22174: Demonstrate knowledge of soils and fertilisers

Level
2

Learner Guide

PrimaryITO
KNOWLEDGE TO GROW

Unit standard 22174 v2	Level 2	Credits 5
Demonstrate knowledge of soils and fertilisers		

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Contents

Introduction

Learning outcomes

To successfully complete this unit standard you will show that you are able to:

- describe what the major components of soil are made up of, and their size and proportions
- describe how the major components of soil affect plant growth
- describe what soil horizons are made up of
- describe how soil aggregates and soil structure affect plant growth
- identify major soil textural types by feel and sight
- describe features of two soils and compare their uses
- describe how the two soils were formed
- describe where the two soils are located, and how they are used, in New Zealand
- describe how macronutrients and micronutrients affect plant growth
- describe how fertilisers and lime affect plant growth
- describe soil testing and leaf analysis
- describe soil and plant deficiencies and toxicities using plant symptom examples.

Notes

- All the tasks you complete must be done within the rules of the following:
  - Workplace procedures
  - Health and Safety at Work Act 2015.

If you require the Learner Guide to be printed on coloured paper, contact Primary ITO on 0800 20 80 20 and talk to our Learner Achievement Team.

Glossary

You may find new words (highlighted in **bold black**) as you read through this Learner Guide. The meaning of these words are in the glossary at the back.

Symbols

You'll also see symbols which we've used to help you know what's going on, for example:

Activity: a written activity for you to do.

Alert: you must be aware of this.

Do this: a practical activity for you to do.

Question: a question for you to think about.

Search online: refer to online references for information on this topic.

Assessment

You will find a separate Assessment booklet for this unit standard. You will need to work through the Activities in the Assessment.

Your Verifier will fill in the Verifier declaration once they are satisfied you have achieved the learning outcomes for the unit standard. Your Verifier may be your Supervisor.

The Assessor will check all declarations and fill in the final sign-off once final competency is achieved. The Assessor may be your Training Adviser or a Workplace Assessor.

Soil types and horizons

In this section, you will learn about what soil is and how it is formed. You will find out about different types of soil and soil horizons.

What is soil and why is it important?

Soil is the thin layer of living and non-living material spread over the planet's surface. All soils feature a mix of **mineral particles, organic matter**, water and air. However they vary by **texture** (the size and shape of the particles) and by the way they are **structured** (the particle arrangement).

Plants depend on soil for life. Soil gives plants water and **nutrients**, and holds them firmly in the ground. Soil influences how your plants and crops grow and develop.

Soil structure

Soil structure is the way mineral particles are grouped (aggregated) into **secondary particles** called soil aggregates.

Soil and plant growth

Soil influences plant growth in various ways. For example:

- If there are not enough nutrients in the soil, plants will not grow as well as they should.
- Where soil has too much clay, it won't drain well and will prevent plant roots being able to spread.
- If the soil is overly sandy, it will drain too quickly.

How do soils form?

Soil forms through two natural processes – weathering and through the addition of organic matter. These processes are constantly working together to form soil.

Weathering

Weathering is the first stage in the process. The earth's surface is exposed to the action of the weather and the surface is broken down into smaller **particles**. Weathering gradually breaks down the parent rock (the rock that a soil is formed from) into smaller pieces called parent material. Slowly weathering breaks down the parent material further into finer (smaller) particles called subsoil.

Air, water and changes in temperature are the main causes of weathering. Air and water act on the minerals in rocks, which makes it easier for wind to wear them away.

Water carries away broken pieces and grinds them down into smaller sizes. Water also attacks the chemical structure of rocks and breaks them into smaller particles and makes new chemical **compounds**.

Addition of organic matter

The addition of organic matter is the second stage in soil forming. As weathering continues, plants begin to establish (set up) themselves in soil. Animals then feed on the plants. As plants and animals die, they decay and form **humus**.

Larger organisms (worms, insects, insect larvae, slugs and other molluscs and some fungi) also play a part in soil forming. They stir up the topsoil and expose it to the air and rain. When they die, their bodies also form humus in the soil.

Bacteria and fungi cause the organic matter to decay. This makes the parent material darker. Once this dark layer can be seen, even if it's quite thin, there is soil.

What types of soil are there?

There are three main types of soil – sandy, silt and clay. Soils are made up of some or all of the following soil types:

- Sandy soil has the largest particles (bits) of all three soil types and doesn't hold many nutrients. When you rub sandy soil it feels rough.
- Silt has soil mineral particles that are smaller than sand yet bigger than clay. Silt feels smooth and powdery when dry and has a smooth feel when it is wet.
- Clay is the soil type with the smallest mineral particles. It is smooth when dry and sticky when wet. Soils with a high quantity of clay are called heavy soils. Clay has the ability to absorb and hold nutrients as well as hold water but does not hold air well due to the small size of pores in the soil.

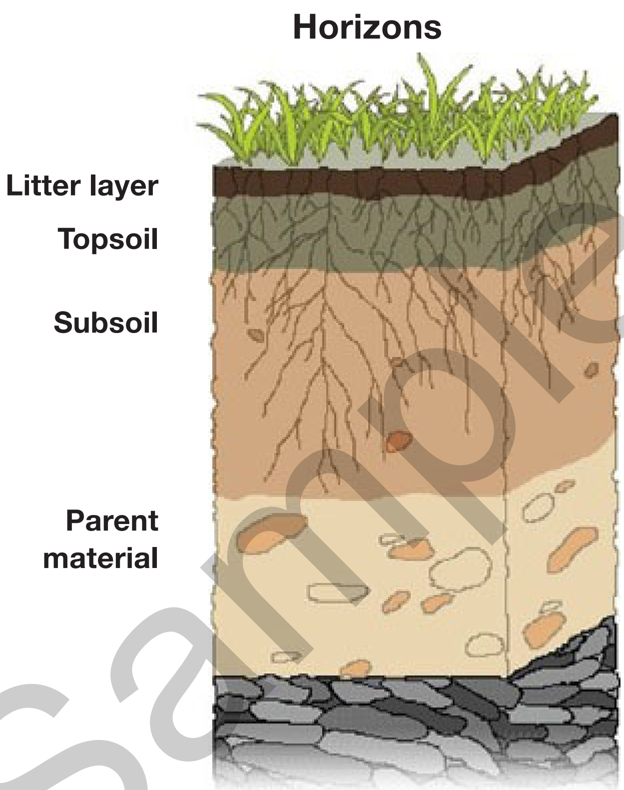
Ask your Supervisor to show you a sandy soil, a silt soil and a clay soil. Take a spade. Dig out a sample of each soil type. Observe and touch each soil sample. Discuss the texture, particle size and components of each soil sample with your Supervisor.

What are soil horizons?

Soil horizons are the layers of soil parallel (side by side) to the surface used to classify (identify) soil.

There are four main categories of soil horizon. You need to become familiar with each one. Take a look at the following image that shows you the different soil horizons:

- O horizon, the litter layer
- A horizon, the topsoil
- B horizon, the subsoil
- C horizon, the parent material.



Litter layer (organic)

The litter layer (or O horizon) is one of the most important layers. It consists of partially decomposed material (such as leaves, needles, twigs, moss, and lichens that has decayed and rotted) deposited on the soil's surface.

Topsoil

Topsoil (or A horizon) is the fertile upper layer of soil where you find most plant roots and soil organisms. It is formed by the weathering of rocks and the organic matter from decaying plants and animals. The quality of topsoil depends on the size of the rock particles it contains, which can vary greatly.

Subsoil

Subsoil (or B horizon) is the layer of soil under the topsoil. Subsoil can include clay or sand partially broken down by air, sunlight, water, and wind. Subsoil is the area where nutrients **leach** from above and new material from below accumulates (builds up).

Parent material

Parent material (C horizon) is made up of residual (what is left) bedrock, sediments or **aeolian deposits** and is usually a light shade of brown or yellow. It contains the deeper roots of large plants, like trees. As a rule, however, very little lives in the C horizon.

Check your understanding of soil horizons by looking at the photo and labelling the six items listed below on the photo. Label the photo by writing each item on the photo where it appears. We have done Item 1 for you to show you what to do. Check your answers at the back of this Learner Guide.

A typical Waikato soil (1,200mm deep) showing three soil horizons.

Item 1	Topsoil	Item 4	B horizon
Item 2	Subsoil	Item 5	Parent material
Item 3	A horizon	Item 6	C horizon

What does soil colour tell you?

Soil colour can tell you about the make-up, condition and quality of the soil. For example, deep brown soils tend to feature organic matter and **nitrogen**. They are usually fertile and provide good **aeration** and low **erosion**, making them ideal soils for growing plants.

Lighter coloured soils, are usually low in organic matter, are less fertile and lack important soil organisms. You can, however, improve light coloured soil by applying organic matter to the soil.

An example of deep brown soil, featuring organic matter (O horizon).

A soil that is 90 cm from the surface and is rust coloured, motley (multicoloured) or grey may suggest you need to install drainage to lower the **water table**.

Ask your Supervisor to show you an example of the four soil horizons (O horizon, A horizon, B horizon and C horizon). Look closely at each horizon, paying particular attention to the soil colour and soil type.

What did you notice when looking at the soil horizons? What was each soil horizon made up of?

Influences of soil on plant growth

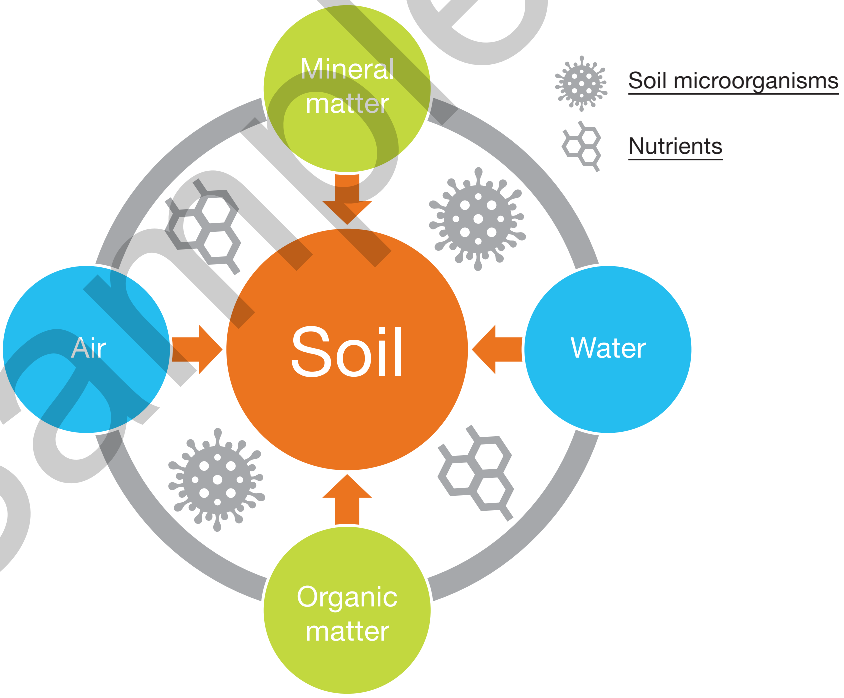
In this section you will learn more about the components (parts) of soil and their main influences on plant growth.

What components make up soil?

There are four major components (parts) of soil:

- mineral matter
- organic matter
- water
- air.

Small quantities of microorganisms and nutrients can also be found in soil.



Components that make up soil.

Mineral matter

Mineral matter, made up of mineral particles, is the largest major component of an ideal soil. The size and shape of a soil's mineral particles influence its ability to:

- **retain** and **percolate** water
- store and move air
- enable plants to grow and develop
- store and release nutrients
- resist chemicals
- adapt to temperature changes.

For example, soils made up of large, solid mineral particles of an irregular (not even) shape that don't fit compactly (closely) together (e.g., a gravelly or sandy soil) will have good aeration and drainage but will lack the ability to hold water and nutrients.

Examples of plants best suited to growing in soils with large, solid mineral particles include succulents, rosemary, lavender and olives.

Organic matter

Organic matter is another factor that improves plant growth. Mixed with clay, it can improve drainage by allowing more air to pass though soil and increasing a soil's ability to hold water. It also improves soil fertility by encouraging soil organisms that feed on the organic matter and adding humus to the soil as the organic matter breaks down.

Organic matter makes up only around 10% of an ideal soil.

Water

Water can influence plant growth in both beneficial and harmful ways. It can improve soil fertility by sitting in the pores (spaces) between soil particles and carrying important nutrients to the roots of a plant. It also helps plants with **photosynthesis**.

However, too much rain and irrigation can fill up soil pores with water and reduce the air left in soil, creating soil saturation and, sometimes, causing crops to die. You will find the amount of water contained in soil varies from soil to soil. For example, water takes up approximately 25% of the soil composition of an ideal loam soil when not dry or fully saturated.

Air

Air influences plant growth in a range of ways. For example, aerobic soil (soil with plenty of oxygen available) can encourage bacteria to quickly turn organic matter into humus. However, anaerobic soil (soil with low oxygen levels) can create a build up of toxins, such as carbon dioxide in the plants.

What features of these four major soil components did you already know about?

Have you learned anything new about the ways they can influence plant growth?

Nutrients

Nutrients also influence plant growth. A soil that is rich in essential elements such as nitrogen will help plants grow faster and last longer. Most plants flourish (grow well) in nutrient-rich soils.

The amount of nutrients in a particular soil depends on many factors, including the:

- soil's parent material (the type of rock the soil has come from)
- soil's texture (i.e., does it have a sandy, silt or clay texture?)
- amount of organic matter in the soil
- amount of water in the soil
- **soil pH.**

Nutrients must change into **ions** before they are useful to plants. This happens as rocks break down and release chemical elements, which dissolve in soil water and split into charged particles called ions.

Some ions sit on the outside of clay particles or humus. They stay there until they dissolve into soil water and become available for plants to use. This process has four stages:

- the nutrients are held by soil particles
- the nutrients move into soil water
- the nutrients move into root hairs
- the nutrients move into the plant through water uptake, a process driven by **osmosis** and **transpiration.**

Soil microorganisms

Soil microorganisms are the bacteria, fungi and protozoa (microscopic, single-celled organisms) that inhabit (live in) the soil in large numbers. They are important because almost every chemical change that occurs in soil involves soil microorganisms. Soil microorganisms can make a soil more fertile by breaking down the nutrients (e.g., carbon and nitrogen) needed for plant growth.

Check your understanding of the influences on plant growth by drawing lines between the soil components on the left with their matching influence on plant growth on the right.

We have matched one item to show you what to do. Check your answers at the back of this Learner Guide.

Soil component	Influence on soil make up
Mineral matter	Encourages bacteria to quickly turn organic matter into humus.
Organic matter	Increases plant growth by moving through soil water and into root hairs, and then into the plant through water uptake.
Water	Proportions influence how much water and nutrients the soil can hold, and releases and stores nutrients.
Air	Makes soil more fertile by breaking down nutrients needed for plant growth.
Nutrients	Sits in between soil particles and carries important nutrients to the roots of a plant, and helps with photosynthesis.
Soil microorganisms	Acts as a store for water, improves drainage by allowing more air to pass through soil, and helps to feed microorganisms.

List any words that are new to you in the spaces provided below. If they aren't in the glossary at the end of this Learner Guide, look them up on the internet or in a dictionary and add them to the glossary yourself.

Soil structure and texture

In this section, you will learn more about soil structure and texture and how both affect plant growth.

How are soils structured?

Soil structure is used to describe how individual soil particles (or bits) of soil clump or bind together into aggregates and pore spaces between them.

Typically, soil aggregates and clumps are bound together by moist clay, organic matter and soil organisms such as fungi and bacteria.

You will find the size of soil aggregates can vary – some fit closely together while others feature a lot of pore space (vital for storing air and water, microorganisms, nutrients and organic matter).

Ask your Supervisor to help you look at the structure of the soil in or around your workplace. Take a spade. Dig out a sample of the soil. Look at how the soil particles bind (stick) together. Ask your Supervisor to describe and point out aggregates, pore spaces, organic matter and any visible soil organisms.

How does soil structure affect plant growth?

Soil structure influences plant growth in the following ways:

- Root development – a soil with a good structure helps plant roots develop easily and take up water and nutrients.
- Water retention – a soil with a good structure holds enough water for healthy plant growth.
- Seed germination – a soil's physical condition must allow germinating seeds to easily break though the surface layer.
- Support living organisms – a good soil structure will support a wide range of living organisms that will, in turn, improve the soil. Worms are a good example of a living organism.

Can a soil's structure become damaged?

Many factors can damage soil structure, such as heavy equipment e.g. tractors, harvesting equipment, vehicles. Damage can become worse under very wet or very dry conditions. Crushed soil components or compacted soil reduces the amount of air and water that can move through the soil and enter plant roots.

Check your understanding of soil structure by answering the questions below. We have completed two examples to show you what to do. Check your answers at the back of this Learner Guide.

Soils with good structure will:

1. Allow rapid drainage of excess water.
2.
3.
4.

Poorly structured soils can have particles joined together into dense sheets or large clumps and may be:

1. Difficult to dig.
2.
3.
4.

How do soil aggregates differ?

Soil aggregates differ mostly by shape and size and fall into the following six categories.

1. Crumb or granular – also know as 'nutty', these soil aggregates are found in surface horizons that resemble crumbs, measuring less than half a centimetre in diameter.
2. Blocky – soil aggregates found mainly in the B horizon (and sometimes the A horizon of clay soils). They are irregular (not even) in shape, measuring between 1.5–5 cm in diameter.
3. Platy – these soil aggregates are thin flat plates of soil that lie horizontally and are usually found in compacted soil.
4. Fine or single grained – soil aggregates that are often found in sandy soils where broken down particles do not stick together.
5. Prismatic – vertical columns of soil several centimetres long, usually found in the lower horizons of soil.
6. Massive – these soil aggregates cannot be seen, they are hard to break apart and are found in large clods (lumps of soil or clay).

Do soil aggregates affect plant growth?

Soil aggregates affect plant growth in different ways. Some aggregates, such as platy types, provide too little water and air for plants to grow well. Other soil aggregates such as crumb or granular aggregates help create soils that give plants good drainage, yet also retain water well.

What is the relationship between soil structure and soil aggregates?

Can you describe the ways different soil aggregates influence plant growth?

What is soil texture?

Soil texture (or the way a soil feels) is determined by the proportions of sand, silt and clay in a soil. You will find sandy soils feel gritty when you rub it between your fingers and thumb. Clay soil will feel very smooth or sticky (depending on the moisture level of the soil).

Example of a smooth clay soil

What is a loam soil?

A loam soil is an ideal soil, featuring sand, silt and clay, and is named after the dominant (main) mineral particle, e.g. silt loam, clay loam or sandy loam.

Loam soils generally:

- contain more nutrients and humus than sandy soils
- have better infiltration and drainage than silty soils
- are easier to till than clay soils
- are gritty, moist and retain water easily.

A loam soil typically features:

- mineral particles such as clay, sand and silt (up to 50%)
- organic matter
- water
- air.

Ask your Supervisor to show you samples of:

- sandy loam
- silt loam, and
- clay loam.

Take some time to feel the different textures of these loam soils. Discuss the textures with your Supervisor.

What about other soils?

Sandy soils are usually made up of approximately 80–100% sand, up to 10% silt and up to 10% clay. They are light and typically very free draining and usually do not hold water well because of their low organic content.

Clay soils are common in hilly areas, particularly around urban areas where fill soils have been used to form grades in subdivisions and developments. They usually contain a mix of up to 45% sand and silt and up to 100% clay.

Clay soils are not typically free draining and water tends to take a long time to pass through them. When wet, clay soils tend to allow nearly all water to run-off. They are heavy and difficult to work when dry.

Work with your Supervisor to carry out the following five-step test to identify the type of soil in your workplace.

1. Take a small sample of soil – enough to fit in the palm of one hand. Discard (take out) any gravel.
2. Moisten the soil with water and knead it until there is no clear change in feel. This will take several minutes.
3. Have a close look at the sample to see if you can see any sand.
4. Squeeze the sample hard to see whether it will form a ball or mould. Check if it stays together or falls apart readily.
5. Finally, squeeze it out between thumb and forefinger with a sliding motion to form a flat ribbon.

Soil classification in New Zealand

In this section, you will learn about the New Zealand Soil Classification (NZSC) system, how it classifies soils and how it can help you at work. Soil profiles are briefly covered in this section.

What is the New Zealand Soil Classification?

The NZSC is a system that categorises (groups) New Zealand soils based on their features. The system was set up by the New Zealand Genetic Soil Classification in the 1980s. Use it to find out what soils will work best in your work.

How does the NZSC categorise soils?

The NZSC uses a hierarchical structure (i.e. graded or ranked) with five levels:

NZSC level		**Level description**
1	Order	The 15 soil orders are the highest and most generalised level of the NZSC. It provides a national overview of New Zealand soils.
2	Group	The soil orders are subdivided into 74 soil groups based on factors such as drainage status, parent material, chemical and physical properties.
3	Subgroup	The soil groups are subdivided into 299 subgroups – this level provides more detail about the range of soils in each soil group.
4	Family	The subgroups are subdivided into families – this level provides further detail about the soil parent materials, rock class, texture and water holding capacity.
5	Sibling	The families are subdivided into this lowest and most specific level. It provides further detail about soil depth, stone content, upper and lower textures, and drainage.

This classification system is used for a range of activities including soil identification, producing soil maps, searching soil databases as well as planning land management in New Zealand.

For more information about the NZSC go to Landcare Research Manaaki Whenua:

https://soils.landcareresearch.co.nz/describing-soils

Te Ara – The Encyclopedia of New Zealand also has useful information about soils that will help you complete the activities below:

https://teara.govt.nz/en/soils

Check your understanding of the NZSC by writing down what each of the following eight soil orders can be used for. You can discuss the list with your Supervisor and refer to the NZSC or Te Ara – The Encyclopedia of New Zealand.

The first one has been completed for you, to show you what to do. Check your answers at the back of this Learner Guide.

Oxidic soils can be productive when well-managed such as in Bay of Plenty orchards.

Podzol soils

Pumice soils

Pallic soils

Brown soils

Allophanic soils

Melanic soils

Organic soils

Now pick two of the soil types that were in the above NZSC list, and do some research on them.

For each soil type, make sure you can answer all the questions listed below. You can discuss your findings with your Supervisor and ask them to check your answers.

Soil type 1

Name the soil type:

Name a place in New Zealand where would you find this soil type:

How was this soil formed?

What is main parent material of this soil?

What are the drainage properties of this soil?

What is the structure of this soil?

What is the texture of this soil?

Does this soil have nutrient deficiencies?

What nutrients are deficient in this soil?

What potential is there for plant growth in this soil?

Soil type 2

Name the soil type:

Name a place in New Zealand where would you find this soil type:

How was this soil formed?

What is main parent material of this soil?

What are the drainage properties of this soil?

What is the structure of this soil?

What is the texture of this soil?

Does this soil have nutrient deficiencies?

What nutrients are deficient in this soil?

What potential is there for plant growth in this soil?

?

What surprised you about the two soil types you chose? What did you like or dislike about researching their characteristics?

What else will the NZSC tell me?

The New Zealand Soil Classification will also give you information about how to manage land in a **sustainable** way by covering the following topics:

- soil acidity
- organic matter, gravel, clay and silt content
- toxicity
- the effect of phosphate retention on nutrient levels and availability to plants
- suitability of soil for the intended use.

How will the system help me work with soil?

Use the classification system to help you work out how to effectively manage and get the best out of soils. Use it to research the drainage, irrigation and fertiliser systems best suited to particular soils and particular crops in your industry.

What is a soil profile?

A soil profile is a rough cross-section or sample of soil created by digging a hole, removing the soil to leave an empty hole and exposing the various layers (e.g., the soil horizons) that make up a particular soil. Refer to the earlier section 'What are soil horizons?'.

Analysing a soil profile will give you information about the component particles, structure, health and texture of a soil.

Ask your Supervisor to help you dig a hole, measuring 60 cm deep by 60 cm wide. As you dig the hole, look at the different colours and shapes in the soil. Look for roots. Note the size and amount of stones. Look for worms, other small animals and insects.

Once your hole has been dug and the soil removed, look at the soil profile. Try to identify any obvious soil horizons (O, A, B and C) – as you did in the exercise in the earlier section 'What are soil horizons?'.

Fertilisers and plant health

In this section you will learn about specific nutrients and soil pH, fertilisers and lime, and the tests that can help you improve plant health and growth.

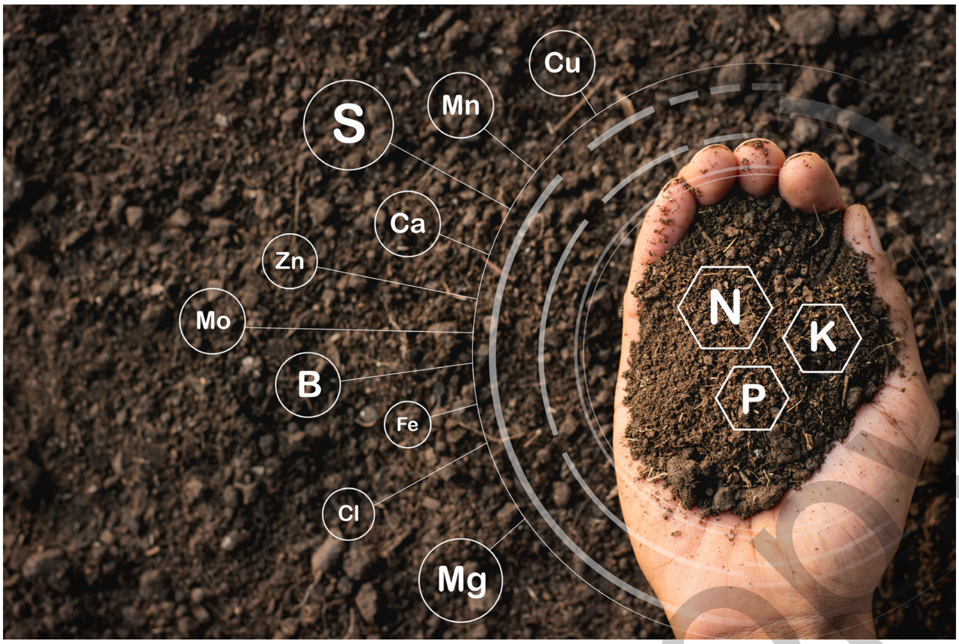
What nutrients do plants need?

Most plants need a range of about 16 nutrients (essential elements) to survive and remain healthy. Plant nutrients fall into two main categories:

- macronutrients (needed by the plant in large amounts)
- micronutrients (needed in very small amounts).

The macronutrients and micronutrients that plants need include:

Macronutrients		Micronutrients	
Element	Symbol	Element	Symbol
Carbon	C	Boron	B
Hydrogen	H	Chlorine	Cl
Oxygen	O	Copper	Cu
Nitrogen	N	Iron	Fe
Phosphorus	P	Manganese	Mn
Potassium	K	Molybdenum	Mo
Calcium	Ca	Zinc	Zn
Magnesium	Mg		
Sulphur	S		



Essential soil nutrients needed by plants

> Which three macronutrients are missing from the image above? Discuss this with your supervisor.

What are the benefits of using fertilisers?

Plants get just three of their essential nutrients directly from the air – carbon (C), hydrogen (H) and oxygen (O). They rely on the soil to provide all others.

Fertilisers add nutrients to soil and can improve soils made nutrient deficient (not enough) by crop and animal harvesting. They are broadly divided into two main categories – organic fertilisers (composed of enriched organic matter from a plant or animal) and inorganic fertilisers (composed of synthetic chemicals or minerals).

Fertilisers help plants by improving their resistance to pests and diseases and helping them grow more quickly. However, it is important to remember using fertilisers incorrectly can damage or destroy your plants. Always check with your Supervisor about how to select the right fertiliser and apply it correctly.

Using the Internet, find out how the following fertilisers help plants to grow:

- calcium
- magnesium
- nitrogen
- phosphate
- potassium.

What is lime used for?

Lime (calcium carbonate) is used to improve an acidic soil (soil with a low pH) in the following ways:

- Correcting soil acidity through raising pH levels, due to lime's carbonate properties.
- Providing important plant nutrients (calcium and magnesium) in less acidic soil.
- Reducing the toxicity (poisonous effects) of certain elements in the soil such as aluminium, manganese and iron.
- Increasing the availability of major plant nutrients.
- Increasing bacterial activity, which encourages favourable soil conditions.
- Improving soil structure by helping the soil to become more **porous** (able to absorb liquid) and hold moisture.

A horticulture worker applies fertiliser (blood and bone) to the soil using an application style called side dressing to distribute the fertiliser evenly.

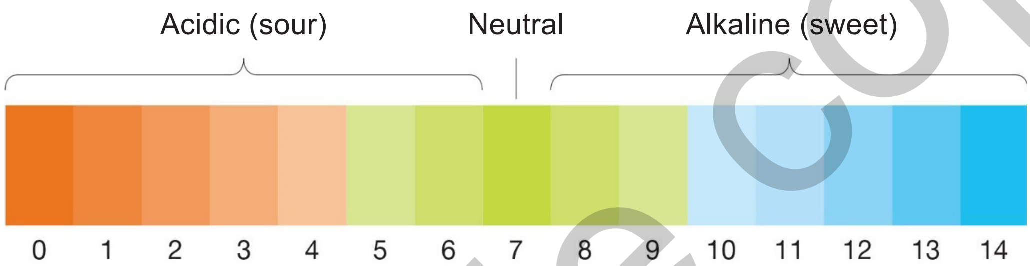
> **!** Always wear gloves when applying fertiliser – some can burn the skin.

What is soil pH and how can it be changed?

The pH scale measures an important aspect of soil chemistry – soil acidity and alkalinity. The scale runs from 0 to 14 with 0 being the most acidic, 7 neutral and 14 the most alkaline.

Acidity and alkalinity (the soil pH) affect plant growth by making plant nutrients available or by locking them away.

The pH scale is **logarithmic**, which means that a soil of pH 5 is 10 times more acid than one of pH 6. The ideal pH range for most plants is 5.5 to 7.5. However, acid-loving plants struggle with a pH above 6.



Soil pH scale, used to measure soil acidity and alkalinity.
Credit: Synapsys. Source: Synapsys.

How soil pH is corrected?

Correcting soil pH takes time and care. A good first step is to find out what pH level best suits the plants you are working with.

For example, plants that thrive in acidic soil include azaleas, blueberries, hydrangeas, rhododendrons and many types of evergreens. Plants that need alkaline soil are most vegetables and fruits.

Acidic to alkaline soil

There are two main ways to make a soil more alkaline.

1. Adjust your soil with lime.
    - You can get lime in several forms, including pulverized lime (ground into a fine powder), granular limestone and hydrated limestone.
    - Spread the lime using a manure spreader or lawn seeder. Be careful

using hydrated limestone, it may harm your plants by increasing the pH level too quickly.

2. Adjust your soil with wood ashes. Wood ashes hold small amounts of minerals and nutrients that will help you make a soil more alkaline. Spread wood ashes over the soil in winter and dig them into the soil in spring. Avoid using too many wood ashes because you may end up reducing the nutrients in the soil.

Alkaline to acidic soil

Soils typically get more acidic over time through rainfall and leaching (loss of chemicals or minerals draining from the soil), and fixing an alkaline soil is a less common problem than fixing an acidic soil. Adding aluminium sulphate or sulphur to a soil will lower its pH. Take care using both aluminium sulphate and sulphur. Both can burn plants if they come into direct contact with them. Compost and manures can also lower a soil's pH, but at a slower rate.

Check your understanding of fertilisers by answering the following questions. An example answer has been provided to help you get started. Check your answers at the back of this Learner Guide.

1. List five major macronutrients and what are they used for. You will have to do some extra research to find out why the plants need these macronutrients and what they do.

Example answer: (K) potassium is necessary for a plant's metabolic processes and growth regulation. Plants need potassium for protein synthesis and for the opening and closing of stomata. Potassium also helps plants with photosynthesis.

Macronutrient 1:

Macronutrient 2:

Macronutrient 3:

Macronutrient 4:

Macronutrient 5:

2. List three major micronutrients and what are they used for. You will have to do some extra research to find out why the plants need these micronutrients and what they do.

Micronutrient 1:

Micronutrient 2:

Micronutrient 3:

3. What is meant by an alkaline soil?

4. What is meant by an acidic soil?

5. What is the best soil pH for growing plants and why?

Why test for nutrient and soil pH levels?

Nutrient deficiency and **nutrient toxicity**, as well as incorrect soil pH levels, can all cause plants to grow poorly and produce unhealthy crops.

It is important to test for nutrient and soil pH levels to see if the levels are correct, otherwise the plant may not have enough nutrients (i.e. deficiency) or too many nutrients (i.e. toxicity), or a plant may have enough nutrients to look healthy but it may not be growing to its full potential.

There are three tools that measure nutrient status and soil pH. The following tools will help you to use fertilisers accurately and sustainably:

1. leaf analysis
2. soil testing
3. visual observation.

What is leaf analysis and soil testing?

Leaf analysis

Using plant tissue samples (e.g. a leaf) to confirm the nutrient status of a plant, and the soil it lives in, is called **leaf analysis**.

A leaf analysis is performed in a laboratory to check whether a plant has a sufficient supply of essential nutrients and evaluates if fertiliser programmes are effective. It commonly tests the plant tissue for the following nutrients:

Nutrient category	Nutrients
Macronutrients	Calcium, Magnesium, Nitrogen, Phosphorus, Potassium, Sulphur
Micronutrients	Boron, Copper, Iron, Manganese, Zinc

There are different types of leaf analysis. Here are some common types:

Type	Setting	Nutrients
Basic plant analysis	Horticultural and arable crops	Calcium, Magnesium, Nitrogen, Phosphorus, Potassium, Sulphur, Boron, Copper, Iron, Manganese, Zinc
Standard pasture analysis	Pastoral	Basic plant analysis + Molybdenum
Brassica/legume analysis	Pastoral, Horticulture	Basic plant analysis + Molybdenum

Soil testing

Using soil samples to confirm the nutrient status of soil and its soil pH levels is called **soil testing**.

A soil test, also performed in a laboratory, is often used to check whether soil has a balanced nutrient status. It commonly tests the soil sample for the following nutrients:

Nutrient category	Nutrients
Macronutrients	Calcium, Magnesium, Nitrogen, Phosphorus, Potassium, Sulphur
Micronutrients	Boron, Chlorine, Copper, Iron, Manganese, Molybdenum, Zinc

There are also different types of soil tests. Each test helps confirm the soil nutrient status and soil pH against how plants are used in a particular setting. Common types of soil tests are:

Type	Setting	Macronutrients (including soil pH)
Basic soil analysis	Horticulture (if sulphate analysis not required)	Calcium, Magnesium, Phosphorus, Potassium
Pastoral soil analysis	Pastoral, Cropping, Horticulture	Basic soil analysis + Sulphur
Cropping soil analysis	Pastoral, Cropping, Horticulture	Pasture soil analysis + Nitrogen

Soil testing by itself does not tell you if plants have all the nutrients they need, and if these nutrients are in the correct proportions. You should use both soil testing and leaf analysis to get the most accurate picture of a plant crop. This will help you to make decisions on what fertilisers to use and how much.

Check your understanding of soil testing and leaf analysis by ticking a box in the questions below. Check your answers at the back of this Learner Guide.

4. Standard pasture analysis helps determine a plant has a balanced supply of:

   ☐ micronutrients

   ☐ nutrients tested in a basic plant analysis, and molybdenum

   ☐ magnesium, phosphorus and nitrogen

   ☐ molybdenum, phosphorus and nitrogen.

5. Cropping soil analysis helps determine if a soil sample has a balanced supply of:

☐ calcium, magnesium and potassium

☐ nitrogen

☐ calcium, magnesium, phosphorus, potassium, sulphur and nitrogen

☐ magnesium and sulphur.

How does visual observation work?

Looking at the growth of plants to check their nutrient status is called visual observation. This can be done in a field to check if a plant is showing unusual symptoms that point to either nutrient deficiencies or toxicities.

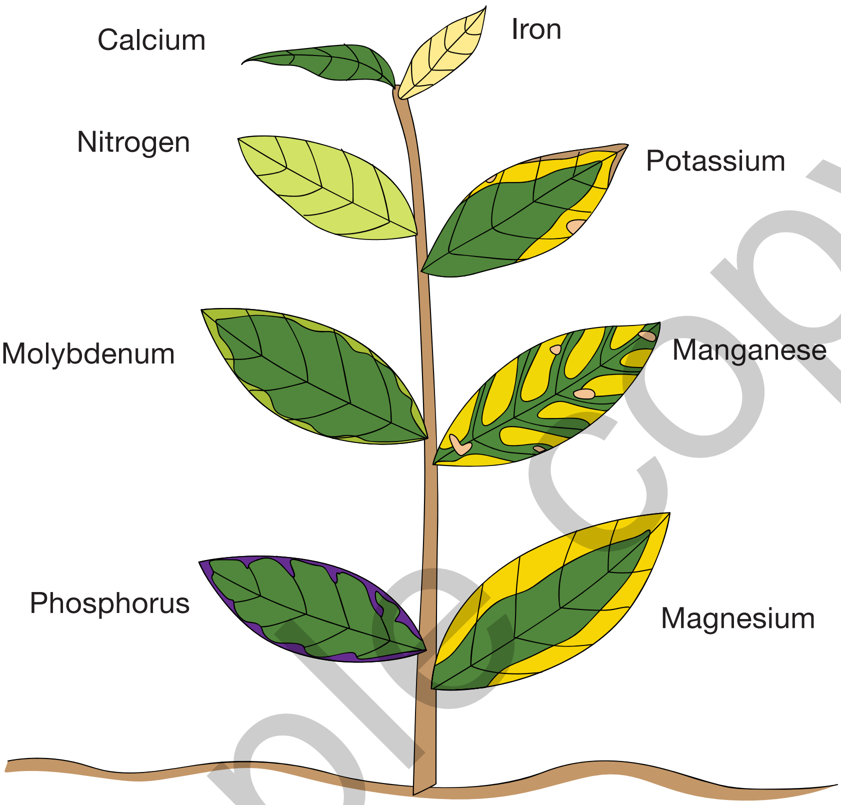
> **!** Using visual observation to quickly check for nutrient deficiency or toxicity can be difficult, as many symptoms can appear similar, and plant species change in the way they show symptoms. Also, plants may be unhealthy without even showing external symptoms - an example being 'brown heart' disease inside brassica. Soil testing or leaf analysis is needed to either confirm nutrient deficiencies and toxicities, or to stop these from happening in the first place.

Nutrient deficiency

Common symptoms in a plant of nutrient deficiency in soil can include:

- Distorted leaves, e.g. stunted growth, a common symptom for many deficient nutrients due to their different roles in helping plants grow.
- **Chlorosis**, a yellowing of plant tissue and found in plants deficient in nutrients needed for photosynthesis and **chlorophyll**.
- A purplish-red discolouring of plant tissue, common when plant functions are stressed due to a lack of the macronutrient phosphorus.
- **Necrosis**, a blackening of plant tissue which happens in later stages of nutrient deficiency, and causes the parts of a plant first affected to die.

Which of these symptoms of nutrient deficiency did you already know about? How can you link a deficiency symptom with a nutrient?



A guide to nutrient deficiency in a plant

There are many online tools that can help you to when checking for nutrient deficiencies. Search under 'plant nutrient deficiency guide' to find out how to identify visible symptoms in your field of interest.

Check your understanding of visual observation by writing down the nutrient that could be deficient in a plant. Think about if the symptom is in new leaves, old leaves or both. You can discuss the list with your Supervisor and refer to online tools.

Three nutrients have been identified for you to show you what to do. Check your answers at the back of this Learner Guide.

Symptom		New leaves	Old leaves	Both old and new leaves
Necrosis	Leaf edges scorched	Calcium		
	Dead blotches			
Chlorosis (yellowing)	All over		Nitrogen	
	Blotchy			
	Between veins			
Purplish-reddening				
Distorted leaves	Curled over			Magnesium
	Curled under, wilted			
	Small, stunted			
	Irregularly shaped			

Nutrient toxicity

High levels of a nutrient in a soil can cause nutrient toxicity in a plant. This can stop a plant from being able to take enough of another essential soil nutrient, which in turn leads to nutrient deficiency symptoms (described above) in the plant.

Relationship between nutrient toxicity and nutrient deficiency

The relationship between a visible symptom of a deficient nutrient (e.g. yellowing of leaves caused by a lack of nitrogen) and a possible toxic nutrient (e.g. too much chlorine) causing this visible deficiency is outlined below:

Visibly deficient nutrient	Toxic nutrients causing visible deficiency
Nitrogen	Chlorine
Potassium	Nitrogen, Calcium, Magnesium
Calcium	Magnesium, Potassium
Magnesium	Potassium, Calcium
Sulphur	Chlorine
Boron	Calcium
Copper	Phosphorus, Molybdenum
Iron	Phosphorus, Manganese, Molybdenum, Nitrogen, Zinc
Manganese	Phosphorus, Iron
Zinc	Phosphorus

Looking at the two tables above, how confident are you in describing which two nutrients may be causing a plant's old and new leaves to curl over and change shape?

Clue: Plants need magnesium to prevent their leaves from curling over.

Ask your Supervisor to show you a plant that is showing symptoms of nutrient deficiency.

- Look at the leaves – are they yellowing, purpling, browning, or distorting?
- Are the symptoms on older leaves, newer leaves, or both?

Discuss the possible nutrient deficiencies and toxicities with your Supervisor.

Glossary

Term	Definition
Aeolian deposits	Deposits made by the wind.
Aeration	The introduction of air into soil.
Brassica	A plant belonging to the plant category that includes broccoli, cabbage and cauliflower.
Chlorophyll	A green pigment found in all green plants and involved in photosynthesis.
Chlorosis	Yellowing of leaf tissue due to lack of chlorophyll.
Compounds	A mixture, something that is made of two or more elements.
Erosion	The process of gradual destruction by wind, water, or other natural means.
Humus	Dark earth made of organic material such as decomposed leaves and plants.
Ions	A positively or negatively charged atom or group of atoms.
Leaching	Loss of chemicals or minerals draining from the soil.
Leaf analysis	Using a plant tissue sample to confirm nutrient status by testing its nutrient content.
Legume	A plant belonging to the plant category that includes beans, lentils and peas. A key feature of all legumes is their ability to fix nitrogen.

Loam soil	An ideal soil featuring a mix of sand, silt and clay.
Logarithmic	Describing a mathematical relationship which compare things (e.g. soil pH) that can vary dramatically in scale.
Mineral particles	Grains such as sand, silt and clay from the original rocks and new minerals that formed the soil.
Necrosis	Darkening and wilting of leaf tissue due to cell death.
Nitrogen	An essential nutrient needed by plants to produce protein so that they can grow.
Nutrients	The chemicals that plants need to live.
Nutrient deficiency	A nutrient is not available in sufficient quantity to meet the needs of a growing plant.
Nutrient toxicity	A nutrient is in excess of a plant's needs and decreases the plant's growth. Can lead to nutrient deficiency.
Organic matter	Living soil organisms, plant roots, manure, compost, dead and decomposing animals, insects, leaves, stems, sawdust and many other substances.
Osmosis	The movement of water from the soil into the root and across the root cells to the plant's water and nutrient carrying vessels (xylem).
Particles	A tiny piece of matter.
Percolation	The movement of a liquid through a filtering medium. In this situation water percolates through the soil.

Photosynthesis Process in which green plants absorb sunlight and then turn that energy into sugars to help build themselves.

Pore space Space in the soil filled by air and water. Pore space takes up about half the volume in fertile soil.

Porous Something that has many small holes in it, which water and air can pass through.

Retain Absorb and hold moisture.

Secondary particles Mineral particles that are grouped together to form soil aggregates.

Soil pH The measure of the acidity or alkalinity of the soil.

Soil testing Using a soil sample to confirm nutrient status by testing its soil pH levels and nutrient content.

Structure The arrangement of the particles.

Sustainable Able to be maintained or kept going.

Texture The size and shape of the particles.

Transpiration The loss of water from leaves through evaporation causing the plant's stems to suck up water.

Water table The level at which subsoil remains constantly saturated with ground water throughout the year.

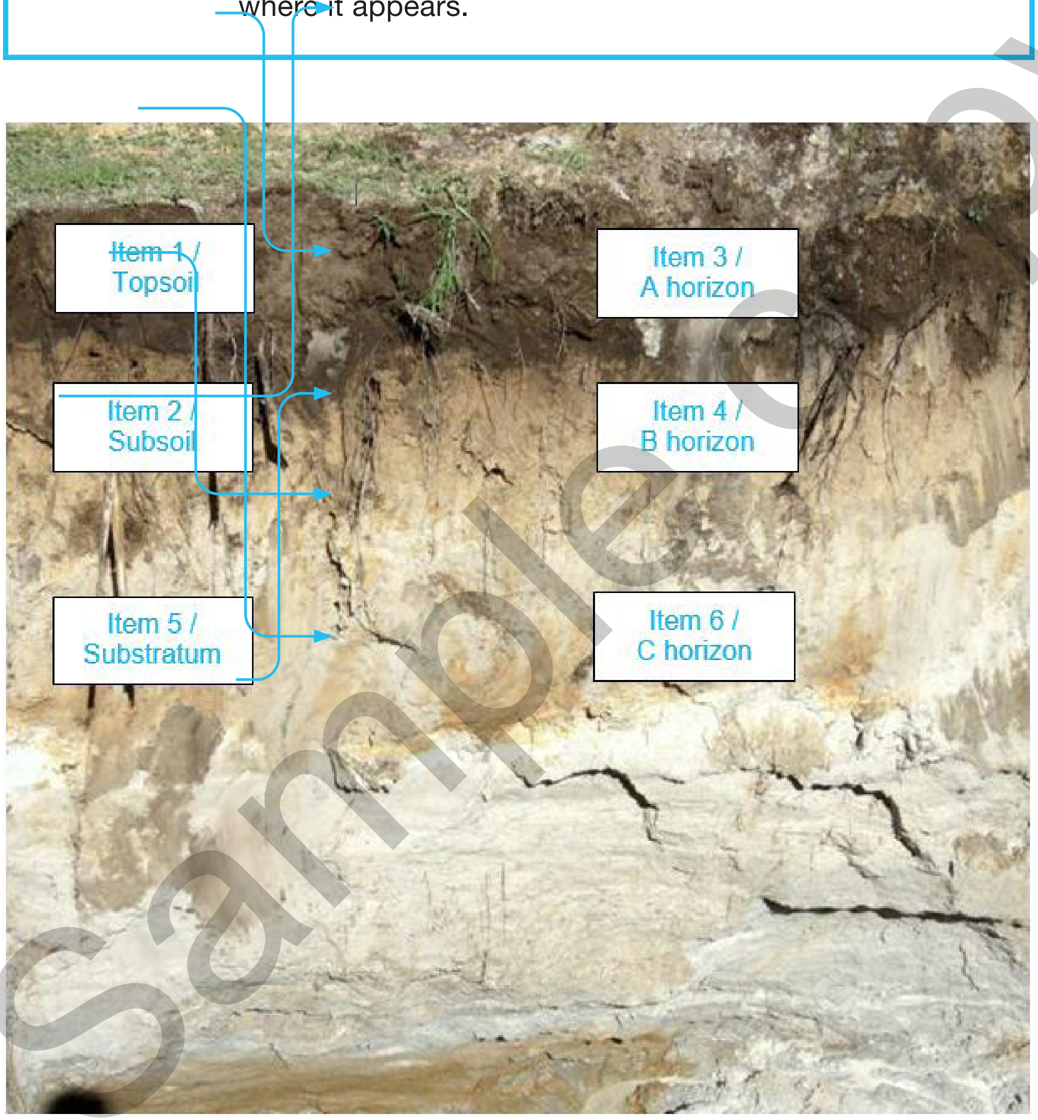
More information

What	Where to go
Environmental Protection Authority Te Mana Rauhī Taiao	www.epa.govt.nz
International Society of Arboriculture	www.isa-arbor.com
Landcare Research Manaaki Whenua	www.landcareresearch.co.nz
Ministry for the Environment Manatū Mō Te Taiao	www.mfe.govt.nz
Primary ITO Rōpū Whakangungu Ahuwhenua Ahumahi	www.primaryito.ac.nz
Resource Management Act 1991	www.mfe.govt.nz/rma
Responsible Care New Zealand	www.responsiblecarenz.com
Standards New Zealand Paerewa Aotearoa	www.standards.govt.nz
WorkSafe New Zealand Mahi Haumaru Aotearoa	www.worksafe.govt.nz

Activity answers

Check your Activity answers below.

Check your understanding of soil horizons by looking at the photo and labelling the six items listed below on the photo. Label the photo by writing each item on the photo where it appears.



Check your understanding of the influences on plant growth by drawing lines between the soil components on the left with their matching influence on plant growth on the right.

Soil component	Influence on soil make up
Mineral matter	Encourages bacteria to quickly turn organic matter into humus.
Organic matter	Increases plant growth by moving through soil water and into root hairs, and then into the plant through water uptake.
Water	Proportions influence how much water and nutrients the soil can hold, and releases and stores nutrients.
Air	Makes soil more fertile by breaking down nutrients needed for plant growth.
Nutrients	Sits in between soil particles and carries important nutrients to the roots of a plant, and helps with photosynthesis.
Soil microorganisms	Acts as a store for water, improves drainage by allowing more air to pass through soil, and helps to feed microorganisms.

Check your understanding of soil structure by answering the questions below.

Soils with good structure will:

1. Allow rapid drainage of excess water.
2. Let air circulate through the soil.
3. Allow nutrients to flow through the plant.
4. Support seeds to break through the surface layer.

Poorly structured soils can have particles joined together into dense sheets or large clumps and may be:

1. Difficult to dig.
2. Blocking the right amount of water and air from entering the plant roots.
3. Stopping living organisms (e.g. worms) improving the soil.
4. Interfering with the flow of nutrients.

Check your understanding of the NZSC by writing down what each of the following eight soil orders can often be used for. You can discuss the list with your Supervisor and refer to the NZSC or Te Ara – The Encyclopedia of New Zealand.

- Oxidic soils can be productive when well-managed such as in Bay of Plenty orchards.
- Podzol soils are best suited to New Zealand's native forests as they occur in areas of high rainfall and with forest trees with high acidity.
- Pumice soils - used in commercial forestry, and for animal farming now that fertilisers are used.
- Pallic soils - have limited uses, mostly for sheep grazing.
- Brown soils - when fertilised make good land for sheep, beef and dairy farming.
- Allophanic soils - topsoil layers are stable and can handle the impact of machinery or grazing animals in wet weather.
- Melanic soils - high natural fertility and are used to grow high quality red wine.
- Organic soils - act like giant sponges and can hold up to 20 times their weight in water.

Please note: your answers may be slightly different, this is just an example.

Check your understanding of fertilisers by answering the following questions.

Please note: your answers may differ, these are just examples.

1. List five major macronutrients and what are they used for. You will have to do some extra research to find out why the plants need these macronutrients and what they do.

   - **Macronutrient 1:** (K) potassium is necessary for a plant's metabolic processes and growth regulation. Plants need potassium for protein synthesis and for the opening and closing of stomata. Potassium also helps plants with photosynthesis.
   - **Macronutrient 2:** (N) nitrogen is the most critical element to help plants grow protein, which is used to undertake all of a plant's processes, including photosynthesis. Plants with sufficient nitrogen will experience vigorous plant health and development. Nitrogen also gives plants the energy to produce fruit or vegetables.
   - **Macronutrient 3:** (P) phosphorus is essential for cell division and development of the growing tip of a plant, and is vital for seedlings and young plants. Phosphorus helps a plant convert other nutrients into usable building blocks with which to grow,
   - **Macronutrient 4:** (S) sulphur is a vital plant for all plant proteins and certain plant hormones. It acts as a soil conditioner and helps reduce levels of salts in soils. Sulphur encourages the growth of rhizobia bacteria on legumes' roots, so that the bacteria can 'fix' nitrogen for the plant to process.
   - **Macronutrient 5:** (Mg) magnesium is the central atom in the chlorophyll molecule, which gives plants their green colour and carries out the photosynthesis process. Magnesium is also used by plants to process carbohydrates and to stabilise cell membranes.

2. List five major micronutrients and what are they used for. You will have to do some extra research to find out why the plants need these micronutrients and what they do.

   - **Micronutrient 1:** (Cu) copper activates enzymes in plants. It is necessary for photosynthesis and is essential for plant respiration and metabolism. Cooper also intensifies flower colour and vegetable flavour and colour.
   - **Micronutrient 2:** (Zn) zinc activates enzymes in plants. It helps form chlorophyll and some carbohydrates, and helps plants deal with cold temperatures. Zinc is essential to control plant growth and stem length.
   - **Micronutrient 3:** (Mo) molybdenum helps plants process nitrogen and absorb potassium. It increases plant health and growth, and helps stop leaves from turning pale and dying. Molybdenum also helps a plant's flowers form.
   - **Micronutrient 4:** (B) boron is necessary to maintain cell walls of all plants. It is important for production of amino acids, and plants need boron for reproduction, flowering and fruiting. Boron also helps control the transport of sugars in plants.
   - **Micronutrient 5:** (Fe) iron is essential in helping carry important elements through a plant's circulatory system, mostly oxygen. It is also essential for the formation of chlorophyll in leaves, and helps reduce nitrate and sulphate.

3. What is meant by an alkaline soil?

   - Alkaline soils (known as 'sweet' soils) are very common in dry climates where soil salts have not leached away but have accumulated in the B horizon. The base rock is usually limestone. The pH level of alkaline soils is above 7, and contain a lot of sodium, calcium and magnesium. Availability of nutrients is often limited, and stunted growth and lack of chlorophyll in plants is common.

4. What is meant by an acid soil?

   - Acid soils (known as 'sour' soils) are very common in cool moist climates where soil organic matter and minerals have broken down. The pH level of acid soils is below 7. Too much water in the soil may also cause key nutrients like potassium, magnesium and calcium being washed away, so availability of nutrients is often limited, and soil can become more vulnerable to structural damage.

5. What is the best soil pH for growing plants and why?

- The ideal pH range for most plants is 5.5 to 7.5. as this is within a neutral range on a scale of zero to 14. Strongly acid soils (soils that fall below a soil pH of 5.5) due to essential nutrient deficiencies. Strongly alkaline soils (soils that go above a soil pH of 7.5) may stunt plant growth due to high levels of sodium.

Check your understanding of soil testing and leaf analysis by ticking the correct option for each of the following two questions.

1. Standard pasture analysis helps determine a plant has a balanced supply of:

   ☐ micronutrients

   ☑ nutrients tested in a basic plant analysis, and molybdenum

   ☐ magnesium, phosphorus and nitrogen

   ☐ molybdenum, phosphorus and nitrogen.

2. Cropping soil analysis helps determine if a soil sample has a balanced supply of:

   ☐ calcium, magnesium, potassium and zinc

   ☐ nitrogen

   ☑ calcium, magnesium, phosphorus, potassium, sulphur and nitrogen

   ☐ magnesium and sulphur.

Check your understanding of visual observation by writing down the nutrient that could be deficient in a plant, depending if the symptom is in new leaves, old leaves or both. You can discuss the list with your Supervisor and refer to online tools.

Symptom		New leaves	Old leaves	Both old and new leaves
Necrosis	Leaf edges scorched	Calcium	Potassium	Phosphorus
	Dead blotches	Boron	Magnesium	Manganese, Chlorine
Chlorosis (yellowing)	All over	Sulphur, Copper	Nitrogen	
	Blotchy		Molybdenum	Chlorine
	Between veins	Manganese, Iron, Nickel	Potassium	
Purplish-reddening		Boron	Phosphorus	
Distorted leaves	Curled over			Magnesium
	Curled under, wilted			Potassium, Copper
	Small, stunted	Sulphur, Manganese	Zinc	Nitrogen, Potassium
	Irregularly shaped	Calcium, Zinc, Manganese	Boron, Molybdenum	

Please note: your answers may differ, these are just examples.

Resource Feedback

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Please contact us via email **product@primaryito.ac.nz** if you have any suggestions that you feel would be useful.

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