Teacher Guide
Year 7-8

Design and Technologies
Science

Sustainable Food and Fibre Production

Supporting students to learn about Australian agriculture's role in sustainability

Lesson 2
Exploring Soil Chemistry: Nutrients and Soil as a Mixture

This resource has been developed by:
Primary Industries Education Foundation Australia | primezone Food and fibre classroom educational resources.
Nutrien Ag Solutions™

Contents

Learning Areas & Australian Curriculum Content

Design and Technologies

Analyse how people in design and technologies occupations consider ethical and sustainability factors to design and produce products, services and environments **(AC9TDE8K01)**

Analyse the impact of innovation and the development of technologies on designed solutions for global preferred futures **(AC9TDE8K02)**

Analyse how food and fibre are produced in managed environments and how these can become sustainable **(AC9TDE8K04)**

Science

Use a particle model to describe differences between pure substances and mixtures and apply understanding of properties of substances to separate mixtures **(AC9S7U06)**

Examine how proposed scientific responses to contemporary issues may impact on society and explore ethical, environmental, social and economic considerations **(AC9S7H03)**

Classify matter as elements, compounds or mixtures and compare different representations of these, including 2-dimensional and 3-dimensional models, symbols for elements and formulas for molecules and compounds **(AC9S8U06)**

Examine how proposed scientific responses to contemporary issues may impact on society and explore ethical, environmental, social and economic considerations **(AC9S8H03)**

Lesson Objective

Students will gain an understanding of soil chemistry by exploring soil as a mixture, separating its mineral particles, learning about the essential nutrients it contains, and applying soil testing to improve plant yield. A case study will illustrate the real-world application of soil testing.

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Lesson Overview

- **Activity 2.1** - Introduction to Soil (40 mins + 20 mins another day)
- **Activity 2.2** - Soil Chemistry and Nutrients in Soil (30 mins)
- **Activity 2.3** - Case Study: Soil Testing at Nutrien Ag Solutions™ (25 min)

Resources and Equipment

Activity 2.1 - Introduction to Soil

1. **Worksheet 2.1a - Introduction to Soil**
2. Introduction to Soil Part 1 (0:00 - 2:38)
3. What is Soil?
4. **Worksheet 2.1b - Experiment: Soil Texture Analysis**
5. Digital device access
6. Five soil samples (collected before the lesson and adjusted using dry clay, sand, or organic matter/ mulch so that they differ)
7. Clear containers with a tight-fitting lid (one for each group) e.g. specimen or mason jars
8. Water
9. Marker pen
10. Ruler
11. Cleaning materials

Activity 2.2 - Soil Chemistry and Nutrients in Soil

1. Journey 2050: Soil Nutrients (5:04)
2. **Worksheet 2.2a - Nutrients in Soil**
3. **Worksheet 2.2b - Soil Chemistry**
4. **Worksheet 2.2c - Soil Chemistry Crossword**
5. Fao Soil Testing Methods Manual (Pages 36-42)
6. Extension: Soil Samples and Materials For Chosen Soil pH Test

Activity 2.3 - Case Study: Soil Testing at Nutrien Ag Solutions™

1. **Worksheet 2.3a - Case Study: Soil Testing at Nutrien Ag Solutions™**
2. Have you ever wondered what the process is for soil testing? (5:28)
3. Scissors
4. Digital device access

Additional Resources

- Introduction to Soil Part 2 (9:39)
- Educational Posters | Global Soil Partnership | Food and Agriculture Organization of the United Nations

Lesson Guide

Activity 2.1 - Introduction to Soil

Hands-on activities, research, and discussions introduce students to the soil. They will investigate soil's properties, analyse its composition and texture using the water separation method, and engage in critical thinking about its importance in agriculture and the environment.

Note: Schools are responsible for generating their own risk assessments for any practical investigations completed.

a) Before the lesson, collect five soil samples from around the school or other locations and place them into containers. If necessary, soil samples can be adjusted by adding dry clay, sand, or organic matter/mulch so that they differ.

b) Show students one of the containers containing soil. Ask students what it is and generate a discussion with students by asking the following questions:

- What is soil?
- Is soil and dirt the same thing?
- How/why do soils vary?
- What makes soil 'good' for growing food like vegetables?
- Where does soil come from? How is it made?
- Why is soil important to us?

c) Distribute **Worksheet 2.1a - Introduction to Soil** and divide students into groups of two to three. Students use digital devices to access the source materials Introduction to Soil Part 1 (0:00 - 2:38) and What is Soil? to discuss and answer the questions provided. **Answers page 8**

d) Reconvene as a class and observe the five soil samples. Allow students to look, feel, and describe the differences between them.

e) Distribute **Worksheet 2.1b - Experiment: Soil Texture Analysis** and outline the method for observing soil composition and measuring soil texture (the amount of sand, silt, and clay) by separating soil fractions in water.

f) Students join their previous groups and follow the method to separate sand, silt, and clay in one of the five different soil samples.

g) Once the soil samples have been placed somewhere to settle (for 24 hours or until the next lesson), revise the states of matter as a class and discuss whether soils are solids, liquids, gases, or a combination. Revise the differences between pure substances and mixtures and discuss how soil would be classified. **Answers page 8**

h) Observe the containers the following day or lesson, allowing comparisons between groups and their different soil samples. Use a marker pen to draw lines at the levels between the organic matter, sand, silt, and clay particles. Sand, with the largest particle size, will have settled at the bottom, followed by a layer of silt, then clay with an organic matter layer on top (note: organic matter is not included in standard soil textural analysis). Measure the height of each layer using a ruler and the total height of the deposits (clay, sand, and silt).

i) Students complete the results and discussion sections and write a conclusion for the experiment. **Answers page 8**

Activity 2.2 - Soil Chemistry and Nutrients in Soil

Students will engage in a class discussion on soil chemistry, centred on nutrients, exploring their significance and role in plant and animal health. Through video, text, and completing questions and a crossword, students will deepen their understanding of soil chemistry, nutrients, and the importance of soil testing methods in agricultural practices.

a) Generate a class discussion centred on nutrients. Pose questions such as:

- What are nutrients?
- Why do humans/animals need them?
- Do plants need them?
- How do animals and plants obtain nutrients? Etc.

b) Explain that animals, including humans, get their nutrients from the plants and animals they eat. Plants take in nutrients and water from the soil and gases from the air. Nutrients are chemicals that are essential to plants and animals for growth, repair, energy production, and overall health.

c) Introduce the idea that plants form the basis of all the food we eat, as animals also rely on plants for their nutrients. Nutrients cycle through ecosystems and are vital when growing food and fibre for humans and other animals. View the video Journey 2050: Soil Nutrients (5:04) and discuss with students.

d) Distribute **Worksheet 2.2a - Nutrients in Soil.** Students read the information and answer the questions in the spaces provided. Students may use a Periodic table if necessary. **Answers page 8**

e) Read the information on **Worksheet 2.2b - Soil Chemistry** as a class, or independently.

f) Distribute **Worksheet 2.2c - Soil Chemistry Crossword** to students. Students complete the crossword puzzle by recalling relevant information and filling in the answers into the corresponding boxes. **Answers page 8**

Extension: Use a soil testing kit or one of the methods from the link FAO Soil Testing Methods Manual (pages 36-42) to determine the pH of a variety of soil samples, illustrating where indicators of chemical change are used for identifying the presence of particular substances.

- Method 1: Soil pH meter method
- Method 2: Colour cards method
- Method 3: Soil pH test strip
- Method 4: Vinegar and baking soda test

Students write an experimental report in their workbooks. **See page 10** for background information.

Activity 2.3 - Case Study: Soil Testing at Nutrien Ag Solutions™

Students will watch a video focused on the vital service of soil testing and analysis provided by an agribusiness to producers. They will learn the key steps involved in conducting soil tests and develop their skills in organising content into a logical sequence.

a) Display **Worksheet 2.3a - Case Study: Soil Testing at Nutrien Ag Solutions** in a central area or distribute it to students. Begin with a discussion on the four focused questions regarding soil sampling and analysis. Record students' responses to facilitate a post-video review.

b) Allocate students into groups and provide them with access to [Have you ever wondered what the process is for soil testing?] (5:28). Instruct students to take detailed notes on the video, paying special attention to the sequence of steps in sampling, testing, and analysing soil samples.

c) At the end of the video, students sequence the soil processing and analysis steps by cutting out the slips of paper on page 2 of their worksheet, placing them in the correct order and recording the step number in the spaces provided. **Answers page 8**

d) As a concluding activity, review the four questions from page 1 of **Worksheet 2.3a - Case Study: Soil Testing at Nutrien Ag Solutions** to determine if students are able to answer the questions in greater detail. Highlight that agribusiness services, such as the Nutrien soil testing, are crucial for productive and sustainable farming systems.

Answers

Activity 2.1 - Introduction to Soil

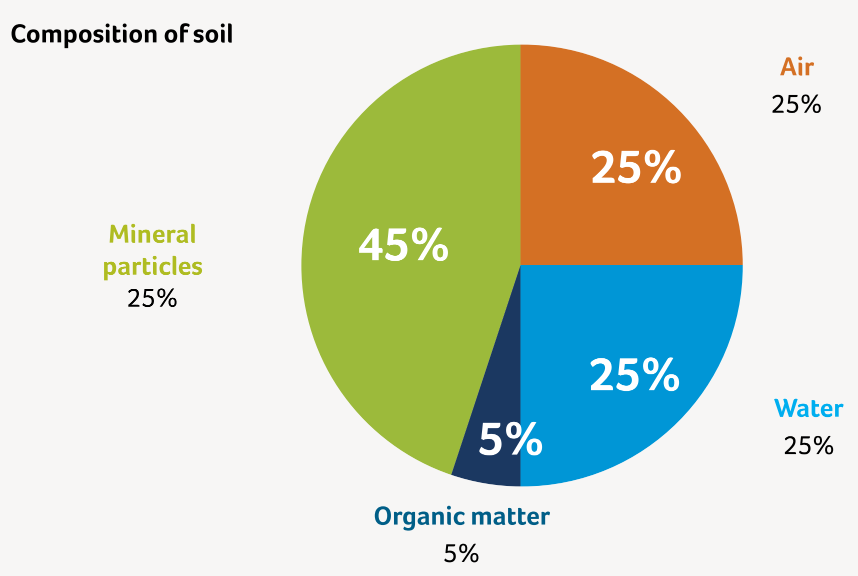
g) Pure substances have a fixed composition and consist of only one type of substance throughout, exhibiting constant physical and chemical properties. Mixtures are composed of two or more substances physically combined, each retaining its own properties, and can be separated into their individual components by physical means.

Soil is considered a mixture rather than a pure substance. It consists of a combination of mineral particles, organic matter, water, air, and living organisms. These components are not chemically bonded together in fixed proportions. Soils vary widely in their composition depending on location, climate, and land use.

Soil exhibits properties of a mixture, and can be separated into its individual components through physical means such as filtration or sieving.

Activity 2.1a - Introduction to Soil

1. Dirt is displaced soil. It has previously been soil and has been moved. Whereas soils are complex **mixtures** of minerals, water, air, organic matter, and countless organisms that together support life on Earth.
2. Producers define soil as a medium for plant growth. It supports roots by providing nutrients and water.
3. Composition of soil



4. **i)** Carbon sequestration, water purification, flood regulation, nutrient cycling, habitat for organisms, provision of food, fibre and fuel, cultural heritage, climate regulation, provision of construction materials, source of pharmaceutical and genetic resources and foundation for human infrastructure.

   ii) A range of responses may be given based on the students' discussion.

5. Soil is a combination of solid, liquid, and gas. It is primarily a solid material but also contains amounts of liquid and gas within its structure. Approximately 50% is solid, 25% is liquid, and 25% is gas.

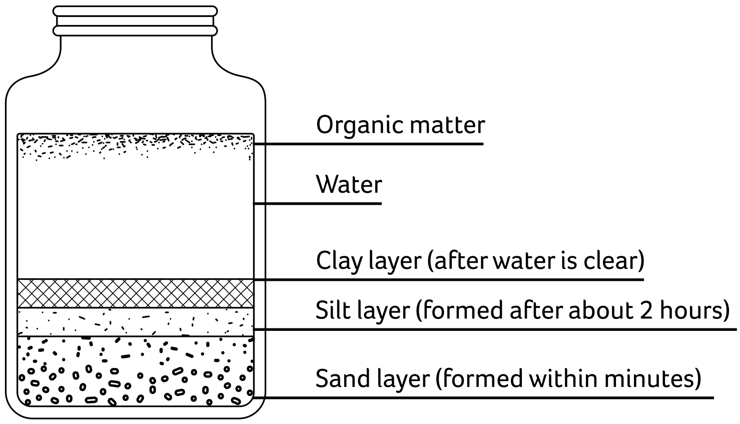
6. Soil is considered a mixture rather than a pure substance. It consists of a combination of mineral particles, organic matter, water, air, and living organisms. These components are not chemically bonded together in fixed proportions (they are not pure substances or compounds) and can vary widely in composition depending on factors like location, climate, and land use.

   Soil exhibits properties of a mixture, and can be separated into its individual components through physical means such as filtration or sieving.

Worksheet 2.1b - Experiment: Soil Texture Analysis

Results:

Students' scientific diagrams will vary depending on the soil sample chosen. Diagrams should be drawn to scale, and labelled. See example below.



Discussion:

1. The sand particles are the most dense and the organic matter is the least dense. The density of the particle will determine how well it floats. The less dense particles will sit further up in the water (or possibly float in the case of organic matter) than the more dense particles which will sink more quickly and will collect on the bottom layer (e.g. sand).
2. Student answers will vary due to their differing soil samples.
3. The proportions of the particles are not likely to be the same if they were collected from different areas. Soils differ depending on their location and the plants growing there. E.g. vegetable patch soil would likely be different from soil under a native tree.
4. Alternative methods include using a series of sieves with different mesh sizes to separate each type of particle based on size.

Conclusion:

Student answers will vary.

Organic matter, sand, silt, and clay was able to be separated and the composition of a soil sample was able to be determined.

Activity 2.2 - Soil Chemistry and Nutrients in Soil

Worksheet 2.2a - Nutrients in Soil

1. Nitrogen **N**
   Phosphorus **P**
   Potassium **K**
2. Calcium **Ca**
   Magnesium **Mg**
   Sulfur **S**
   Manganese **Mn**
   Zinc **Zn**
   Copper **Cu**
   Boron **B**
   Molybdenum **Mo**
3. The size of the chemical symbols correlate with their typical abundance or amounts in the soil. The larger symbols represent the macronutrients. These are required by plants in relatively large quantities and include: nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S). Micronutrients (also known as trace elements) are required by plants in smaller quantities but are equally important for their growth and health. Micronutrients include the remaining nutrients.

Worksheet 2.2c - Soil Chemistry Crossword

1. Soil chemistry
2. Nitrogen
3. Toxicity
4. Deficiency
5. Aluminium
6. Fertiliser
7. Nutrient
8. Legumes
9. pH
10. Efficiency

Extension background information:

The pH of soil can be tested to see how acidic or alkaline it is. Soil pH is important to determine because it impacts plant growth by influencing the nutrients available to plants, the microorganisms in the soil, and root health. The optimal pH for Australian soils varies depending on the specific soil type, climate, and crops grown in different regions. However, in general, for most agricultural crops the optimal pH range is between 6 and 7 (slightly acidic to neutral). When soil pH conditions are optimal, they support efficient nutrient uptake and allow microorganisms to thrive, which is important for soil health. However, when pH levels are too high or too low, they can lead to nutrient deficiencies, toxicities, and soil problems. These issues can have a direct and significant impact on crop productivity and health.

Soil testing allows farmers to assess the pH of their soil and take corrective measures if necessary, such as applying lime (calcium carbonate) or dolomite (calcium carbonate and magnesium carbonate) to raise pH, or sulfur to lower pH. Maintaining the optimal pH level ensures that plants have access to essential nutrients for healthy growth.

Activity 2.2 - Case Study: Soil Testing at Nutrien Ag Solutions™

Worksheet 2.3a - Case Study: Soil Testing at Nutrien Ag Solutions

Step 1 A universal soil probe is used to obtain samples (10 cm at a time), which are then collected into a bowl, bagged, scanned, GPS-located via an app, and sent to a lab by post for analysis.

Step 2 The lab supervisor obtains the samples (soil or plant) for testing and analysis. The samples are organised and dried overnight at 60 degrees Celsius.

Step 3 The dried samples are then placed in the grinder before being bagged and sent to the Prep Lab for weighing. After weighing the samples, they are bottled and placed into tumble trays (100 samples per tray).

Step 4 Tumble tray samples are strapped in and tumbled for approximately one hour. They are then transferred to test tubes, where they are clarified by centrifuging for 10 minutes.

Step 5 After centrifuging, the clear samples are taken to the instrument room and placed in an ICP machine for one minute per test tube.

Step 6 After this step, the samples are reviewed, and the results of the sample are determined.

Step 7 Sample results are uploaded to a database and forwarded to agronomists for recommendations.

References

- FAO/GSP. (2020). Soil testing methods manual. In openknowledge.fao.org. FAO ; **https://openknowledge.fao.org/items/08f3bf38-5df7-4c79-b78b-a8a910824969**
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- The Science Basement. (2015a). Introduction to Soil part 1. In YouTube. **https://www.youtube.com/watch?v=p166fVxwyuY**
- The Science Basement. (2015b). Introduction to Soil part 2. In YouTube. **https://www.youtube.com/watch?v=uimJY25uMR8**

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Nutrien Ag Solutions™

Student Activities
Year 7-8

Design and Technologies
Science

Sustainable Food and Fibre Production

Supporting students to learn about Australian agriculture's role in sustainability

Lesson 2
Exploring Soil Chemistry Nutrients and Soil as a Mixture

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Introduction to Soil

Access the links to view the source materials and answer the questions in the space provided.

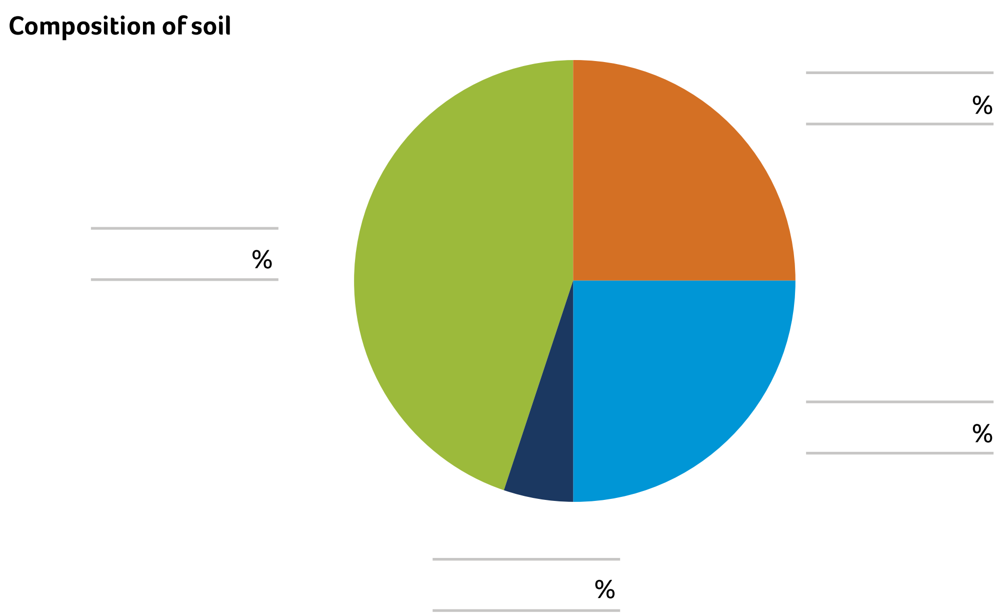
Introduction to Soil Part 1 (0:00 - 2:38)
https://www.youtube.com/watch?v=p166fVxwyuY

What is Soil?
https://openknowledge.fao.org/server/api/core/bitstreams/ce4e2f14-ebcb-4b1a-a54b-861f7e1bb30c/content

1. Outline the difference between soil and dirt.

2. How do producers or people involved in agriculture define soil?

3. Complete the pie chart to show the average composition of soil. Write the name and percentage of each component.



4. i) List the reasons why soil is important to humans and essential for life.
   ii) Discuss in your group and number them (1-11) from the most important to the least important.

5. Is soil a solid, liquid, gas, or a combination of these? Explain your answer.

6. Is soil a mixture or a pure substance? Explain your answer.

Experiment: Soil Texture Analysis

Soil is a mixture of a number of different particles. Use this experiment to determine the amount of each type of particle in your soil sample - this is called soil texture analysis.

Aim

To determine the composition of soil by separating the solid particles using water.

Method

Note: A risk assessment must be carried out before conducting this investigation.

1. Select a soil sample and an empty container with a tight-fitting lid.
2. Fill the container with soil up to one-fifth (1/5) of its capacity.
3. Add water to the jar until it nearly reaches the top, leaving a small airspace.
4. Screw the lid on tightly.
5. Vigorously shake the container for approximately two minutes to thoroughly mix the soil and water.
6. Leave the container to **stand undisturbed for at least 24 hours.**
7. Wipe down surfaces and wash hands using soap and water.
8. After 24 hours, observe the layers formed in the container.
9. Use a marker pen to draw lines at the levels between the organic matter, clay, silt and sand particles. (Sand, with the largest particle size, should have settled at the bottom, followed by a layer of silt, then clay with an organic matter layer on top.)
10. Measure the height of each layer using a ruler and the total height of the layers (clay, sand, and silt).

Results

Draw a scaled, labelled scientific diagram of the jar and its contents after standing for at least 24 hours. Label the container, organic matter, water, clay, silt, and sand layers.

Discussion

1. Which particles are the most dense (the heaviest) and which are the least dense (the lightest)? How did you determine this?

2. The proportions of sand, silt, and clay in the sample can be estimated by measuring the thickness of each layer formed after settling using a ruler. List the layers in your sample that had the greatest volume (thickest layer) to those with the lowest volume (thinnest layer).

3. Compare your group's results with another. Are the proportions of sand, silt, and clay the same? Why do you think this is the case?

4. Can you suggest any alternative methods for separating the components of soil and determining soil texture?

Conclusion

Nutrients in Soil

Animals, including humans, get their nutrients from the plants and animals they eat. Plants take in nutrients from the soil and gases from the air. Nutrients are essential to plants and animals for growth, repair, energy production, and overall health.

Plants need 17 essential nutrients to grow well.

- Nutrients, particularly **nitrogen, phosphorus,** and **potassium**, are essential for photosynthesis; the process by which plants convert sunlight into glucose (a sugar) to fuel their growth.

$$\text{Carbon dioxide + Water} \xrightarrow{\text{Light energy}} \text{Glucose + Oxygen}$$

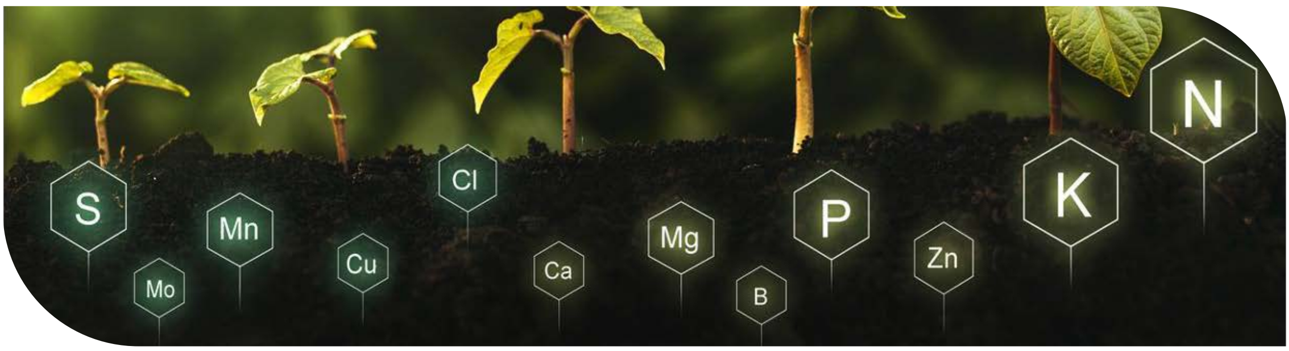
- Nutrients, especially **phosphorus**, are crucial for healthy root development, enabling plants to absorb water and essential minerals from the soil.
- Nutrients, such as **potassium**, contribute to plant defences against diseases, pests, and environmental stresses by strengthening cell walls and aiding the movement of nutrients and water within the plant to where they're needed most.

1. Write the chemical symbol for

Nitrogen	Phosphorus	Potassium

2. List the chemical symbol and name of the other elements shown in the image below.

3. Why do you think some chemical symbols for nutrients are shown larger than others?



12 essential elements for plants (Iron, chlorine, nickel, cobalt and silicon are not shown).

Soil Chemistry

Soil chemistry refers to the various chemical characteristics of soil, including nutrient levels, pH levels (indicating soil acidity or alkalinity), organic matter content, and other chemical properties. These chemical characteristics of soil play a crucial role in influencing plant growth, crop yield, and animal health and productivity, affecting the production of food and fibre essential for human consumption and use.

Essential nutrients in the soil, including macronutrients (nitrogen, phosphorus, and potassium) and micronutrients (such as iron, zinc, and manganese), are vital for plant growth and development. Adequate soil nutrients support optimal plant growth, flowering, fruiting, and crop yield.

Canola crops

Nitrogen deficiency in tomato plants

Influence of Nutrient Availability on Crop Health

Nutrient deficiencies (when the level of nutrients is too low) or imbalances in soil can significantly affect crop health and productivity.

For example:

- **N** Nitrogen deficiency can lead to stunted growth, yellowing of leaves (chlorosis), and reduced yields.
- **P** Phosphorus deficiency can result in poor root development, delayed maturity, and decreased fruit or seed production.
- **K** Potassium deficiency can cause weak stems, disease susceptibility, and poor fruit quality.

Excessive levels of certain nutrients (when the level is too high) can also cause problems, leading to nutrient imbalances, soil toxicity, and environmental pollution, negatively impacting crop and pasture health and ecosystems.

Soil pH levels also influence nutrient availability. Acidic soils (low pH) often lead to aluminium and manganese toxicity, while alkaline soils (high pH) can result in nutrient deficiencies, such as iron and zinc.

Management Strategies for Optimising Soil Nutrients

- Soil testing and analysis are essential for assessing nutrient levels and pH in the soil and determining fertiliser requirements. Based on soil test results and crop or pasture nutrient requirements, a balanced plan is developed to ensure that crops receive the optimal amounts of nutrients they need.
- Soil amendments, such as organic matter (compost, manure) and mineral fertilisers, can be added to replenish essential nutrients, alter the pH to optimum levels and improve soil fertility.
- Proper timing and placement of nutrients are critical for optimising nutrient uptake and minimising nutrient losses through leaching or runoff. Fertilisers are applied at the appropriate growth stages and close to the plant's root zone.
- Crop rotation, cover cropping, and minimum or no tillage practices can help maintain soil health, suppress weeds, reduce nutrient losses, and enhance nutrient cycling. Some cover crops (legumes) also contribute to nitrogen fixation, reducing the need for synthetic nitrogen fertilisers.
- Sustainable agricultural practices, such as using precision agriculture technologies and integrated nutrient management, aim to optimise nutrient use efficiency, minimise environmental impacts, and promote long-term soil sustainability.

Soil testing is carried out by specialists to analyse nutrient levels and pH and determine fertiliser requirements.

Soil

Fertiliser application

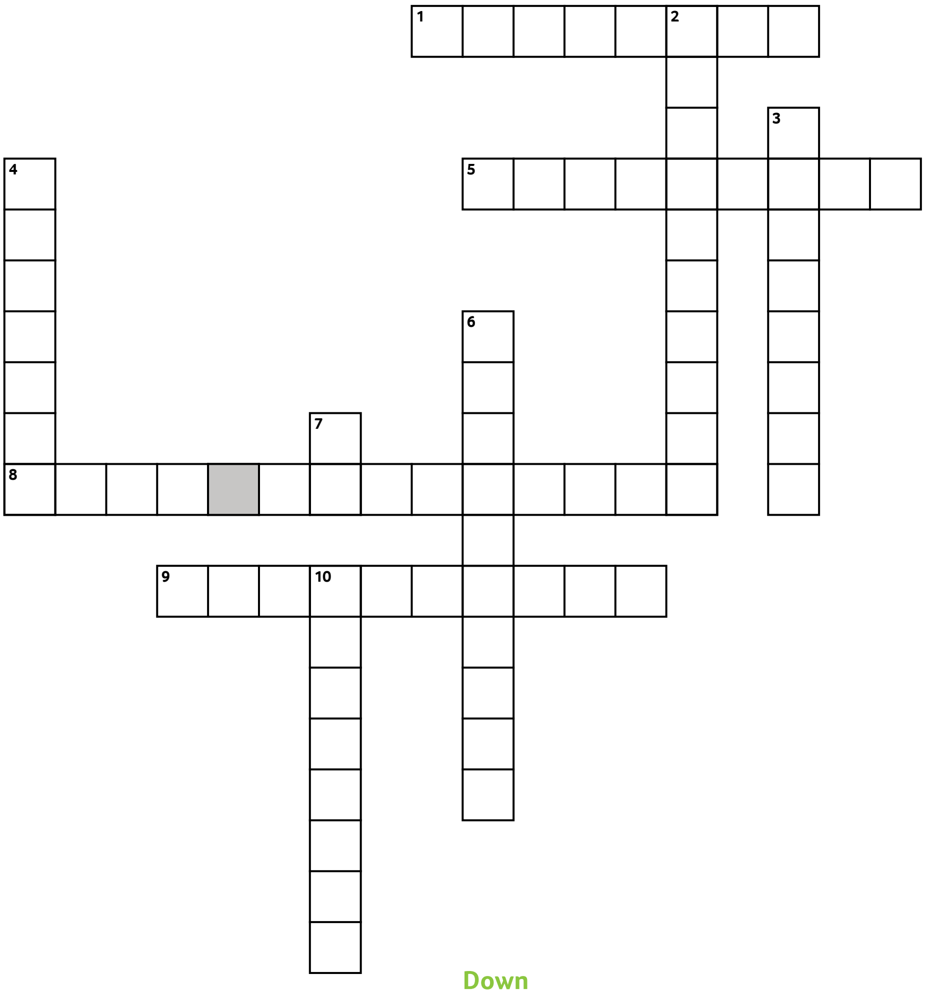
Drones are used to apply fertilisers to specific areas of the crop

Cover crops such as legumes

Precision agriculture technologies

Soil Chemistry Crossword

Complete the crossword by answering the questions or completing the sentences and writing one- or two-word answers in the corresponding boxes.



Across

1. Proper timing and placement of nutrients are critical for optimising nutrient uptake and minimising ____________________.
5. What nutrient might be present in acidic soils at toxic levels?
8. What term describes the chemical characteristics of soil, including nutrient levels and pH? (two words)
9. Give an example of a soil amendment used to replenish essential nutrients and improve soil fertility.

Down

2. The aim of nutrient management practices is to strive to optimise nutrient use ____________________.
3. Name the macronutrient essential for plant growth that has N as its chemical symbol.
4. Name the cover crops that are used to reduce the need for synthetic nitrogen fertilisers.
6. Nutrient __________________ in plants may occur when the level of certain nutrients is too low.
7. The purpose of soil testing and analysis is to assess nutrient and ________ levels in the soil.
10. What can happen if there are excessive levels of certain nutrients in the soil?

Case Study: Soil Testing at Nutrien Ag Solutions™

As a class, discuss the questions below before watching the video.

Questions

1. How do you think soil is tested and analysed on a farm, and what do you think the tests are looking for?

2. Why do you think that producers have soil tests done on their farms?

3. After the soil has been analysed, what actions do you think producers can take as a result of the findings?

4. How do you think this process was performed in the past?

View the video and sequence the soil processing and analysis steps by cutting out the slips of paper, placing them in the correct order, and recording the step number in the space provided.

Have you ever wondered what the process is for soil testing? (5:28)
https://www.youtube.com/watch?v=HDCqkh2RI9w

After viewing the video, sequence the soil processing and analysis steps by cutting out the slips of paper, placing them in the correct order, and recording the step number in the space provided.

Soil Testing and Analysis

Step ________

Tumble tray samples are strapped in and tumbled for approximately one hour. They are then transferred to test tubes, where they are clarified by centrifuging for 10 minutes.

Step ________

The lab supervisor obtains the samples (soil or plant) for testing and analysis. The samples are organised and dried overnight at 60 degrees Celsius.

Step ________

Sample results are uploaded to a database and forwarded to Agronomists for recommendations.

Step ________

A universal soil probe is used to obtain samples (10 cm at a time), which are then collected into a bowl, bagged, scanned, GPS-located via an app, and sent to a lab by post for analysis.

Step ________

After centrifuging, the clear samples are taken to the instrument room and placed in an ICP machine for one minute per test tube.

Step ________

After this step, the samples are reviewed, and the results of the sample are determined.

Step ________

The dried samples are then placed in the grinder before being bagged and sent to the Prep Lab for weighing. After weighing the samples, they are bottled and placed into tumble trays (100 samples per tray).