the fertilisation program accordingly?	
Can I prepare for a fertiliser application?	
Can I describe the potential effects of over- or under-applying fertiliser on trees or soil?	
Can I explain calculate the total amount of fertiliser required for an application?	
Can I calculate the number of trees in an orchard?	
Can I check, weigh and measure agrochemicals before collection?	
Can I perform agrochemical applications?	

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0105	Commercial fertilisers and mixtures are listed and described	A5, C1, D2, E2, J1
IAC0106	Nutrient application methods are described	A5, C1, C2, D2, E2

KM-05-KT02:
Soil Properties
(13%, 0.52 credits)

Topic Elements

The content of this chapter covers the following topic elements:

- KT0201: Physical chemical and biological soil properties
- KT0202: Growth requirements of plants

1. KT0201: Physical Chemical and Biological Soil Properties

IAC0201: The texture, structure, water holding capacity and drainage capacity is discussed in terms of its effect on crop growth

- Commercial citrus trees require soil for growth.
- Soil provides many benefits to citrus trees.
- Soil provides anchorage, allowing roots to keep the tree upright and grow deeply into the ground.
- Soil enables nutrient uptake, as roots absorb essential nutrients necessary for tree growth.
- Soil facilitates water absorption, allowing roots to take up the water they need.
- Soil supports air exchange, providing roots with oxygen and carbon dioxide required for respiration.
- Soil is composed of minerals, air spaces, water, and organic material, all of which influence its properties.
- The properties of soil affect root growth, nutrient and water uptake, and root respiration.
- Understanding soil properties is critical for orchard management because natural soils are often not ideal for growth.
- Soil properties are divided into two main categories, physical properties and chemical properties.
- The physical properties of soil are largely fixed, and do not change significantly or easily over time.
- Physical soil properties are vital for the sustainable productivity of soils and can often be evaluated visually.
- The most important physical properties of soil are texture, structure, depth, layering (AKA stratification), and aeration.
- Soil texture is determined by the ratio of various soil particles, including clay, silt, and sand in the soil.
- Soil texture is largely a fixed property that cannot be cost-effectively altered.

- Different combinations of clay, silt, and sand are grouped into textural classes, ranging from clay to sand.
- Soil particles vary in size, with clay particles in soil having an average size of less than 0.002 mm, silt particles ranging from 0.002 mm to 0.05 mm, and sand particles ranging from 0.05 mm to 2 mm.
- Soil texture is best accurately determined in a laboratory through soil sampling but can also be estimated in the field.
- The field test for soil texture involves taking approximately 50g of soil, adding water to form a thick paste, kneading it, rolling it into a tube, and attempting to bend the tube into a circle.
- The results of this field test are compared to standard tables to classify the soil into its textural class, as shown below:

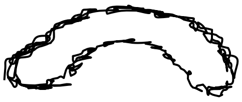
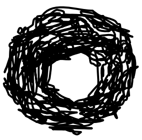
Textural Class	Shape of Sausage	Clay Content	Illustration
Sand	It is not possible to roll a sausage in the palm. The soil does not stick together.	Less than 10%	
Loamy Sand (LoSa)	It is possible to roll a sausage, but the sausage cannot be bent at all without cracking or breaking.	10 to 15%	
Sandy Loam (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 bent to form a complete circle without cracking in the middle	>50%	

Table 5: Soil Structure Field Test Classes

- Soil texture can also include particles larger than 2 mm, referred to as gravel or stones.
- Soils with a gravel content exceeding 10% will influence the chemical composition of the soil, as gravel dilutes the concentration of available nutrient elements.
- Humus (organic material) also affects soil properties.
- Humus content can be increased through management practices, but agricultural activity usually decreases it over time.
- Clay content is a fixed property that cannot be realistically changed in an economically viable manner.

- The type and concentration of clay determine key soil properties, including cation-exchange capacity, water-holding capacity, and aeration.
- Ideal soil for citrus production contains less than 50% fine particles (fine sand, silt, and clay) and less than 25% clay.

	7%	30%	40%
Marginal	**Optimal**	**Marginal**	**Risky**

Table 6: Clay Content of Soil vs. Suitability for Citrus Production

- 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 describe in the table below:

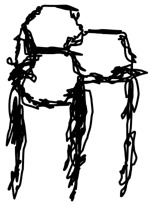
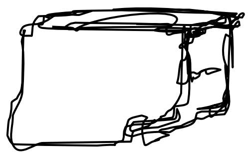
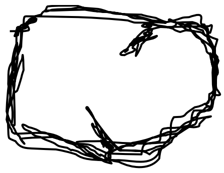
Structural Unit	Description	Illustration
No structure	This is usually the case in sandy soils where soil particles do not stick together. The soil falls apart when removed from the profile.	
Plate-like	The natural cracks are horizontal.	
Prismatic	The vertical cracks are better displayed than the horizontal 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 units 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.	

Table 7: Soil Structural Units

- Soil structure affects aeration, water penetration, and drainage, and if destroyed, the soil becomes anaerobic and waterlogged, making it unsuitable for citrus production.
- Soil depth refers to how far down impermeable layers or parent material occur in the soil.
- Soils with a depth of less than 500mm are generally considered low quality, but some practices can improve soil depth.
- Effective soil depth for citrus refers to the depth roots can penetrate easily.
- Effective depth is measured where soil strength (measured as pressure) is less than 2,000 MPa/cm², and soil strength increases with depth.

- Soil strength (and thus effective depth) can be measured using a soil penetrometer, which assesses the resistance of soil to root or probe penetration.
- Soil layering (AKA stratification) refers to the formation of layers (also called horizons) within the soil, where layers have different soil characteristics.
- Layering occurs as soil particles separate and accumulate over time, forming layers.
- These layers affect root growth and water movement, especially if texture changes too drastically between layers.
- The texture of soil should not change by more than 50% between layers, as severe stratification impedes root penetration and water flow.
- Aeration refers to how much air is in the soil and is essential for plant roots to respirate.
- Aeration depends on soil pore size influenced by texture, structure, and strength.
- Soil pores are filled with air and water, with the air content at a minimum when the soil is at field water capacity (FWC).
- As roots absorb water, air content increases.
- Field water capacity (FWC) is reached when soil drains freely after saturation and no free water remains, with all water bound to soil particles.
- Poorly drained or waterlogged soils have low air content, creating anaerobic conditions that can lead to root death.

IAC0202: The effects of pH, EC, CEC, etc. on crop growth is described

- The chemical properties of soil are constantly changing, and can usually be altered, although this can be costly.
- The most relevant chemical properties of soils are pH, electrical conductivity (EC), salinity, fertility, and cation exchange capacity (CEC).
- pH indicates the acidity or alkalinity of soil and is measured on a scale from 1 to 14.
- The lower the pH, the more acidic the soil is, and the higher it is, the more alkaline the soil is.
- A pH of 1 is extremely acidic and a pH of 14 is extremely alkaline (AKA basic), with 7 being a neutral pH.
- Soil pH can be tested in a few different ways, including using a pH test kit, a pH meter, or through laboratory soil analysis.
- Most citrus trees prefer slightly acidic to neutral soil (6.0–7.0).
- If the pH is outside this range, lime or sulphur may need to be applied to adjust pH levels and improve nutrient uptake.
- The pH of the water used in agriculture is very important, as it directly affects plant health, production practices and soil pH.
- The optimal pH of water used in citrus production is 6.5 to 7.5.
- If the pH of irrigation water drops below 5.3, aluminium becomes toxic to roots and inhibits root growth.
- If the pH of irrigation water rises above 7.5, nutrient elements like phosphate, zinc, and manganese become insoluble, potentially inducing deficiencies.
- In soils with neutral to acidic pH, the subsoil typically has a lower pH than the topsoil.

- Electrical conductivity (EC) refers to the ability of soil water to conduct an electrical current.
- EC is expressed in siemens (S), while resistance (how difficult it is for electricity to pass through the medium, the opposite of conductivity) is measured in ohms (Ω).
- EC is determined by the total dissolved salts (ions) in the soil solution, and if a sample is too salty, EC is measured to accurately determine salinity (salt levels).
- Salts accumulate in soils primarily due to poor drainage or salty irrigation water and gradually affects soil fertility and physical properties such as soil structure.
- Fertility refers to the soil's status in terms of essential nutrients.
- Fertile soil contains enough of these nutrients to sustain plant growth.
- Generally, if it is not possible to have ideal nutrient content, it is better to have a slight deficiency than an excess.
- Adding nutrients is relatively easy and inexpensive, whereas removing excess nutrients or correcting large imbalances is difficult and costly.
- For commercial citrus production, the ideal soil contains:
    - Between 25 and 50mg/kg phosphorus (P).
    - A ratio of 5% to 7,5% potassium (K).
    - A ratio of 70% to 80% calcium (Ca).
    - A ratio of 20% to 25% magnesium (Mg).
    - Less than 1% sodium (Na).
- Cation Exchange Capacity (CEC) refers to the ability of soil to retain positively charged ions, or cations.
- Cations include potassium, calcium, and magnesium, which are essential nutrients for citrus trees.
- Clay particles in soil usually carry a negative charge, which allows them to attract and hold cations from the soil solution.
- The CEC of soil is influenced by the type and amount of clay minerals and organic matter present, and it is expressed in centi-molar charge per kilogram of soil (cmol+/kg).
- A higher CEC indicates a greater ability of the soil to retain essential nutrient cations, preventing them from being leached away with water movement.
- Soils with higher CEC are generally more fertile, as they can provide more nutrients for plant uptake.

IAC0203: The role of micro-organisms and organic matter on crop growth is explained

- Understanding the relationship between micro-organisms, organic matter, and crop growth is vital for managing soil health and ensuring the growth and yield of citrus trees.
- Micro-organisms in soil include bacteria, fungi, nematodes, and protozoa, and they are essential for maintaining a healthy soil ecosystem.
- Micro-organisms perform critical functions such as nutrient cycling, nitrogen fixation, disease control, and soil improvement.

- In nutrient cycling, micro-organisms decompose organic matter, breaking complex molecules into simpler compounds like nitrogen and phosphorus, which are available for tree uptake.
- Nitrogen fixation is the process by which certain bacteria convert atmospheric nitrogen from the air (N_2) into nitrogen compounds that trees can use, reducing reliance on fertilisers.
- Some soilborne micro-organisms help control diseases by outcompeting pathogens for resources or producing chemicals, such as antibiotics, that destroy the pathogens.
- Micro-organisms improve soil by contributing to the formation of natural soil structures, enhancing water drainage, aeration, and root penetration, which support healthy tree growth.
- Organic matter refers to remnants of living organisms, including dead plants, animal manure, and compost, and it is essential for healthy soil.
- Micro-organisms assist in decomposing organic matter, releasing essential nutrients slowly and consistently, benefiting plant growth and reducing fertiliser costs.
- Organic matter improves water retention and soil aeration by trapping moisture and preventing compaction, which supports root development and resilience during drought.
- Organic matter also promotes microbial activity, as micro-organisms feed on it, multiplying and enhancing overall soil fertility and health.
- Organic matter helps stabilize soil pH, maintaining levels optimal for nutrient availability and uptake, and protecting trees from sudden pH changes.

self-assessment

KT0201: Physical Chemical and Biological Soil Properties

Can I?	Y/N
Can I explain the role of soil in citrus trees growth?	
Can I identify the main components of soil?	
Can I identify the ideal soil composition for citrus production?	
Can I identify and describe physical soil properties?	
Can I explain soil texture and how it is determined?	
Can I determine soil structure?	
Can I define and measure soil depth?	
Can I define and identify soil layering?	
Can I define field water capacity (FWC) and its significance for soil drainage?	
Can I identify and describe chemical soil properties?	
Can I measure and alter soil and water pH?	
Can I define and assess electrical conductivity (EC) and soil salinity?	
Can I define and assess soil fertility?	
Can I define and assess Cation Exchange Capacity (CEC)?	
Can I identify and classify micro-organisms in soil?	

Can I describe the critical functions micro-organisms perform in soil?	
Can I explain the function of organic matter in soil?	

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0201	The texture, structure, water holding capacity and drainage capacity is discussed in terms of its effect on crop growth	A1, B1, B3, B7, D2
IAC0202	The effects of pH, EC, CEC, etc. on crop growth is described	A1, B1, B3, B7, D2
IAC0203	The role of micro-organisms and organic matter on crop growth is explained	A1, B1, B3, B7, D2

2. KT0202: Growth Requirements of Plants

IAC0204: The physical and chemical soil requirements of different crops are outlined

Refer to IAC0201: The texture, structure, water holding capacity and drainage capacity is discussed in terms of its effect on crop growth.

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0204	The physical and chemical soil requirements of different crops are outlined	A1, B1, B3, B7, D2

KM-05-KT03:
Sampling Procedures
(13%, 0.52 credits)

Topic Elements

The content of this chapter covers the following topic elements:

- KT0301: Leaf, soil and fruit sampling and analysis

1. KT0301: Leaf, Soil and Fruit Sampling and Analysis

IAC0301: Methods of measuring nutritional status of plant through analysis (leaf, soil and fruit) are outlined

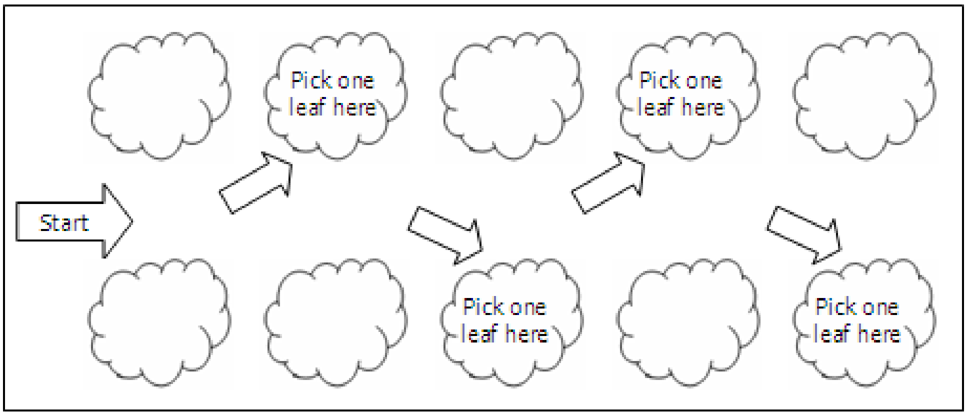
- Measuring the nutritional status of citrus trees is essential to identify and rectify deficiencies before production is seriously affected.
- A fertilisation program cannot be developed solely in response to visible nutrient deficiencies, because by the time symptoms appear, the deficiency has already affected tree growth and production.
- Leaf and soil analyses are the primary tools for measuring nutritional status in citrus production.
- Soil sampling involves collecting soil and analysing it to determine soil nutrient levels and certain chemical and physical soil properties.
- Soil sampling helps guide soil preparation and corrective activities before planting.
- Soil samples are also collected after orchard establishment to monitor nutrient availability and optimise nutrient supply through fertilisation.
- Leaf sampling involves collecting leaves and analysing them to determine the nutrient status of the plant itself.
- The results of leaf and soil sampling are used to create and modify the fertilisation program.
- Fruit sampling is not used to assess nutrient status in citrus production and is only used for maturity indexing or post-harvest inspections.
- Despite fruit sampling not being used for nutrient analysis, fruit should still be visually monitored for signs of nutrient deficiencies.

IAC0302: Sampling methods (soil, leaf, and fruit) are discussed in terms of merits and appropriate application

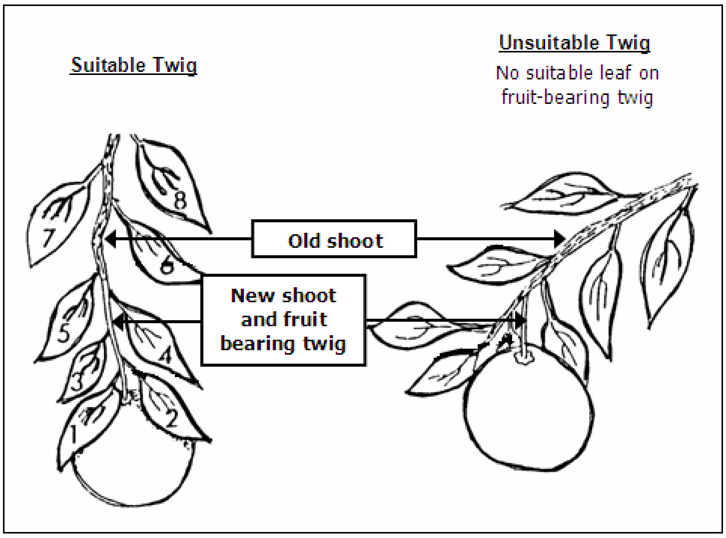
- Sampling is only effective when samples represent the whole orchard rather than representing only a piece or section of it.
- A sample is defined as a smaller, manageable volume that reflects the characteristics of the bulk material being analysed.

- In citrus production, a sample is a small, representative portion of fruit, leaves, soil, or other material collected for the purpose of analysis.
- To ensure that samples are representative and provide reliable information, soil and leaf samples should be taken from the same set of trees or orchard area throughout the year.
- Two to four rows of trees should be selected to represent the orchard for sampling, and these are referred to as the index rows.
- Index rows should be marked, and all future samples for that orchard should be taken consistently from these trees.
- Leaf sampling in South Africa is typically performed between February and May, and it should be done at the same time each year for consistency.
- Sampling must be done before harvesting, particularly for early varieties like Satsuma.
- For leaf sampling, the following procedure is followed:

1. Enter the path between two of the rows in the index block.
2. Using clean hands or gloves, pick leaves from every second tree on the left and right, as shown below:



3. Pick 50 to 100 leaves per sample.
4. Pick only healthy, undamaged leaves.
5. Pick leaves that are between 1 and 2 metre from the orchard floor, between about the waist and head of a person of average height.
6. Pick leaves from fruit bearing twigs, as shown below:



7. Put the leaves in a new, clean plastic bag.
8. Squeeze the air out of the bag and close it tightly.
9. Label the sample as prescribed below.
10. Keep the samples until they are dispatched to the laboratory in the shade or in a cool place, but do not freeze the samples.

- For soil sampling, the following procedure is followed:
  1. Enter the same index block where leaf samples are taken.
  2. Identify areas under every second to fourth tree for collecting small samples, or sub-samples, which will be used to make up the eventual sample.
  3. Remove any visible plant debris from the surface of the soil but take care not to remove the topsoil.
  4. Take the sub-sample from the surface down to a depth of 30cm depth using a sterilised spade or soil auger.
  5. Take a total of between 15 and 20 sub-samples per index row.
  6. Collect the sub-samples in a plastic bucket.
  7. Mix the soil in the bucket and place about 500g in a plastic bag to form the sample that will be sent for analysis.
  8. Seal the bag tightly.
  9. Label the sample as prescribed below.
  10. Keep the samples until they are dispatched to the laboratory in the shade or in a cool place, but do not freeze the samples.
- When labelling samples, the following procedure is followed:
  1. Attach a label to the container, by either sticking it on or tying it on securely with string.
  2. Do not write the information directly onto the container, because even permanent marker ink rubs off during transport.
  3. Never place a label inside the bag with the sample.
  4. If the laboratory handles samples from multiple producers, the labels should contain all the details of the sender, including:
     - Name of producer
     - Address
     - Telephone number
     - Details of analysis required in case of special instructions
     - Order number, if used
     - Sample reference (such as the orchard number)
     - Type of sample
     - Date of sampling
  5. If the laboratory is on farm or only handles the grower’s samples, the labels only need to include:
     - Details of analysis required

- Sample reference (such as orchard number or location on farm)
- Type of sample
- Date of sampling

- The sample references, whether they are the orchard name, number, or on-farm location, must be standardised for recordkeeping practices.
- The laboratory report will contain this reference, and the sender must be able to connect the results with the relevant orchard or location.
- References should not be overly detailed and should be as simple as possible while still being standardised and informative.
- Workers, especially those involved in sampling, must be aware of the reference system used on the farm and instructed to follow it.
- Samples must be kept separate from potential sources of contamination, as contamination could alter the analysis results.
- Before packing samples for transport to the laboratory, ensure that all samples are correctly labelled and that the labels are legible.
- Check each sample against the Samples Dispatched list as you pack them to confirm accuracy.
- When packing, place the samples in a sturdy box and use packing materials such as bubble wrap or newspaper to secure and protect them during transport.
- All equipment used during sampling, including cups, spatulas, buckets, and mixing tools, must be thoroughly cleaned and sterilised before use to prevent contamination.
- Sampling equipment should be washed after use, then properly stored, inventoried, and maintained like any other farm equipment.

IAC0303: The practical use of soil and leaf analysis reports is explained

- Soil and leaf analysis reports are critical tools for understanding the nutritional status of the soil and the trees in an orchard.
- Soil analysis reports provide information on soil properties, including nutrient content, pH level, organic matter content, and physical characteristics such as texture and structure.
- If reports show a nutrient deficiency, fertilisation practices can be adjusted accordingly to correct deficiencies before they negatively affect tree growth.
- Soil analysis reports can reveal an unsuitable pH level in the soil and determine the need for pH adjustment practices.
- If analysis reports reveal a lack of organic matter content in the soil, compost or organic mulches may need to be incorporated into the soil.
- Leaf analysis provides a direct indication of the nutrient status of the trees themselves, reflecting actual nutrient uptake rather than just availability in the soil.
- Leaf analysis results can identify nutrient deficiencies in trees, guiding the appropriate corrective measures in the fertilisation program.
- By collecting multiple leaf and soil reports over time, fertilisation programs can be fine-tuned in terms of fertiliser types, application rates, and timing.
- The most effective approach is to combine soil and leaf analysis, considering both sets of data together.

self-assessment

KT0301: Leaf, Soil and Fruit Sampling and Analysis

Can I?	Y/N
Can I explain the purpose of soil sampling?	
Can I perform soil sampling?	
Can I describe the purpose of leaf sampling?	
Can I perform leaf sampling?	
Can I use sampling results to create and modify fertilisation programmes?	
Can I explain why fruit sampling cannot be used for nutrient analysis?	
Can I visually monitor fruit for nutrient deficiency signs?	
Can I select representative samples of trees, soil, leaves, and fruit?	
Can I properly label samples?	
Can I safely pack, store, and transport samples before analysis?	
Can I clean and sterilise sampling equipment before use?	
Can I clean, store, inventory, and maintain sampling equipment after use?	
Can I create leaf and soil analysis reports?	
Can I properly instruct workers involved in sampling on all of the above?	

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0301	Methods of measuring nutritional status of plant through analysis (leaf, soil and fruit) are outlined	A3, D1, D2, D3, D4
IAC0302	Sampling methods (soil, leaf, and fruit) are discussed in terms of merits and appropriate application	A3, D1, D2, D3, D4
IAC0303	The practical use of soil and leaf analysis reports is explained	A3, D1, D2, D3, D4

KM-05-KT04: Principles of Soil Preparation and Remediation (13%, 0.52 credits)

Topic Elements

The content of this chapter covers the following topic elements:

- KT0401: {Principles of soil preparation and remediation} Application of fertiliser

1. KT0401: {Principles of Soil Preparation and Remediation} Application of Fertiliser

IAC0401: The basic concept and principles of soil preparation and remediation is explained

IAC0402: The importance of soil preparation and remediation is explained

- Healthy, high-quality soil is essential for the successful growth of a citrus orchard.
- Occasionally, the soil in an orchard may not naturally be suitable for citrus production and will require preparation and remediation.
- Soil preparation and remediation practices are implemented to improve soil properties to make the land productive and suitable for farming.
- Soil preparation is the process of preparing soil for planting and use in production, and involves numerous practices performed to increase soil quality.
- Soil preparation practices include soil testing, tillage, pH adjustment, fertilisation, and organic matter incorporation.
- Soil testing involves analysing soil via sampling before any preparation practices are implemented and using the collected data to guide soil preparation.
- Tillage is the process of preparing the soil by manually agitating it, such as by digging, stirring, and overturning it.
- Tillage increases aeration and drainage, while allowing for better root penetration by mitigating compaction.
- Excessive tillage should be avoided, as it can lead to erosion.
- Various methods can be used to adjust the soil pH if soil testing reveals a pH outside the ideal range, such as adding lime (to increase pH) or sulphur (to decrease pH).
- Fertilisation is performed to increase the availability of essential nutrients in the soil.
- Fertiliser applications should always be balanced, aiming to mitigate deficiencies without causing an excess.

- Organic matter incorporation is the process of manually adding organic matter to the soil if there is too little.
- Soil remediation is the process of rectifying existing soil problems, and can include numerous practices, some of which overlap with soil preparation.
- Soil remediation practices include contaminant removal, reversing soil compaction, improving drainage and pest and disease control.
- Contaminants refer to unwanted substances that negatively affect soil health, tree growth, fruit quality, or food safety.
- Contaminant removal (or decontamination) involves removing or neutralising these contaminants.
- There are numerous methods used to decontaminate soil depending on the specific contaminants ranging from soil stabilisation to chemical oxidation.
- These practices are complex and will often require expert advice or the hiring of outside companies that specialises in decontamination.
- Compacted soil presents a problem to production, as it impedes root growth and water drainage.
- Various methods can be used to mitigate compaction, such as incorporating organic matter or physically aerating the soil through tillage.
- Waterlogging causes issues for tree health and production practices, and practices to improve drainage may be necessary to prevent waterlogging.
- These practices to improve drainage can include constructing drainage channels or performing ridging, among other practices.
- Soil can house pathogens or pests that can be very detrimental to trees, and it may be necessary to implement soil pest and diseases control measures.
- These soil pest and diseases control measures include soil fumigation or the use of biological controls to counteract these dangers, among others.

IAC0403: The practical application of physical and chemical corrective measures such as mechanical soil preparation, pre-planting soil improvement for fertility and soil conditions is outlined and motivated

- Soil corrective measures can be divided into physical, chemical, and biological soil preparation methods.
- Physical soil preparation methods are the most commonly practiced methods of soil preparation.
- The most common physical improvement methods (AKA mechanical soil preparation methods) are mixing, loosening, and ridging.
- Mixing is a physical process where soil is moved in an up-and-down motion to reduce layering in the soil profile.
- Ploughing is the most common method of mixing, which slices and turns the soil, bringing subsoil to the top and pushing topsoil deeper.
- Repeated ploughing creates a healthy topsoil distinct from the subsoil in colour, strength, and phosphorus concentration.
- Ploughing also increases the soil quality beneath the topsoil.

- Dish ploughs of various sizes are commonly used for mixing, with tractor size and type influencing the depth achievable.
- Loosening lifts soil without mixing, reducing soil compaction but maintaining the original soil profile.
- Tine implements are used for loosening, with modifications like wings or ripper tines enhancing effectiveness to reach desirable depths.
- Combinations of mixing and loosening can be applied to achieve specific soil profile changes.
- Ridging is the process where some of the soil between rows of trees in moved to the areas where the trees will be planted, creating ridges with a greater depth than the natural soil.
- Ridging was originally developed to increase effective rooting depth, but other advantages and disadvantages have subsequently been discovered and researched.
- Ridging increases rooting depth, allowing soils that would be too shallow for production to still be used.
- Ridging also improves surface drainage, limiting waterlogging.
- Ridged soil is warmer, which is an advantage in areas with cold winters or springs.
- Motor traffic control within the orchard is easier after ridging because rows are clearly demarcated.
- Ridging does have some disadvantages, and they should be considered before it is implemented.
- Soil that has been ridged dries out quicker than natural soil, due to the higher soil temperatures in ridges.
- This faster drying poses a problem, especially in hot areas and when the trees are young with the soil surface exposed to the sun.
- This faster drying may require increased irrigation, and soil moisture levels, especially in the ridges, should be carefully monitored.
- Ridging increases erosion in the valleys between ridges, especially in the early stages in the establishment of the orchard.
- Harvesting can be more complicated on ridged surfaces due to uneven ground and with the increased relative height of the trees.
- Subsurface drainage is a physical soil preparation method used when the internal drainage of the soil is poor.
- Subsurface drainage involves installing a draining system, typically trenches, throughout the orchard.
- Trenches are dug to a depth greater than 70 cm or to the top of the compacted soil layer.
- Trenches are filled halfway with stones, covered with plastic, and then backfilled with soil.
- Water moves horizontally through the soil toward the trench and then flows down the trench slope to exit the orchard.
- For orchards where simple trenches are unable to sufficiently improve drainage, irrigation or drainage engineers should be consulted to design an adequate system.
- Chemical improvement methods vary and are usually performed based on the results of soil analyses.

- Chemical improvement methods include modifying soil pH, supplementing nutrients through fertiliser, among others.
- pH modification is generally performed through the use of liming materials to increase the soil pH and supply Ca and Mg.
- These liming materials include dolomitic and calcitic limes, oxides and hydroxides and mixtures of these.
- Gypsum can also be used to supplement calcium without changing the pH.
- Phosphates and other nutrient sources are used to supplement the nutrient supply from the soil.
- Mulching is the main biological soil improvement method used in citrus production.
- Mulching involves covering the topsoil with organic material to protect the soil surface and reduce evaporation, particularly for non-bearing trees.
- Common materials used for mulching include veld grasses, straw, sugar cane tops, and maize stalks, while plastic mulch is mostly used during severe droughts.
- Mulching is not widely practiced due to limited availability of materials, transport and application challenges, and the risk of veld fires.
- Records of all soil preparation actions must be kept, preferably in an electronic database.
- These records should include the date, cultivation depth, preparation method, chemicals applied, type of implements used, contractors employed, drainage installed, and directions ploughed.

IAC0404: Methods of pre-planting fertiliser application during soil preparation is discussed

Refer to IAC0106: Nutrient application methods are described.

self-assessment

KT0401: {Principles of Soil Preparation and Remediation} Application of Fertiliser

Can I?	Y/N
Can I identify when soil may require preparation and remediation?	
Can I describe the purpose of soil preparation and remediation practices?	
Can I explain and perform soil testing before preparation?	
Can I describe and perform tillage?	
Can I identify and perform methods to adjust soil pH?	
Can I explain the purpose of and perform fertilisation?	
Can I incorporate organic matter into soil?	
Can I explain the concept of soil remediation?	
Can I describe contaminants and their impact on soil health and crop production?	
Can I remove contaminants or hire outside organisations to assist where needed?	
Can I explain the risks of soil compaction and mitigate them?	

Can I describe the effects of waterlogging and prevent it?	
Can I classify soil corrective measures?	
Can I describe and perform common physical soil preparation methods?	
Can I explain and implement subsurface drainage methods?	
Can I describe and perform the most common chemical soil improvement methods?	
Can I keep current, accurate records of all soil preparation actions?	
Can I properly instruct workers involved in soil preparation and remediation on all of the above?	

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0401	The basic concept and principles of soil preparation and remediation is explained	A1, A3, B1, B3, D2
IAC0402	The importance of soil preparation and remediation is explained	A1, A3, B1, B3, D2
IAC0403	The practical application of physical and chemical corrective measures such as mechanical soil preparation, pre-planting soil improvement for fertility and soil conditions is outlined and motivated	A1, A3, B1, B3, D2
IAC0404	Methods of pre-planting fertiliser application during soil preparation is discussed	A1, A3, B1, B3, B6

KM-05-KT05:
Irrigation
(12%, 0.48 credits)

Topic Elements

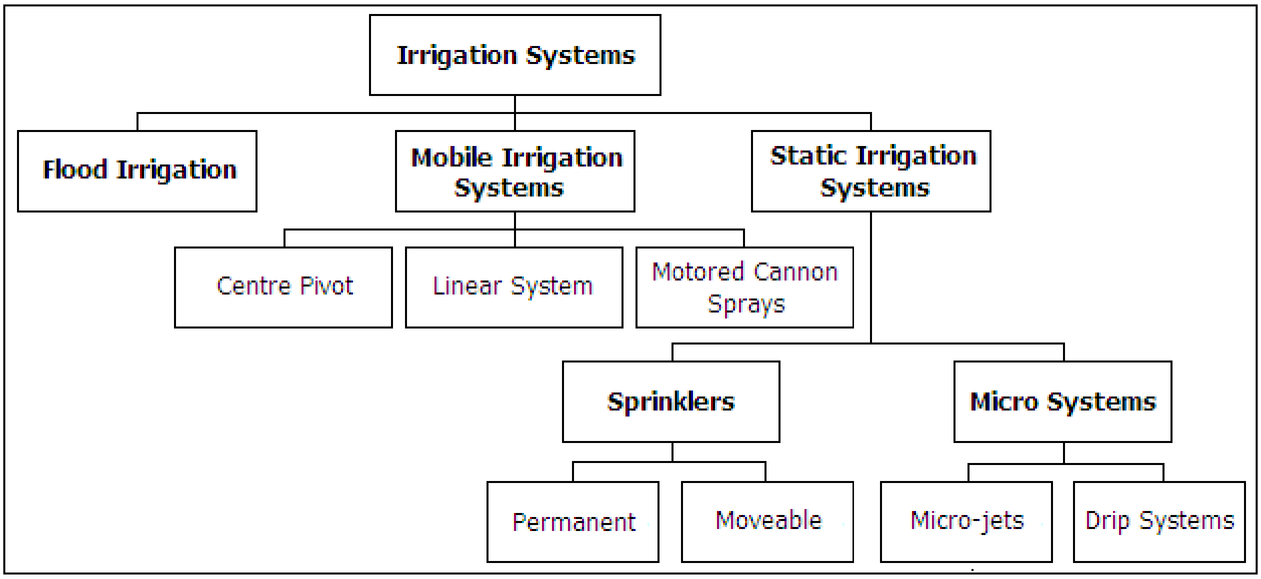
The content of this chapter covers the following topic elements:

- KT0501: Different irrigation systems
- KT0502: Role of water supply in plant growth
- KT0503: Principles of irrigation scheduling and application
- KT0504: Leaching and contamination

1. KT0501: Different Irrigation Systems

IAC0501: Different irrigation system plans and designs are compared in terms of advantages and disadvantages

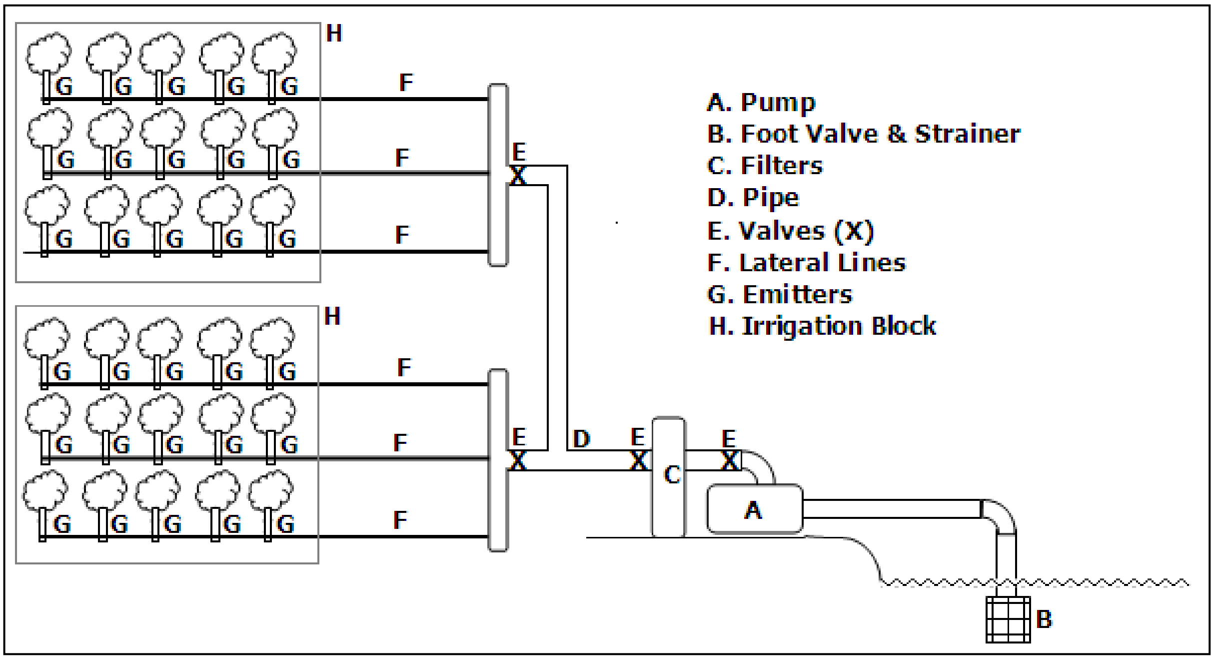
- Various types of irrigation systems are available, but not all of them are suitable for citrus production.
- The type and specifications of irrigation system selected for a particular farm will be determined by:
  - Water availability
  - Water quality
  - Crop type
  - Soil water holding capacity
  - Cost
  - Management requirements
  - Maintenance requirements
- A SABI (South African Irrigation Institute) accredited irrigation designer should be contacted with assistance in selecting and evaluating irrigation systems.
- These accredited designers are also available to assist with the evaluation of irrigation systems.
- Irrigation systems can be classified as follows:



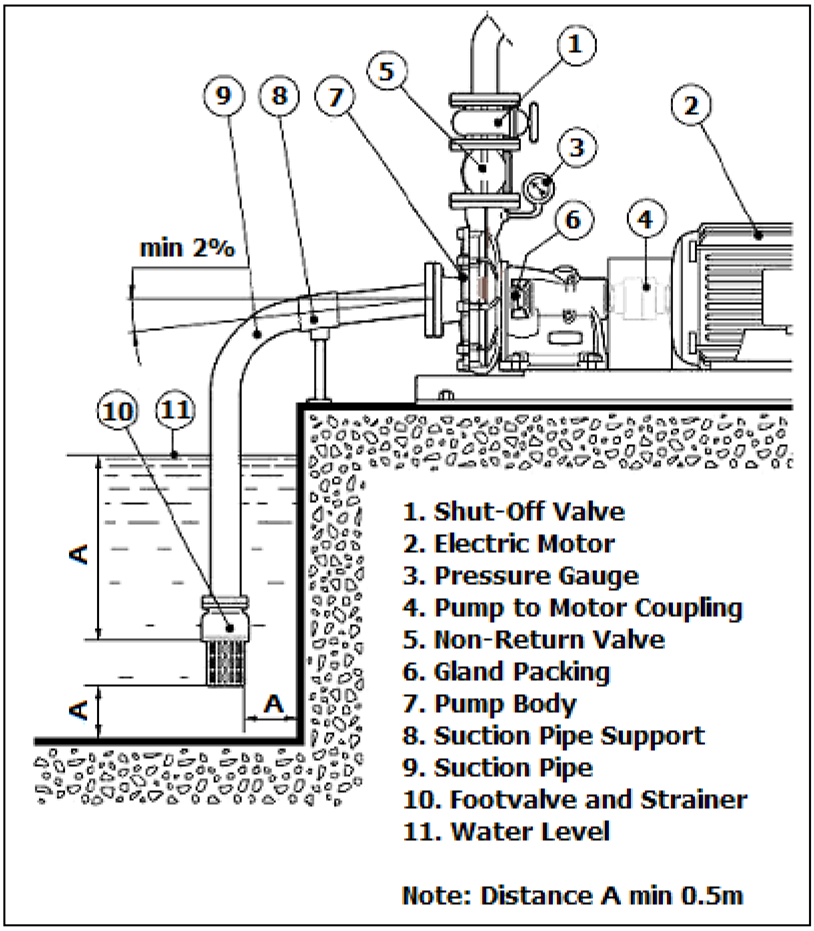
- Flood irrigation systems channel water to crops via furrows, requiring a consistently sloped area, and sometimes uses basins around plants to hold water.
- Mobile irrigation systems irrigate while moving and include centre pivots, linear systems, and motored cannon sprays.
- Centre pivot systems consist of wheeled sections that rotate around a fixed tower.
- Linear systems are similar to centre pivots but move in a straight line across the field.
- Motored cannon sprays are large sprinklers mounted on trailers, propelled by mechanisms such as water-powered winches.
- Static irrigation systems remain in place while irrigating and include permanent and non-permanent sprinklers, as well as micro-jet and drip systems.

IAC0502: Irrigation system components are given and the function of each is described

- A basic static irrigation system consists of the following components:



- Almost all irrigation systems, except gravity-fed systems, rely on pumps to move water and provide pressure to emitters.
- Pumps draw water from sources like rivers, dams, or reservoirs and propel it through the irrigation system.
- Pumps vary in type, size, and shape, and include centrifugal, submersible, and positive displacement pumps.
- Pumps are powered by diesel engines or electric motors.
- Single-stage centrifugal pumps contain one impeller and stage, while multistage pumps have two or more stages and deliver higher pressures.
- Pumps consist of various components, shown below:



- Filters clean suspended material from the water that can block emitters.
- Various types of filters are used, most commonly sand, disc and screen filters.
- Suspended material consists of clay, silt, sand, and organic debris from plants and animals that do not dissolve in water.
- Filters cannot remove materials that are dissolved in water.
- Pipes channel water between points, such as from the water-source to the pump, or from the pump to the main lines and from the mainlines to the trees.
- A wide range of pipes are available and used on citrus farms, made of a variety of materials.
- PVC, steel and fibreglass pipes are used for main and sub-main lines.

- In some older installations, asbestos or cement pipes are still in use, but these should not be installed in new installations.
- Asbestos and cement pipes are unsuitable where acid is introduced into the irrigation water for fertigation purposes.
- Poly-pipe is used for lateral lines, which are a specific type of pipeline that moves water into the orchards.
- Valves control the flow of water by opening or closing, thereby allowing water through, or cutting it off.
- Gate and butterfly valves are used to open or close a pipeline.
- Pressure control valves are used to regulate pressure and flow rate.
- Non-return valves are used to prevent the reverse flow of water when the pump is switched off.
- Air and vacuum valves are used to expel air in the pipeline and to prevent a vacuum from forming after a line is closed or the pump is switched off.
- Emitters apply water to individual trees and are placed in lateral lines.

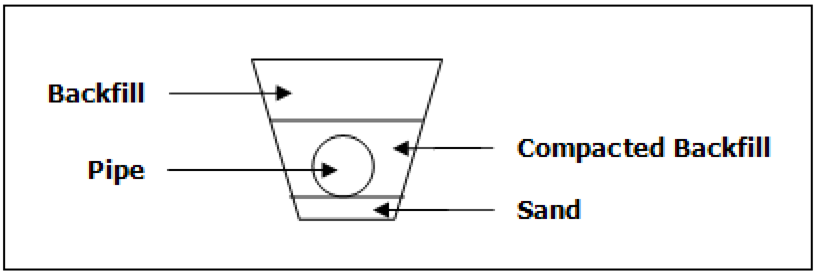
IAC0503: Installation and maintenances principles are outlined and motivated

- Irrigation system is only effective if it is properly installed and regularly maintained.
- An irrigation system can only be properly installed with the help of a good irrigation design plan.
- When reading an irrigation design plan, the first step is to get the orientation right.
- The orientation refers to the 'direction' of the plan and involves aligning the plan so that directions (such as north) on the plan matches the same direction the farm.
- The plan must be turned so that landmarks on the plan match the actual landmarks, such as dams, canals, hills, or any other distinguishable features that are shown on the map.
- After aligning the design to match the layout of the farm, workers in charge of installation can work out where the block and pipes on the plan will go on the farm.
- On an irrigation design plan, certain symbols or different colours are used to depict the various pipes, valves and other features.
- Usually, a key is provided with the symbols and their meaning.
- The notations next to the different sections of pipes indicate the pipe size and class for that particular section of pipe, and the length of the pipe.
- Pipe sections are indicated by a short line (/ or -). In the example above, the different sections of the lateral lines are marked in this way.
- Classes are usually not specified for the laterals, because class 3 poly-pipe is used as a rule. If drippers are used, the drip line would be specified.
- The class of the pipe indicates, for plastic, PVC and poly-pipe, how much pressure in Bar the pipe can withstand.
- The class notations for asbestos and cement pipes are more complicated and have to be verified with the supplier.
- On the irrigation design plan information with regard to each block is given in a table that shows the block number, area, spacing, emitter delivery and application rate.

- The area of each block is indicated in hectares (ha), and the plant spacing is indicated.
- The plant spacing is used to calculate the number of plants per hectare, and therefore the number of emitters that is required.
- The plant spacing is multiplied to calculate the area per plant, and area in hectare is divided by the area per plant, which will give the plant population per hectare.
- The emitter delivery in the table is used to calculate the precipitation and to check the emitters.
- The irrigation design plan also contains a table with the pressure and flow per block. This information is used in the irrigation scheduling.
- When a system is designed from scratch or if new blocks are designed, a bill of quantities is supplied along with the irrigation design plan.
- If the company that designed the system is delivering the materials as well, the bill of quantities is used to check and verify all the materials that are delivered.
- If the designer is not delivering the materials, the bill of quantities is used to obtain quotations for the materials and for budgeting.
- Before installation, the land must be cleared, the soil must be prepared, and other infrastructure items, such as roads and waterways, must be demarcated.
- Based on the design plan, irrigation blocks must be laid out carefully and precisely.
- Blocks are laid out by marking the corners of the blocks, then marking the rows, and finally marking the plant positions, usually using pegs.
- For ridged orchards, rows are ridged after marking, and row markers are checked again to account for any displacement by grading equipment.
- Conveyance system trenches are dug to bury irrigation pipelines and must first be laid out with pegs and lines before being dug.
- Trenches are typically 400–600mm wide, with depths of about 600mm; deeper trenches (1,000mm) are used for mainlines and sub-mainlines, while mother lines can be shallower at 400mm.
- Trenches can be dug manually, which is slower but cheaper, or with a back-end loader (excavator), which is faster and better for rocky terrain but more expensive.
- Asbestos cement pipes and large PVC pipes must be laid down on a bed of sand.
- Pipes are installed in trenches as follows:
  1. Before installing pipes in trenches, ensure that the trenches are free of stones and sharp edges.
  2. Place the first pipe into the trench and secure it by backfilling the trench near the ends of the pipe.
  3. Place a collar over the end of the pipe, making sure the collar and the end of the next pipe is clean.
  4. Lubricate the inside of the collar and the end of the next pipe with pipe lubricant or soap water, do not use oil because this will damage the rubber.
  5. Insert the end of the second pipe into the collar.
  6. Place a wooden block over the other end of the second pipe and tap the block with a hammer to force the pipe into the collar.

7. Drive the pipe in up to the depth marked on the pipe, taking care not to pinch the rubbers.
8. If the pipe refuses to go into the collar, remove the pipe and inspect the collar, as the rubbers may have shifted.
9. Ensure that there are no foreign objects inside the pipes that can cause blockages in the irrigation system.
10. As the pipes are laid, backfill near the edges, but leave joints open to check for leaks.

- Bends and end caps in pipelines can cause joints to kick out, except for steel joints.
- Bends and end caps must be anchored using Y-standards tied down or by casting thrust blocks.
- Pipes should be flushed during installation, by first flushing the mainline before fitting valves, flushing mother lines before laterals, and flushing laterals before fitting emitters.
- After testing the system, trenches can be fully backfilled, ensuring the 100mm of soil around and above the pipe is stone-free and compacted.
- The remaining backfill does not need to be compacted, as shown below:



- Pump and filter bank installation is a specialised job that should be carried out by a competent contractor.
- The various components of the irrigation system should be tested as they are installed, and the performance of the entire system is tested once the installation is complete.
- As the pipes are laid and flushed, joints should be inspected for leaks.
- Once the pipes are partially backfilled with the joints exposed, the system should be brought up to working pressure.
- Pressure readings should be taken before and after the valves and compared with the values noted on the irrigation design plan in the Pressure and Flow at Nodes table to ensure that they match.
- If the readings do not match, it may be an indication of wrong pipe size, incorrect hydraulic valve settings, or pump or filter malfunction.
- Hydraulic valves are calibrated after taking pressure readings by inserting a pressure gauge downstream (after the valve) and adjusting the pressure if needed.
- Once the hydraulic valves have been calibrated, the pressures in the lateral lines can be checked by checking that the pressure at the end of each lateral is close to the pressure that the valve is set at.
- Alternatively, each lateral can be assessed visually, and the pressure of the laterals measured that appears to have a different distribution pattern than the other lines.
- Emitter delivery can also be checked to see if it corresponds with the irrigation plan by measuring its output over a certain time period.

- When this emitter test is done with a representative sample for the whole block, it is called a CU (Coefficient of Uniformity) test.
- After this test is done and the system has been operating for a few days, joints should be inspected for leaks, and if no leaks are found, the trenches can be backfilled completely.
- Irrigation systems that have been properly installed and managed should never require major maintenance under normal circumstances.
- A high quality preventative maintenance plan ensures that minor problems do not turn into major problems.
- Constant evaluation and monitoring of the system ensures that the system operates within the required parameters, and that problems are picked up and dealt with when they occur.
- A comprehensive maintenance plan will include regular actions performed on daily, monthly, annual, and multi-year frequencies.
- These actions can range from checking daily for leaks and flushing filters, to replacing pipes every ten years.
- Consult with the designer of the irrigation system and parts supplier for recommendations on which maintenance actions to perform and how often to perform them.
- Citrus is continuously irrigated, but water demand is lowest during winter, making it the ideal time to perform maintenance and repair operations that require a system shut down for a few days.
- Water quality is a very important factor in planning preventative maintenance, as different levels of water quality may require more or less frequent maintenance activities.

self-assessment

KT0501: Different Irrigation Systems

Can I?	Y/N
Can I identify the types of irrigation systems suitable for citrus production?	
Can I describe the factors that influence the choice of irrigation system?	
Can I select an appropriate irrigation system for a specific farm?	
Can I contract an accredited irrigation designer during system selection and design?	
Can I classify irrigation systems?	
Can I differentiate between mobile and static irrigation systems?	
Can I describe the various water sources used by irrigation pumps?	
Can I describe the function of pumps in an irrigation system?	
Can I identify types and components of pumps?	
Can I explain the function of filters in an irrigation system?	
Can I describe the effects of suspended material in irrigation water?	
Can I describe the different types of pipes used and their purposes?	
Can I describe the different types of valves used and their purposes?	
Can I describe the purpose of an irrigation design plan?	

Can I interpret an irrigation design plan?	
Can I explain and read a bill of quantities in irrigation system installation?	
Can I prepare land before installing an irrigation system?	
Can I mark irrigation blocks?	
Can I plan and dig conveyance system trenches?	
Can I install pipes in trenches?	
Can I test components of irrigation systems during installation?	
Can I inspect components of irrigation systems during installation?	
Can I describe and perform Coefficient of Uniformity (CU) tests?	
Can I describe the importance of maintenance for irrigation systems?	
Can I create a preventative maintenance plan for irrigation systems?	
Can I properly instruct workers involved in irrigation installation and maintenance on all of the above?	

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0501	Different irrigation system plans and designs are compared in terms of advantages and disadvantages	A1, B1, B4, E1, I7
IAC0502	Irrigation system components are given and the function of each is described	A1, B1, B4, E1, I7
IAC0503	Installation and maintenances principles are outlined and motivated	I1, I2, I3, I4, I5

2. KT0502: Role of Water Supply in Plant Growth

IAC0504: The necessity of water supply (supplementation) through irrigation is explained

- Citrus trees need a consistent supply of high quality water to remain healthy and productive in the long term.
- Water is essential for photosynthesis, as well as being the medium through which nutrients are dissolved and transported within the trees.
- Without sufficient water, trees can easily develop nutrient deficiencies, even in soils that are nutrient rich.
- Water stress can also weaken trees, making them more susceptible to diseases and pests.
- In most places, rainfall is not consistent or plentiful enough to meet the water needs for citrus production.
- Irrigation is required to supplement these unmet water needs and is thus a fundamental aspect of orchard management and citrus production as a whole.
- A well-irrigated orchard is likely to have healthier trees with a longer productive lifespan, contributing to the long-term sustainability and profitability of the citrus operation.

IAC0505: Water quality requirements for specific crops are given

- The quality of water used in irrigation impacts the irrigation system, soil productivity and crop production.
- Water quality factors are classified as physical, chemical or biological.
- The major physical water quality factors are suspended solids.
- The main impact of the physical water quality hazards is blocking or clogging emitters.
- The recommendations for hazard levels of suspended solids are as follows:

Rating	Suspended Solids per Litre Water (mg)
Minor hazard	less than 50mg
Moderate hazard	50mg to 100mg
Severe hazard	more than 100mg

Table 8: DWAF Standards for Suspended Solids

- The effects of clogged emitters can be extremely damaging, and thus even water classified as having a minor hazard above still needs treatment.
- Filtration is the standard treatment for improving physical water quality by removing suspended solids from water.
- Continuous monitoring of the suspended solids in the piping and emitters, and of the effectiveness of the filter system, is essential.
- Measuring and managing chemical water quality is more difficult than measuring and managing physical water quality.
- Certain chemical factors cannot be economically improved, and the water quality manager can only take steps to limit or correct the impact on production and the environment.

- In citrus production, the impact of biological water quality factors is limited to those that promote the growth of bacteria and slimes in the piping after filtration.
- The bacterial and slime growth act as agglomerating (binding) agents to bind other suspended material into lumps that block the emitters.
- The growth is aggravated by the addition of nitrogen, phosphorus and organic carbon, such as molasses, organic acids or buffers.
- Applying nutrient solutions through the irrigation system stimulates the growth of the microbes.
- The best results for treatment for biological water quality are obtained when the complete system, being filters, supply lines, laterals and emitters, is disinfected.
- Drip irrigations systems need continuous disinfection.
- The bacteria population in the irrigation system must be continuously monitored, and action must be taken when needed.
- The most effective method to determine the presence of the different microbes is to evaluate the deposits in the pipes when flushing the system.

self-assessment

KT0502: Role of Water Supply in Plant Growth

Can I?	Y/N
Can I explain the role of water in plant growth and function?	
Can I describe the process of photosynthesis?	
Can I explain the relation between water and nutrition in plants?	
Can I explain the purpose of irrigation in citrus production?	
Can I classify water quality factors?	
Can I explain the effects of physical water quality on irrigation systems?	
Can I describe the various hazard levels of suspended solids?	
Can I treat water and use filtration to improve physical water quality?	
Can I explain the effects of chemical water quality on irrigation systems?	
Can I manage the impact of chemical water quality?	
Can I explain the effects of biological water quality on irrigation systems?	
Can I treat water and use agrochemicals to improve biological water quality?	
Can I disinfect irrigation systems?	
Can I monitor physical, chemical, and biological water quality?	

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0504	The necessity of water supply (supplementation) through irrigation is explained	A5, B4, B7, D2, E1
IAC0505	Water quality requirements for specific crops are given	A5, B4, B7, D2, E1

3. KT0503: Principles of Irrigation Scheduling and Application

IAC0506: Irrigation scheduling in different climatic and weather conditions and stages of fruit production is outlined and motivated

IAC0507: The impact of soil properties and conditions on irrigation scheduling are discussed

IAC0508: The use of irrigation scheduling equipment in measuring soil water status is described

- Irrigation schedules are adapted as follows:
  1. Determine field water capacity (FWC) through lab tests or with scheduling equipment such as tensiometers and probes.
  2. Determine permanent wilting point (PWP) through lab tests or with scheduling equipment.
  3. Determine effective root depth (ERD) by digging a profile hole.
  4. Calculate plant available water (PAW) using the formula PAW = FWC – PWP.
  5. Calculate easily available water (EAW) using the formula EAW = PAW x ERD x 50%.
  6. Calculate crop water requirements from soil water balance or using industry information.
  7. Obtain and read operations table, pressure and flow table, and irrigation schedule from irrigation design plan.
  8. Use scheduling equipment such as E-pans, probes and tensiometers to optimise the stand time.
- Climatic and weather conditions affect the water requirements of citrus crops, and irrigation scheduling must be adapted to meet these requirements.
- At times when more water is available, the irrigation schedule must be managed to prevent over-irrigation, especially true during rainy seasons.
- The soil water content must be managed so that it does not exceed field water capacity, otherwise waterlogging will occur.
- Adapting irrigation schedules during a drought is more complex, as available water sources are under pressure.
- During droughts, growers should determine the available water from the existing sources and the estimated crop water use and then determine how long available water will last.
- Growers should determine if all the blocks can be irrigated or if irrigation must be stopped on some of the blocks because there is simply not enough water.
- If one or more blocks will have to stop being irrigated, growers must decide which blocks to prioritise, based on several factors.
- Young trees with higher yield potential should be prioritised over old trees, as they use less water because of a smaller leaf area and likely have newer, more efficient irrigation systems.
- Trees with drippers have generally smaller and more localised root-zones, so require more irrigation.

- Micro-jets tend to have better developed root systems that can utilise underground reserves better, so require less irrigation.
- High value crops pose a bigger economic risk to the farm and should be prioritised over low value crops.
- Drought sensitive crops and cultivars should be prioritised over drought sensitive crops and cultivars.
- Irrigation efficiency can be optimised by irrigating night when evaporation losses are at a minimum, limiting irrigation during windy days and nights, and lowering the block pressure to reduce the misting of micro-jets.
- Growers can also decrease the wetted area to decrease water application, and with drippers, the wetted area is already limited, but with micro-jets the area can be decreased.
- Growers should avoid over-irrigating and wetting the soil beneath the roots, as this is a waste of water.
- Reduce the number of cycles to limit water losses at start-up and shutdown, as it is more effective to wet trees fully once or twice a week than a number of small half irrigations.
- Pumps and filters require special attention during droughts, as low water levels cause pumps can suck air or physical water contaminants more easily.
- Irrigation managers must ensure that the water extraction point is wide and deep enough with a non-turbulent inflow.
- During dry spells, chemical and physical water quality is also more likely to be poor, and the workload on filters will increase.
- Irrigation managers must ensure that filters operate properly and that they are back-flushed often enough.
- Back-flushed water can be recycled, provided the dirt settles out of the water before entering the pump again.
- Fertigation programmes must also be adapted, as water tends to have a higher salt content during dry periods.
- These increased salt levels in combination with the fertiliser can be detrimental to the soil and plants.

IAC0509: The principles of using irrigation efficiency reports to determine the need for maintenance and repairs are explained

- Irrigation efficiency can be assessed through a combination of coefficient of uniformity (CU) tests, scheduling equipment data, visual inspection of profile pits, tree health, and crop yield data.
- None of the factors to determine the irrigation effectiveness should be viewed in isolation, as one test may show high efficiency, but other tests may reveal inefficiency.
- CU tests determine how efficiently emitters are delivering water in terms of delivery rate, which is used to determine the exact volume and uniformity of water delivery.
- Data obtained from scheduling equipment, especially equipment such as probes and tensiometers, also indicates the volume of water being delivered.
- This data can be compared to the actual water meter readings for the specific block to determine water loss due to evaporation and misting during irrigation.

- Profile pits can also help to determine irrigation effectiveness by visually determining the depth and width of the wetted profile while allowing inspection of root growth and health.
- Good root growth and health indicate that the profile is wetted correctly and consistently, while bad root health can be attributed to under- or over-irrigation.
- General tree health is a subjective method of determining irrigation effectiveness, but it must be kept in mind that tree health is influenced by a wide range of production factors.
- Evaluating the functioning of the irrigation system is important in that it ensures that the system operates within the set parameters, which protects the components of the system.
- All the data required to monitor and evaluate the operation of the irrigation system is provided on the irrigation design plan.
- This data includes the list of operations, a table with pressures and flows at valves and at nodes, and a table with the plant spacing and precipitation for each block.
- Irrigation efficiency reports provide detailed information on how effectively water is being delivered to citrus trees, helping growers identify areas where water is being lost.
- Regular analysis of these reports allows producers to detect declining system performance early, preventing long-term damage to both the irrigation equipment and the crop.
- By comparing current irrigation efficiency data with historical records, growers can schedule timely maintenance before serious problems arise.
- Identifying poor efficiency through data-driven assessment reduces unnecessary water use, energy costs, and fertiliser leaching.
- If issues are detected in irrigation efficiency reports, other methods of inspection (like those described above) can be used to determine where the problem is and determine the appropriate maintenance actions required.

IAC0510: Irrigation system maintenance plans and emergency response procedures are outlined

Refer to IAC0503: Installation and maintenances principles are outlined and motivated.

self-assessment

KT0503: Principles of Irrigation Scheduling and Application

Can I?	Y/N
Can I adapt irrigation schedules?	
Can I explain how climatic and weather conditions influence citrus water requirements?	
Can I describe how to manage irrigation during varying climatic conditions?	
Can I prioritise trees and blocks for irrigation?	
Can I explain how irrigation efficiency can be optimised?	
Can I adapt fertigation programmes during varying climatic conditions?	
Can I describe the methods of and perform irrigation efficiency assessment?	
Can I monitor irrigation system operation?	
Can I write irrigation efficiency reports?	
Can I interpret historical and current irrigation efficiency data?	

Can I properly instruct workers involved in irrigation management on all of the above?	

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0506	Irrigation scheduling in different climatic and weather conditions and stages of fruit production is outlined and motivated	A3, D2, D3, D4, E1
IAC0507	The impact of soil properties and conditions on irrigation scheduling are discussed	A3, D2, D3, D4, E1
IAC0508	The use of irrigation scheduling equipment in measuring soil water status is described	A3, D2, D3, D4, E1
IAC0509	The principles of using irrigation efficiency reports to determine the need for maintenance and repairs are explained	E1, I3, I4, I5, I6
IAC0510	Irrigation system maintenance plans and emergency response procedures are outlined	E1, I3, I4, I5, I6

4. KT0504: Leaching and Contamination

IAC0511: The management of nutrient leaching through irrigation scheduling is discussed

- Nutrient leaching refers to a process whereby water-soluble nutrients in the soil are washed away due to excessive irrigation or rainfall.
- Nutrient leaching leaves less nutrients available in the soil for uptake by trees.
- Nutrient leaching only really effects nutrients that are 'mobile', such as nitrogen in the form of nitrates in the soil.
- Nutrient leaching can be mitigated through the use of well-planned irrigation scheduling.
- Irrigation should be scheduled to ensure that trees' water needs are met, without exceeding the soil's capacity to hold water to limit nutrient leaching.
- Growers need to have a clear understanding of both the water requirements of trees and the water-holding capacity of the soil to effectively schedule irrigation.
- The choice of irrigation method also affects nutrient leaching, with drip irrigation in particularly reducing the risk of leaching compared to other irrigation methods.
- Consistent monitoring of soil moisture levels is essential for mitigating nutrient leaching.
- Soil moisture levels can be monitored in numerous ways, and all data collected should be recorded in a standardised form and kept on a database.
- Aligning fertiliser applications with irrigation schedules can improve nutrient uptake efficiency, and fertilisation should only occur when the trees' uptake potential is high.
- Rainfall must also be closely monitored, and irrigation schedules adjusted accordingly to avoid under- or over-irrigation.

IAC0512: The prevention of contamination through sound fertilisation and irrigation practices is described

- Contamination refers to pollution of the soil, and pollutants include excessive fertiliser, improperly applied agrochemicals, human or animal waste, refuse (such as chemical containers), and low quality water.
- These untreated pollutants can be introduced into the water system directly or indirectly through the ground water by leaching from the soil.
- Points of pollution refer to the physical locations where pollution can occur, and can include the fertigation equipment, the water treatment plant equipment, spray cart filler points, and irrigation equipment.
- In irrigation blocks and orchards, if not properly managed, salts and chemicals can build up in the soil and some chemicals can leach through the soil if not applied correctly.
- Packhouses and on-farm processing plants can create effluents that are environmentally harmful if not properly disposed of.
- Workshops can create contaminants such as oil or cleaning chemicals if they are not properly disposed of.
- Toilets and the sewerage systems can contaminate water sources with organisms, such as cholera if not operated properly.

- Prevention is better than cure in the case of contamination, and it is advisable to have protocols in place to prevent or limit pollution.
- The proper handling and storage of chemicals reduces the likelihood of pollution, and chemicals used for fertilisation should be well managed and carefully stored.
- Emergency plans to manage and prevent issues such as for spills must be in place and well known to all staff.
- Suitable wastewater systems, such as suitable catchments and septic tanks or French drains must be available where chemicals are washed down or where mixes are disposed of.
- These include points such as fertigation and chemical dosing points, packhouse water outlets, and spray cart refill points.
- A septic tank is recommended, but a French drain can be used in the case of the refill point, and polluted water can also be collected in a tank and disposed of at a central septic tank.
- Suitable effluent systems where water from the workshop and processing plant can pass through a trap to remove oils and other contaminants.
- If the water is free of chemicals, it can be returned to the water source, if not, it must be collected in a septic tank or storage facility.
- Proper disposal of used chemical containers and unused chemicals will prevent contamination from these sources.

self-assessment

KT0504: Leaching and Contamination

Can I?	Y/N
Can I explain nutrient leaching?	
Can I describe the effect of nutrient leaching on soil nutrient availability?	
Can I use irrigation scheduling to mitigate nutrient leaching?	
Can I determine the water requirements of trees?	
Can I explain how the choice of irrigation method affects nutrient leaching?	
Can I monitor soil moisture levels?	
Can I record and manage soil moisture data?	
Can I align fertiliser application with irrigation schedules to improve nutrient uptake efficiency?	
Can I monitor rainfall and adjust irrigation schedules accordingly?	
Can I identify potential contaminants that can cause soil contamination?	
Can I identify points of contaminants on a farm?	
Can I prevent contamination through carefully managing production practices?	
Can I properly handle and store agrochemicals?	
Can I design emergency plans for incidents such as spills?	
Can I implement suitable wastewater systems to prevent contamination?	

Can I properly dispose of used chemical containers and unused chemicals?	

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0511	The management of nutrient leaching through irrigation scheduling is discussed	A3, D1, D2, E1, E2
IAC0512	The prevention of contamination through sound fertilisation and irrigation practices is described	D2, E1, E2, K1, L1

KM-05-KT06:
Safety Principles for Using Plant Nutrition Chemicals
(12%, 0.48 credits)

Topic Elements

The content of this chapter covers the following topic elements:

- KT0601: Regulatory measures
- KT0602: Internal audits
- KT0603: Contamination risks
- KT0604: Recordkeeping

1. KT0601: Regulatory Measures

IAC0601: The regulatory measures relating to the use of agrochemicals are given

- Agrochemicals are a broad categorisation encompassing a variety of chemicals used in farming, include fertilizers, pesticides, herbicides, fungicides, and growth regulators.
- There are numerous laws and regulations that govern the use of agrochemicals, and it is every grower's responsibility to be aware of and comply with these laws and regulations.
- Non-compliance with these laws and regulations can lead to serious legal and financial consequences for the farm.
- There are four main pieces of legislation that relate to agrochemicals, namely:
  - Health Act of 1977.
  - Registrar of Fertilisers Act No. 36 of 1947.
  - Farm Feeds, Agricultural Remedies and Stock Remedies Act of 1947.
  - Occupational Health and Safety Act No. 85 of 1993 and the Amendment Act No. 181 of 1993.
- All agrochemicals must be approved and registered with the Department of Agriculture (DoA) in terms of Act 36 of 1947.
- The product label is part of the registration of the agrochemical, and agrochemical labels should include:
  - Full instructions on using the chemical and detailed information on the registered uses of the product.
  - The chemical composition of the product.
  - The toxicity of the product, along with instructions on how to handle it safely.

- A physical description of the product, including its colour and whether it is a fluid, powder, or granules.
- The pre-harvest interval (or PHI) of the product.
- The product expiry date.

➢ Pictograms on the product label are used to give further information about the product.

➢ Pictograms can be classified as activity, advice, warning, and storage pictograms.

➢ These pictograms describe the type of product, storage requirements, PPE requirements, and the danger that the product holds for animals.

➢ The following sections of the Occupational Health and Safety Act, 1993, are relevant to handling agrochemicals on a farm:

- Section 10 – General Duties of Manufacturers and Others Regarding Articles and Substances for Use at Work
- Section 17 – Health and Safety Representatives
- Section 21 – General Prohibitions

➢ The farm will get a quotation from the supplier so that they know what the cost of the stock will be, but they will not usually enter into a contract with the supplier.

➢ In some cases, however, it is advisable to have a contract in place with a supplier, such as for agrochemical stock that is supplied regularly at a fixed price by the same supplier.

➢ These contracts protect the supplier and the farmer because they make it clear who is supposed to do what, and when, and at what price.

➢ Being in breach of a written contract can lead to serious consequences for the farm or the supplier, and they are useful for protecting the farm in situations where the supplier provides the wrong or low quality agrochemicals.

➢ All workers must be fully trained in workplace safety rules and regulations, and these regulations should be enforced at all times.

➢ The safety rules and regulations, specifically for agrochemical use, include:

- No smoking, drinking, or eating is allowed in the vicinity of where chemicals are mixed, applied or stored.
- No person that is under the influence of alcohol or other drugs is allowed to handle chemicals for whatever purpose under any circumstances.
- Safety regulations regarding the use of chemical application equipment.
- Regulations regarding proper utilisation of PPE.
- Prescriptive regulations on how chemical spills, leakages and other emergencies should be handled
- Instructions concerning the chemical to be applied.

➢ During applications, all people in or around the orchard must be informed of the activity, even if they are not directly involved.

➢ This ensures that they will not wander into the area and be contaminated by accident.

➢ Chemicals should only be mixed in areas designated for the purpose, such as at filling points.

➢ These areas should be clearly marked, and unauthorised personnel should not be allowed into these areas while chemicals are being handled.

- Regulations also require signage that is approved by the authorities and is easily observable in all locations designated for a specific purpose.
- These signs must give a bold, concise message such as:
  - Danger.
  - No Entry.
  - No Smoking.
  - No Drinking and Eating.
  - Fire Extinguisher.
  - First Aid Equipment.
  - Emergency Exit.
  - Protective Clothing Required.

self-assessment

KT0601: Regulatory Measures

Can I?	Y/N
Can I define agrochemicals?	
Can I explain the responsibility of growers regarding agrochemical laws and regulations?	
Can I describe the potential consequences of non-compliance with agrochemical legislation?	
Can I identify the main pieces of legislation that relate to agrochemicals?	
Can I explain the registration requirements for agrochemicals with DoA?	
Can I describe the information that must be included on an agrochemical product label?	
Can I explain the purpose and meanings of pictograms on agrochemical labels?	
Can I describe the purpose of Occupational Health and Safety Act, 1993?	
Can I determine when and why a contract with a supplier is needed?	
Can I train all workers in workplace safety rules and regulations?	
Can I explain safety requirements for chemical application equipment and PPE use?	
Can I prescribe the procedures for handling chemical spills, leakages, or emergencies?	
Can I design safe areas for mixing chemicals?	
Can I design signage for chemical handling areas?	

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0601	The regulatory measures relating to the use of agrochemicals are given	A4, A6, J1, J2, L1

2. KT0602: Internal Audits

IAC0602: The purpose and principles internal audits are explained

- In the context of citrus production, an internal audit is a systematic, documented review process conducted to evaluate compliance with established standards, procedures, and regulatory or certification requirements.
- Internal audits serve to verify that all production practices meet the right standards of internal quality systems, food safety protocols, environmental regulations, and customer specifications.
- A well-designed agrochemical management system is useless if it is not implemented correctly and consistently.
- Internal audits are used to ensure that the agrochemical management system is being implemented as prescribed.
- Although we are discussing internal audits as they relate to agrochemical storage, the internal audit system is also used for many other aspects of farm management.
- There are no fixed rules that prescribe exactly how internal audit systems should be designed and executed.
- The approach to conducting an internal audit is often closely related to the quality management system.
- There are certain common elements that occur in all internal audit systems, being:
  - An audit charter.
  - Risk assessment process.
  - An audit plan.
  - An audit cycle.
  - Audit work programs.
  - Audit reports.
  - Requirements for audit documentation.
  - Follow-up procedures.
  - Professional development programs.
- The audit charter (or mission statement) outlines the purpose, objectives, organisation, authorities, and responsibilities of the internal auditor, audit staff, audit management, and the audit committee.
- A risk assessment process describes and analyses the risks inherent in a given line of business.
- The level of risk should be one of the most significant factors considered when determining the frequency of audits.
- Auditors should update the risk assessment at least annually, or more frequently, if necessary, to reflect changes to internal control or work processes, and to incorporate new lines of business.
- An audit cycle identifies the frequency of audits.
- While staff and time availability may influence the audit cycle, they should not be overriding factors in reducing the frequency of audits for high-risk areas.

- The audit plan details the internal audit budgeting and planning processes, and describes audit goals, schedules, staffing needs, and reporting.
- The audit plan should cover at least 12 months and should be developed by combining the results of the risk assessment and the resources required to facilitate the timing and frequency of the planned audit cycle.
- The audit committee should formally approve the audit plan annually, or, in the case of multi-year audit plans, review it annually.
- The internal auditors should report the status of planned versus actual audits, and any changes to the annual audit plan, to the audit committee for its approval on a periodic basis.
- Audit work programs set out the required scope and resources for each audit area, including the selection of audit procedures, the extent of testing, and the basis for conclusions.
- Well-planned, properly structured audit programs are essential for effective risk management and to the development of comprehensive internal control systems.
- Written audit reports inform the board and management of individual department or division compliance with policies and procedures.
- These reports should state whether operating processes and internal controls are effective and describe deficiencies as well as suggested corrective actions.
- The audit manager should consider implementing an audit rating system approved by the audit committee.
- The rating system facilitates conveying to the board a consistent and concise assessment of the net risk posed by the area or function audited.
- The requirements for audit documentation (work papers) should be clearly described in the audit charter, including work paper retention policies.
- Follow-up processes require internal auditors to determine the disposition of any agreed-upon actions to correct significant deficiencies.
- Professional development programs must be in place for the institution's audit staff to maintain the necessary technical expertise.
- The documents used for internal audits should be standardised wherever possible.

self-assessment

KT0602: Internal Audits

Can I?	Y/N
Can I explain what internal audits are in the context of citrus production?	
Can I design and implement an agrochemical management system?	
Can I describe the aspects of farm management that internal audits are applicable to?	
Can I explain the relationship between internal audits and quality management systems?	
Can I identify the common elements of internal audit systems?	
Can I explain what a risk assessment process involves in an internal audit?	
Can I define what an audit cycle is and what it determines?	

Can I describe the contents and purpose of an audit plan?	
Can I describe the role of the audit committee in approving and reviewing the audit plan?	
Can I describe the contents and purpose of audit work programs?	
Can I describe the purpose and content of written audit reports?	
Can I explain the role of professional development programs for audit staff?	

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0602	The purpose and principles internal audits are explained	A2, A3, A4, A6, K2

3. KT0603: Contamination Risks

IAC0603: The contamination risks during the use of plant nutrition chemicals are identified and matched to the relevant preventative measures

- Pollution (or contamination) is very damaging to the environment, and a major source of pollution on a farm is agrochemicals that are not handled properly.
- All agrochemicals can cause damage to the environment if they are at a high enough concentration, even if they seem to be harmless.
- Growers must take care to prevent accidents that lead to agrochemicals getting into the soil and water supply.
- Growers must also minimise the amount of runoff agrochemicals during applications.
- Chemical storage and mixing facilities should be constructed at least fifty meters away from natural water sources, including boreholes.
- To limit soil contamination, chemical mixing areas must also have a separate drainage system where chemicals can be trapped and contained.
- In terms of application, care should be taken when applying sprays so that spray drift does not contaminate water sources, such as dams, streams, and springs.

IAC0604: Safe handling and storage principles related to plant nutrient chemicals are evaluated

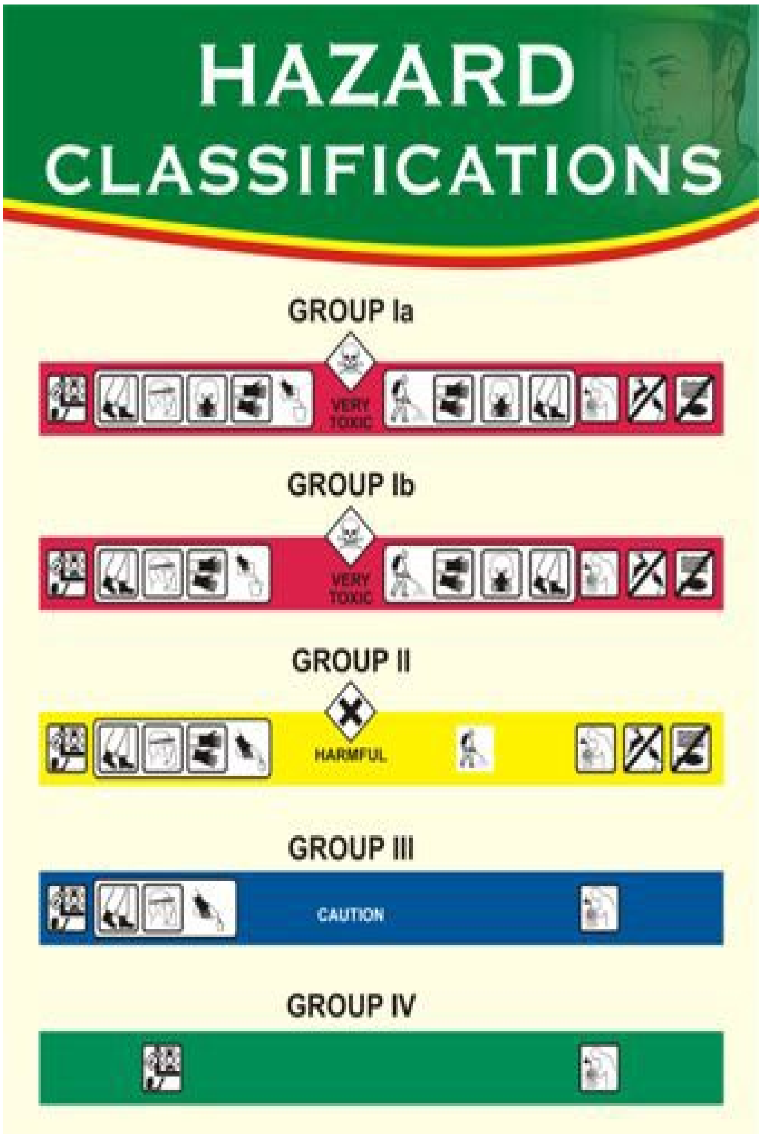
- All agrochemicals must be considered as dangerous, and can harm workers, animals, and the environment, meaning that they must be stored carefully.
- Agrochemicals have special storage requirements, which are prescribed in detail in occupational health and safety legislation and GlobalGAP regulations.
- Storage requirements for particular agrochemical products are prescribed on the product labels.
- All agrochemicals must be stored, handled, and applied as indicated on their registration certificates and labels.
- Workers handling the products must be trained in the correct and safe handling procedures.
- Agrochemicals must be stored in a secure, well-ventilated, cool, dry building that cannot be accessed by children, animals, or unauthorised persons.
- The storeroom must have a smooth, level cement floor.
- Warning signs must be placed on the outside of the storeroom, and they must clearly show that this is an agrochemical storeroom.
- There must be easy access to washing facilities with running water, soap, and towels in the storeroom.
- An eye-flushing bottle must be available in the event that eyes are contaminated.
- The storeroom must have at least two 9kg dry-powder fire extinguishers on hand.
- No food products, animal feed or seeds may be taken into the storeroom. No eating, drinking, or smoking is allowed inside the storeroom.
- Classifying agrochemicals is a big part of storing and managing them effectively, and agrochemicals can be classified as:

- Fertilisers (granular and liquid).
- Plant protection products (granular, powdered and liquid).
- Growth regulators (liquid).
- Herbicides (liquid).

➢ Granular products, like fertilisers and some plant protection products, must always be stored in a separate area from liquid agrochemicals.

➢ Signs should be used to mark liquid products and keep them from contaminating granular products in case of breakage and spillage.

➢ Plant protection products are classified according to their toxicity, by way of colour bands on the product labels, demonstrated below.



➢ In the storeroom, plant protection products must be stored according to this classification. Red band products (groups 1a and 1b) must be stored in a separate space, which must be kept locked at all times.

➢ Internationally recognized symbols are used to indicate the toxicity of chemicals in groups one and two:

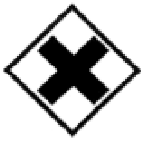
Group	Hazard Statement	Symbol Description	Symbol
Ia – Extremely Hazardous	Highly toxic	Skull and Crossbones	
Ib – Highly Hazardous	Toxic		
II – Moderately Hazardous	Harmful	St. Andrew's Cross	

Table 9: Symbols for Toxicity Classification

- There must also be a separate, secure area in the storeroom where used and empty containers are kept before they are disposed of.
- These containers must not be left lying around where they can be taken and put to some other use.
- Any discarded agrochemicals must also be kept secure and disposed of safely.
- Tools and agrochemicals should not be stored in the same place, as tools may puncture the containers and some agrochemicals are corrosive and can cause the tools to rust.
- Before agrochemicals can be put in the storeroom, the storeroom has to be prepared by clearly marking different areas and cleaning the storeroom.
- Agrochemicals that are in bottles and boxes should be stored on sturdy shelves.
- Granular agrochemicals that are in bags, such as fertilisers, must be stored on pallets on the floor.
- They should not be stored directly on the floor, because they can then more easily get wet or contaminated.
- The storeroom is likely to get dirty and contaminated and needs to be cleaned regularly, and especially before receiving new stock.
- Cleaners in the storeroom should wear protective clothing while cleaning, including overalls, rubber boots and rubber gloves.
- A respirator is required when cleaning up agrochemical spills.
- All cleaning products should be used according to manufacturer's instructions.
- Pest infestations in the storeroom should be carefully monitored, and any infestation, such as by ants, cockroaches, or rats, must be immediately reported, and a pest control company contacted immediately.

self-assessment

KT0603: Contamination Risks

Can I?	Y/N
Can I explain the environmental and health risks posed by agrochemicals?	
Can I prevent agrochemicals from contaminating soil and water?	
Can I minimise runoff during chemical applications?	

Can I design appropriate chemical storage and mixing facilities?	
Can I explain the legal and regulatory requirements for agrochemical storage?	
Can I train workers in safe handling procedures?	
Can I describe the requirements of a secure and safe agrochemical storeroom?	
Can I implement appropriate warning signs outside the storeroom?	
Can I ensure that washing facilities and eye-flushing equipment are available in the storeroom?	
Can I describe the fire safety requirements for a chemical storeroom?	
Can I describe which stock can and cannot be stored in the agrochemical storeroom?	
Can I classify agrochemicals for storage and management?	
Can I store different types of agrochemicals in their appropriate location?	
Can I store and safely dispose of used and empty agrochemical containers?	
Can I clean the storeroom before receiving new stock?	
Can I describe the appropriate PPE to be worn while cleaning the storeroom?	
Can I select and use appropriate cleaning products?	
Can I monitor and manage pest infestations in the agrochemical storeroom?	
Can I properly instruct workers involved in agrochemical storage on all of the above?	

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0603	The contamination risks during the use of plant nutrition chemicals are identified and matched to the relevant preventative measures	F1, F2, J1, K1, L1
IAC0604	Safe handling and storage principles related to plant nutrient chemicals are evaluated	F1, F2, J1, K1, L1

4. KT0604: Recordkeeping

IAC0605: Basic principles of recordkeeping (such as accuracy and currency) is motivated

IAC0606: The need for record-keeping of nutrient and water applications is motivated

- Recordkeeping is an essential aspect of agrochemical applications and irrigation.
- Records must be kept of chemicals issued from the store, quantities used, and in which orchard and block the chemicals were applied.
- These records are only effective if they are current, meaning up to date, and accurate.
- Currency refers to records being up to date by recording information as soon as possible after an event occurs.
- Citrus producers must maintain current records for audits, and outdated data can lead to compliance violations or penalties.
- If a quality issue or contamination arises, current records help quickly trace the problem back to a specific date, lot, or orchard block.
- Current records ensure that all workers and managers are working with the same, most recent information — avoiding confusion or duplication of work.
- Accuracy means the records are correct, complete, and reflect the true situation in the storeroom.
- A system must be in place from which we must always be able to tell what agrochemicals are in storeroom, and how much there is of each one.
- There are various ways to keep stock records in an agrochemical store, but any system must record the details of any agrochemicals in the storeroom.
- The systems must also record any issuing, use, or disposal of agrochemicals.
- All incidents must be recorded, including accidents or near accidents where workers were or could have been injured or killed, safety was compromised, or property was damaged.
- Records should also be kept of all chemical applications, as these are often required by buyers overseas, or by various government bodies.
- These reports also play a role in the financial management of your farm by keeping track of actual agrochemical stock usage compared to the usage recorded by workers.

self-assessment

KT0604: Recordkeeping

Can I?	Y/N
Can I explain the importance of recordkeeping for agrochemical applications and irrigation?	
Can I define the concepts of currency and accuracy in recordkeeping?	
Can I describe how records are used for audits?	
Can I design a system that tracks agrochemical stock levels in the storeroom?	

Can I describe what information must be recorded when agrochemicals are issued, used, or disposed of?	
Can I explain the importance of records of chemical applications for buyers and government compliance?	
Can I describe how recordkeeping supports financial management?	

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0605	Basic principles of recordkeeping (such as accuracy and currency) is motivated	A3, A5, A6, D4, I1
IAC0606	The need for record-keeping of nutrient and water applications is motivated	A4, D4, E1, F1, F2,

KM-05-KT07:
Food Safety
(12%, 0.48 credits)

Topic Elements

The content of this chapter covers the following topic elements:

- KT0701: Orchard / vineyard hygiene
- KT0702: Food safety related to chemical control of pests, diseases and weed

1. KT0701: Orchard / Vineyard Hygiene

IAC0701: The principles of hygiene are outlined

- Orchard hygiene is a fundamental part of citrus production that aims to prevent the spread of pests, diseases, and weeds by maintaining clean and orderly orchard conditions.
- Effective hygiene practices begin with the regular removal and disposal of diseased, damaged, or fallen fruit that can be a breeding ground for pathogens and pests.
- Regular pruning, especially of dead or diseased branches and fruit, prevents the spread of diseases.
- Equipment, tools and machinery used in the orchard must be sanitised and cleaned in between orchard blocks and trees to minimise the risk of spreading diseases and pests.
- Weeds should be controlled through mulching, herbicides, or mechanical removal to reduce potential hosts for pests and prevent competition with trees for nutrients and water.
- Removing plant debris such as fallen leaves from orchards also limits potential breeding grounds for pests and diseases.
- All plant debris, waste fruit, or other waste, should be properly disposed of to ensure that potential disease carriers are not reintroduced into the orchard environment.
- Personnel hygiene is also critical, and orchard workers should be trained to recognise and report symptoms of disease and to follow cleaning protocols for clothing, footwear, and tools.
- Water sources used for irrigation or sprays should be monitored and kept free from contamination to prevent the introduction of diseases and pests into the orchard.
- Only healthy, certified trees should be planted in the orchard to ensure they don't' carry diseases or pests into the orchard.
- Regular orchard inspections and recordkeeping help identify hygiene issues early, allowing for prompt corrective action before pests or diseases become widespread.
- Integrating orchard hygiene with other production practices such as pest monitoring, nutrition management, and irrigation scheduling supports overall orchard health and productivity.

- A consistent and well-documented hygiene program not only improves fruit quality and yield but also supports long-term sustainability and compliance with biosecurity standards in citrus production.

IAC0702: The causes of contamination are described

- Contamination refers to when fruit comes into contact with harmful substances or micro-organisms.
- Cross-contamination refers to when harmful substances or micro-organisms are transferred from contaminated fruit to uncontaminated fruit through human contact or other means.
- Food becomes hazardous by contamination and cannot be sold.
- The sources of contamination (referred to as hazards) are categorised into three types, being:
  - Chemical hazards.
  - Physical hazards.
  - Biological hazards.
- Food safety systems and basic precautions usually ensure that food is protected against physical and biological hazards.
- Chemical hazards require special care and attention and pose the biggest threat for citrus grower.
- All production practices on the farm must be managed in such a way that the possibility of chemical contamination is minimised.
- Chemical hazards are mostly invisible, and food and fruit can be exposed to chemicals in many ways on a farm.
- Fruit is directly exposed to pesticides and other agrochemicals in the orchard, and indirectly to other chemicals, such as cleaning materials, oil and grease, and chemicals that are added to irrigation water.
- Agrochemicals must be registered with DoA before they may be used, as this guarantees that they can be safely used on citrus.
- Even though a chemical may be registered and therefore approved for use, the residue levels on the fruit when it is exported is very important.
- Standards regarding maximum residue levels and pre-harvest intervals must be observed at all times.
- All PPPs must be used only in the manner and for the purpose that they are approved and intended for.
- They should only be used in accordance with the manufacturer’s instructions and the RUR, and any relevant codes of good practice must be observed.
- Physical food safety hazards refer to all visible, physical items that can contaminate food during production, harvesting, packing, or anywhere else where food is handled.
- Physical items can in themselves contaminate fruit and can also cause injuries to the fruit which present an entrance point for pathogens.
- Biological hazards are mostly invisible and include pathogens such as viruses, parasites, fungi, and bacteria.

- Pathogens may be present on products when you purchase them, and fresh produce such as fresh fruit and vegetables is generally not sterile.
- Of all the pathogens, bacteria pose the greatest biological hazard to food safety. Bacteria are single cell, living organisms that can multiply quickly in favourable conditions.
- Not all bacteria are harmful, but some bacteria (such as E. coli) are pathogens for some very serious diseases which can be fatal.
- If these dangerous bacteria are allowed to come into contact with food, they use the nutrients found in the food to multiply.
- Some bacteria are not harmful on their own, but when they multiply in food, they produce toxins that can poison humans when the food is eaten.
- Food handling practices must prevent harmful bacteria from contaminating and growing in food.

self-assessment

KT0701: Orchard / Vineyard Hygiene

Can I?	Y/N
Can I explain the importance and purpose of orchard hygiene in citrus production?	
Can I describe the practices involved in orchard hygiene?	
Can I sanitise and clean equipment, tools, and machinery?	
Can I identify methods for controlling weeds in the orchard?	
Can I explain why removing plant debris is important for pest and disease control?	
Can I describe the proper disposal methods for orchard waste?	
Can I train workers in the practices and importance of personnel hygiene?	
Can I select healthy, certified trees for planting in the orchard?	
Can I implement regular orchard inspections and recordkeeping?	
Can I design an orchard hygiene program?	
Can I define cross-contamination and explain how it occurs?	
Can I describe how contamination affects food safety?	
Can I identify the three main types of contamination hazards?	
Can I monitor and record residue levels on fruit?	
Can I adhere to maximum residue levels and pre-harvest intervals?	
Can I explain food handling practices that prevent bacterial contamination and growth?	
Can I properly instruct workers involved in orchard work on all of the above?	

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0701	The principles of hygiene are outlined	B3, D2, G3, H1, H2
IAC0702	The causes of contamination are described	A6, D2, J1, K1, L1

2. KT0702: Food Safety related to Chemical Control of Pests, Diseases and Weed

IAC0703: The actions that ensure traceability are outlined

- Traceability refers to the ability to trace any product back to its original source.
- In citrus production, traceability is the ability to trace a specific carton of fruit from its overseas destination all the way back to the orchard in which the fruit was grown.
- Farmers are legally required to have traceability systems in place.
- Traceability is also an important requirement of standards bodies such as GlobalGAP.
- When a food safety hazard is detected, it must be assumed that all fruit in the same area (such as in the same port or container) is unsafe.
- When a safety issue is detected, the fruit will be identified, first by country of origin, then grower or production unit, narrowing down which fruit can be considered unsafe.
- If the grower is able to identify the orchard from which the fruit originated, fruit from other orchards can be considered safe.
- If the necessary records are not kept ensuring this traceability, exporters and importers have no choice but to consider all the fruit of this grower unsafe and reject it all.
- This rejection of an entire consignment can be financially disastrous for a grower, and lead to huge losses of an entire harvest, for what may have been an isolated incident in one orchard.
- Traceability requires an effective recordkeeping system and well-defines processes.
- Orchard practices, harvesting practices, packing practices, procedures and protocols, and shipping practices, procedures and protocols must all be recorded and documented.
- Every worker involved in production, harvesting, packing, and shipping must be aware of the requirements of traceability and the importance of recordkeeping.

IAC0704: The need to prevent spraying of chemicals when they are not applicable is explained

- Unnecessary chemical application can harm the environment, as when agrochemicals end up in the soil, they can contaminate water sources and harm beneficial soil microorganisms.
- This leads to decreased soil quality and a disruption of the natural ecosystem, including natural biological control mechanisms present in the orchard.
- Killing these beneficial insects and microorganisms that usually naturally control pest populations can increase pest populations.
- Excessive and unnecessary chemical applications can also have serious consequences for the health of people on and off the farm.
- Increased agrochemical exposure increases the risk of serious health issues to workers.
- Runoff from over-sprayed areas can also pollute nearby water sources, affecting aquatic life and public safety.
- Unnecessary and excessive applications run the risk of exceeding MRLs, which can cost growers a lot of money and may harm the farm’s reputation, while putting consumers at risk.

- Pests and diseases develop resistance to agrochemicals at an increased rate the more they are exposed to it.
- Resistance refers to the ability of certain members of a pathogen or pest population to survive or to be immune to agrochemicals.
- After resistant organisms have survived the applications, they alone are left to repopulate, leading to the entire population on that farm being resistant.
- This newly resistant population will make future applications less effective if not totally ineffectual.
- As the agrochemicals become less effective, growers will have to either use more of them, or switch to other, possibly more expensive or harmful chemicals.
- Both of these options not only increase costs for the producer but also place further pressure on the environment.
- Excessive agrochemical usage also wastes chemicals, wasting the money of the farm as a whole.
- Chemicals can be very expensive, and it is unwise to increase these already-high costs without any additional benefit.

IAC0705: Withholding periods are defined and the need for them is motivated

- Agrochemicals serve numerous functions in citrus production, but they must be used carefully, and there are numerous regulations that deal with them.
- All agrochemicals used must be approved by the government, and all are subject to strict national and international standards regulating their use, set by numerous groups and governments.
- One of the most important aspects of these regulations is that of withholding periods.
- A withholding period is the minimum length of time that must pass between the last application of a particular agrochemical and the harvest date of the crop that the agrochemical was applied to.
- This withholding period must be strictly adhered to at all times, even in unforeseen circumstances, such as a sudden pest outbreak.
- Withholding periods are determined through scientific research to ensure that any agrochemical residues left on fruit are at a level considered safe for human consumption.
- Choosing to ignore or failing to meet these requirements can put consumers at risk and have serious legal and financial ramifications for farmers.
- Withholding periods are generally found on the product label, and they are determined to ensure that fruit, particularly export fruit, complies with international standards regarding MRLs.
- Maximum residue levels (MRLs) refer to the highest amount of agrochemical residue that is legally tolerated on fruit.
- These levels are based on research and aim to ensure that any chemical residue remaining on fruit does not harm consumers' health.
- MRLs are prescribed by the food safety legislation and regulations and must be strictly adhered to.

- The prescriptions are contained in a document called Default Maximum Residue Levels for Fungicides and Pesticides for Export Citrus, which is a legally enforceable document that is available from DoA.
- MRLs are set individually for each pesticide and each crop, and different counties have different MRL requirements based on the product being used and the crop it was used on.
- Growers must research the specific MRL requirements of target markets, as they may differ significantly from other markets.
- MRL prescriptions determine how long before harvesting PPPs can be applied to plants, referred to as the pre-harvest interval.
- The best way to avoid food contamination is to adhere to the pre-harvest intervals.
- Residues are monitored by the PPECB and fruit with residues that exceed MRLs will be rejected for export, with serious legal consequences for the grower.
- In South Africa, The Citrus Growers' Association (CGA) and Citrus Research International (CRI) jointly publishes a Recommended Usage Restrictions (RUR) document regularly.
- The RUR indicates the farming practices that will ensure that MRLs are not exceeded and if growers apply the RUR, the resultant residues on fruit will be below the MRLs.

self-assessment

KT0702: Food Safety related to Chemical Control of Pests, Diseases and Weed

Can I?	Y/N
Can I explain the concept of traceability in citrus production?	
Can I explain the legal requirements for traceability systems on farms?	
Can I describe the role of standards bodies such as GlobalGAP in traceability?	
Can I identify the origins of food safety hazards when detected?	
Can I describe the consequences of not maintaining proper traceability records?	
Can I identify the components of traceability systems?	
Can I describe the role of workers in maintaining traceability?	
Can I explain the importance of recordkeeping?	
Can I explain the environmental and health risks of unnecessary chemical applications?	
Can I explain the concept and risks of pest and disease resistance?	
Can I describe how excessive chemical use contributes to pest and disease resistance?	
Can I describe the risks of wasting agrochemicals?	
Can I explain withholding periods and why they are important?	
Can I explain maximum residue levels and their purpose?	
Can I explain the relationship between MRLs and food safety regulations?	
Can I explain pre-harvest intervals?	
Can I explain how failing to comply with MRL or withholding period regulations affects exports?	

Can I describe the role of PPECB, CGA, and CRI in monitoring residues and setting restrictions?	
Can I explain the purpose of the Recommended Usage Restrictions (RUR) document?	

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0703	The actions that ensure traceability are outlined	A6, A7, A8, D4, L1
IAC0704	The need to prevent spraying of chemicals when they are not applicable is explained	A6, D2, F1, F2, L1
IAC0705	Withholding periods are defined and the need for them is motivated	A2, A6, F1, F2, J1

IAC0706: OHS directly related to the use of pesticides & fungicides & herbicides (IPM) is outlined

- All chemicals should be considered hazardous until indicated otherwise.
- Agrochemicals (including pesticides, fungicides, and herbicides) can be very hazardous to humans, animals and to the environment.
- Health and safety regulations must be strictly observed when applying, storing, transporting, or handling agrochemicals.
- All workers must be provided with the appropriate PPE and training when using agrochemicals.
- Pictograms are displayed on product labels advising on the protective gear and safety equipment that are necessary when handling a particular chemical.
- The biggest risk to workers that handle agrochemicals is poisoning.
- Agrochemicals can poison workers orally (swallowing), dermally (skin contact), or through inhalation (breathing).
- The most common manner of poisoning is through skin contact (dermally).
- Depending on the agrochemical being used, workers may require cotton overalls, aprons, goggles, raincoats, hats, rubber gloves, rubber boots, facemasks, or respirators.
- The contact details of emergency services must be readily available to all persons who handle agrochemicals.
- These emergency contact details should be clearly displayed on signs throughout the workplace, and close to the telephone so that they are easily accessible.
- The specific numbers that should be displayed vary depending on the specific farm, but generally, the following numbers should be available:
  - Poisons Information Centre.
  - Local doctor.
  - Local hospital.
  - Local ambulance service.

IAC0707: The procedure for dealing with alien invaders is outlined

- Introduced species are plants that are not indigenous to South Africa, meaning that they were introduced here, generally through human action, and did not naturally occur here.
- Ecosystems are often fragile, in the sense that removing a single member of the ecosystem (such as a major predator or a common prey) can destroy the ecosystem entirely.
- Some introduced species are harmless to the ecosystem or environment and can be a benefit to farmers (such as citrus, which originates in Asia).
- Some introduced make the transition to becoming invasive species, which are dangerous to the ecosystems they enter.
- An invasive species is defined as "an introduced organism that begins to spread or expand its range beyond the site of its original introduction and that has the potential to cause harm to the environment, the economy, or to human health."

- Invasive species can cause this harm to the environment by outcompeting and replacing indigenous organisms and overtaking the ecosystem.
- This overtaking of the ecosystem can lead to the decline and even extinction of other species.
- The first step to managing invasive species is effective, efficient monitoring, including surveys of the immediate environment around the farm to look for invasive species.
- Invasive plants can be controlled in through mechanical, chemical, and biological methods.
- Mechanical methods include felling, removing, or burning invading alien plants.
- Chemical methods include herbicides.
- Biological methods involve using species-specific pests and diseases from the alien plant's country of origin to kill the invaders.
- Growers can also implement a combination of the various control methods in severe cases of infestation.
- Landowners (including farmers) are under a legal obligation to control invading alien plants occurring on their properties.
- When monitoring for invasive species, workers need to know how to identify any species they encounter, how to categorise them, and how to remove them if necessary.
- Historically, problem plants were classified into two groups, declared weeds and plant invaders.
- These classifications were revised, and these problem plants are now classified into three groups.
- Category 1 plants, also known as declared weeds, are prohibited plants that cannot be allowed to grow except with the written permission of the executive officer or in an approved bio-control reserve.
- Category 1 plants may not be planted or propagated, and all trade in their seeds, cuttings or other propagative material is prohibited.
- Category 1 plants may not be transported or be allowed to disperse.
- Category 2 plants, also known as plant invaders or declared invaders, have the proven potential of becoming invasive, but which nevertheless have certain beneficial properties.
- These beneficial properties mean that, despite being invasive, there may be good reason to allow their presence in certain circumstances.
- Category 2 plants may be retained in specific areas demarcated for that purpose, but any Category 2 plants occurring outside these areas must be controlled.
- Category 2 plants may also be retained or cultivated in biological control reserves, where the plants will serve as host plants for the breeding of biological control agents.
- Category 3 have the proven potential of becoming invasive, but many of them are nevertheless popular ornamentals or shade trees that will take a long time to replace.
- Category 3 plants are not allowed to occur anywhere except in biological control reserves, unless they were already in existence when regulations went into effect.
- Category 3 plants may only be kept if they do not grow within 30m from the 1:50 year flood line of watercourses or wetlands, and all reasonable steps must be taken to prevent them from spreading.

- The Executive Officer has the power to impose additional conditions or even prohibit the growing of Category 3 plants in any area where they have reason to believe that these plants will pose a threat to the agricultural resources.
- If any unknown or new plant species appear during monitoring operations, these weeds should initially be treated as "unwanted plant growth" and not necessarily as invasive species.
- Workers should report any unrecognised or new plant species to management, as they might be an indication of soil degradation and might be emerging as pioneer species."
- Pioneer species of plants can only exist in poor soil conditions, and they are nature's way of trying to repair the nitrogen balance in the soil.
- If pioneer species are emerging in orchards, this should be reported immediately, and soil analysis should be performed.

IAC0708: The impact on the environment and contamination of resources is discussed

Refer to IAC0704: The need to prevent spraying of chemicals when they are not applicable is explained.

self-assessment

KT0702: Food Safety related to Chemical Control of Pests, Diseases and Weed

Can I?	Y/N
Can I describe the risks agrochemicals pose to humans, animals, and the environment?	
Can I explain the health and safety regulations that must be followed when applying, storing, transporting, or handling agrochemicals?	
Can I ensure that all workers have the appropriate PPE and training required when handling agrochemicals?	
Can I interpret pictograms on chemical labels?	
Can I explain the different methods of poisoning by agrochemicals?	
Can I make display appropriate emergency contact details to workers?	
Can I explain what the difference between introduced and indigenous species?	
Can I describe how ecosystems can be affected by the removal or introduction of species?	
Can I explain the risks posed by invasive species?	
Can I monitor the farm environment for invasive species?	
Can I describe and implement the various methods used to control invasive plants?	
Can I describe the legal obligations of landowners and farmers regarding the control of invasive plants?	
Can I train workers on identifying, categorising, and reporting invasive species?	
Can I describe the various categories of invasive species?	
Can I define and identify pioneer species?	
Can I train all workers involved in monitoring on all of the above?	

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0706	OHS directly related to the use of pesticides & fungicides & herbicides (IPM) is outlined	F1, F2, J1, K1, L1
IAC0707	The procedure for dealing with alien invaders is outlined	D2, D3, H1, H2, L1
IAC0708	The impact on the environment and contamination of resources is discussed	A6, D2, F1, F2, L1

KM-05-KT08:
Plant Protection Application Principles (IPM)
(12%, 0.48 credits)

Topic Elements

The content of this chapter covers the following topic elements:

- KT0801: Legislation and standards
- KT0802: Safety aspects
- KT0803: Integrated pest management (IPM)

1. KT0801: Legislation and Standards

IAC0801: The procedures for monitoring and reporting on chemical applications are outlined

- Agrochemical applications must be carefully monitored and managed for the safety of workers, the trees, and the environment as a whole.
- Well-structured, formalised reports must be drawn up for each application and stored on a database.
- Management should design and train all workers on proper reporting procedures, and these procedures must be applied and enforced at all times.
- Workers should immediately report problems or unusual occurrences to their supervisor or team leader.
- All necessary information, such as orchards to be sprayed, spray cover, and chemical attributes (especially toxicity), must be recorded and reported to all workers involved.
- Supervisors must ensure that all workers are fully informed on the activities being performed, and that all workers are properly equipped with PPE.
- All equipment and tools used should also be recorded.
- Supervisors must check that the correct chemicals, mixed properly, in the correct concentration, are being applied.
- Workers must check that the agitator of the spray machine is functioning adequately and that the chemicals placed inside the spray tank are well mixed.
- Supervisors should check the spray coverage of the trees and ensure that enough chemical is being applied.
- Supervisors should ensure that all nozzles are spraying onto the tree and may have to close or alter the direction of nozzles.

- Supervisors should check that the number of litres being applied per tree is within an acceptable range by checking the number of spray tanks used against the number of trees sprayed.
- Supervisors should observe the climatic conditions and react accordingly.
- Spraying must be immediately stopped if it starts raining, or if it becomes too windy or too hot.

self-assessment

KT0801: Legislation and Standards

Can I?	Y/N
Can I monitor agrochemical applications?	
Can I create and store formal reports for chemical applications?	
Can I train workers in reporting procedures?	
Can I train workers to report problems or unusual occurrences during spraying?	
Can I ensure that workers are informed and equipped with the correct PPE?	
Can I record all equipment and tools used during spraying?	
Can I verify that the correct chemicals are mixed at the proper concentration?	
Can I check spray coverage?	
Can I adjust nozzle placement and direction during spraying?	
Can I check the volume of chemical applied per tree against the number of spray tanks used?	
Can I observe climatic conditions and adjust spraying accordingly?	
Can I determine the need to stop spraying in adverse conditions?	

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0801	The procedures for monitoring and reporting on chemical applications are outlined	A6, D3, E2, F1, F2

2. KT0802: Safety Aspects

IAC0802: The OHS and GAP for safe handling of chemicals is described

Refer to IAC0604: Safe handling and storage principles related to plant nutrient chemicals are evaluated.

IAC0803: GAP for record-keeping of chemical applications is delineated and motivated

Refer to IAC0605: Basic principles of recordkeeping (such as accuracy and currency) is motivated.

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0802	The OHS and GAP for safe handling of chemicals is described	F1, F2, J1, K1, L1
IAC0803	GAP for record-keeping of chemical applications is delineated and motivated	A3, A5, A6, D4, I1

3. KT0803: Integrated Pest Management (IPM)

IAC0804: IPM reporting requirements and traceability is explained

Refer to IAC0703: The actions that ensure traceability are outlined.

work scenario reference

To learn about how the above information is applied in practice, please look at the following workplace scenarios:

IAC Code	IAC Title	Relevant Work Scenario(s)
IAC0804	IPM reporting requirements and traceability is explained	A6, A7, A8, D4, L1