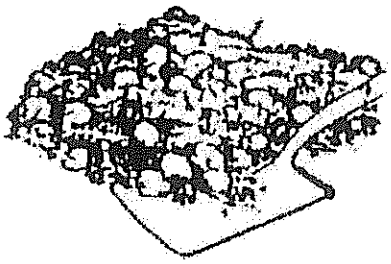
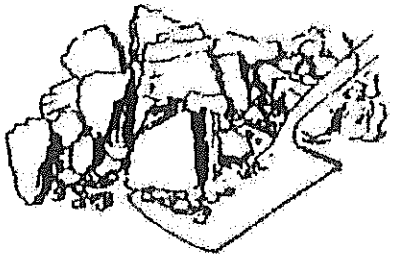
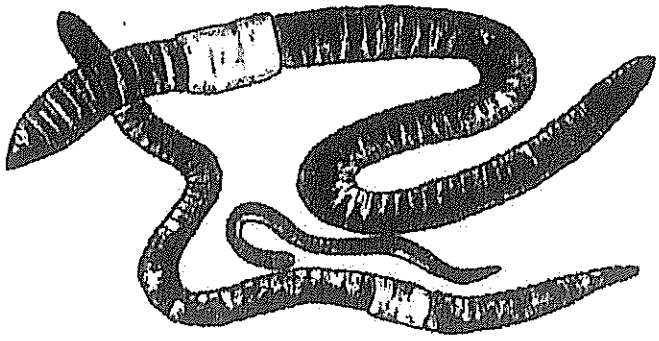
Gore High School

90158 Soil Science







1.3 Demonstrate knowledge of soil management practices.

Achieve	Merit	Excellence
• Demonstrate knowledge of soil management practices	• Demonstrate in-depth knowledge of soil management practices.	• Demonstrate comprehensive knowledge of soil management practices.

- Demonstrate knowledge requires describing how soil management practices are carried out.
- Demonstrate in-depth knowledge requires explaining why soil management practices or steps within practices are carried out.
- Demonstrate comprehensive knowledge requires applying knowledge of soil management practices to given situations. This may involve comparing and or contrasting, or justifying management practices.

1.3 Demonstrate knowledge of soil management practices.

Credit	Merit	Excellence
❑ **Describe how soil management practices are carried out** **Describe** the function and importance of the **Components of soil** • Inorganic matter (soil texture) • Air • Water • OM • Soil organisms • Soil structure **Soil properties** *Physical*-drainage, aeration, WHC, temperature *Chemical*- nutrient retention, NHC, pH *Biological* effect on soil organisms, OM **Describe** how **management practices are carried out** • Fertiliser application • Liming • Crop rotation • Addition of OM effluent, green manure • Drainage • Irrigation • Cultivation	❑ **Explain why soil management practices are carried out** **Explain** why soil components affect the soil properties **AND** How or why these affects plant growth Explain why management practices are used to modify soil and relate these to plant growth.	❑ **Contrast or justify management practices used to modify soil in response to given situations** **Contrast of justify MEANS** Select the best management practice to solve the problem and explain how and why it is the best solution based on • Effect on plant growth • Cost • Efficiency- effect on production • Possible effect on the environment • Effect on soil **AND** Explain why it is better than the other options or explain why the other solutions were not as good based on • Effect on plant growth • Cost • Efficiency- effect on production • Possible effect on the environment • Effect on soil

AIM: Demonstrate knowledge of soil management practices.

Specific objectives

A **Knowledge**

At the end of the unit students should be able to:

1 Describe the composition and basic properties of soil.

1.1 List the major soil components and describe their variable nature.

mineral matter, organic material, water, air

1.2 Discuss the major components of soils and explain how they influence plant growth.

mineral matter, organic material, water, air

1.3 Name the main soil horizons and described their composition.

litter layer, topsoil, subsoil, parent material

1.4 Discuss basic soil properties. (physical, chemical, and biological properties).

Physical properties (drainage, aeration, water holding capacity, temperature)

Chemical properties (nutrient retention, status and soil pH)

Biological properties (living organisms, decomposition of organic matter, disease status)

2 Identify soil texture and structure.

2.1 Describe soil particles and aggregates in general terms

2.2 Describe major soil textural and structural types and identify by feel and sight.

Soil textural :sand, sandy loam, silt loam, clay loam, clay

Soil Structure; single grain, crumb, blocky, massive

3 Demonstate knowledge of soil management practices

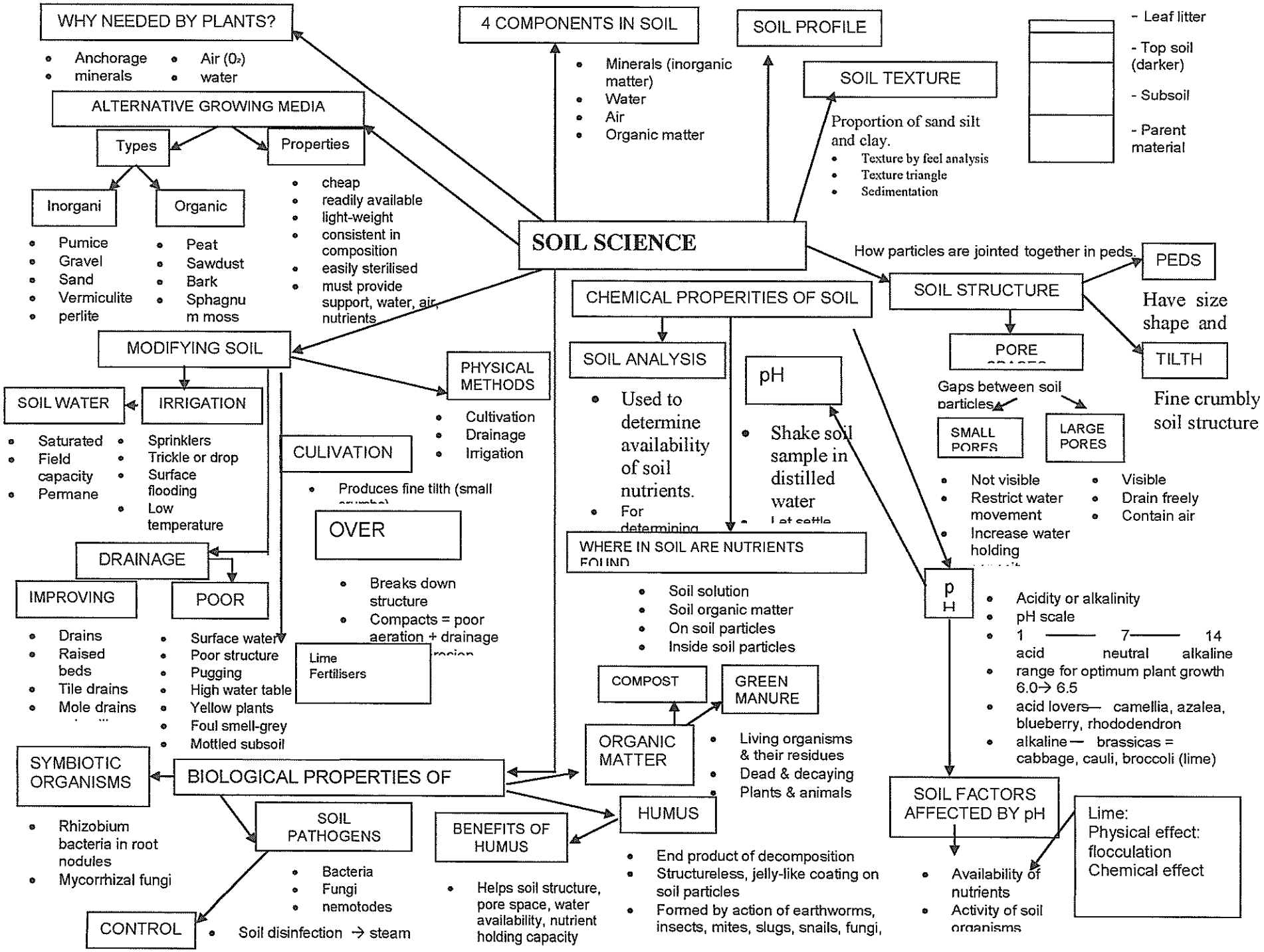
3.1 Explain the major factors which effect soil suitability for plant growth.

nutrient retention and availability, water holding capacity/ drainage, aeration, organic matter levels, soil pH, temperature, disease status

3.2 Explain management practices used by producers to maintain and improve soil suitability for plant growth in general terms.

conventional cultivation, minimum tillage, drainage, irrigation, adding organic matter(green manure crops, crop residues, compost or effluent application), liming, fertilizer application, crop rotations,

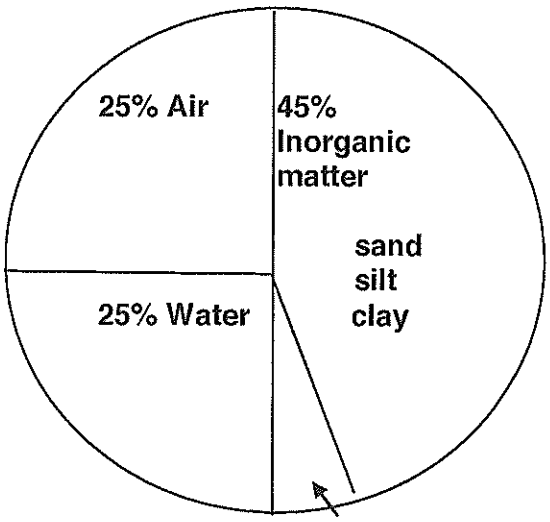
4 Compare or justify management practices used to modify soil in response to given situations


SOIL SCIENCE
WHY NEEDED BY PLANTS?
Anchorage
minerals
Air (O_2)
water
ALTERNATIVE GROWING MEDIA
Types
Properties
Inorgani
Organic
Pumice
Gravel
Sand
Vermiculite
perlite
Peat
Sawdust
Bark
Sphagnum moss
cheap
readily available
light-weight
consistent in composition
easily sterilised
must provide support, water, air, nutrients
4 COMPONENTS IN SOIL
Minerals (inorganic matter)
Water
Air
Organic matter
SOIL PROFILE
- Leaf litter
- Top soil (darker)
- Subsoil
- Parent material
SOIL TEXTURE
Proportion of sand silt and clay.
Texture by feel analysis
Texture triangle
Sedimentation
How particles are jointed together in peds
SOIL STRUCTURE
PEDS
Have size shape and
TILTH
Fine crumbly soil structure
PORE
Gaps between soil particles
SMALL PORES
LARGE PORES
Not visible
Restrict water movement
Increase water holding
Visible
Drain freely
Contain air
CHEMICAL PROPERITIES OF SOIL
SOIL ANALYSIS
Used to determine availability of soil nutrients.
For determining
pH
Shake soil sample in distilled water
Let settle
WHERE IN SOIL ARE NUTRIENTS FOUND
Soil solution
Soil organic matter
On soil particles
Inside soil particles
pH
Acidity or alkalinity
pH scale
1 —— 7 —— 14
acid neutral alkaline
range for optimum plant growth 6.0→ 6.5
acid lovers— camellia, azalea, blueberry, rhododendron
alkaline — brassicas = cabbage, cauli, broccoli (lime)
SOIL FACTORS AFFECTED BY pH
Availability of nutrients
Activity of soil organisms
Lime:
Physical effect: flocculation
Chemical effect
MODIFYING SOIL
SOIL WATER
IRRIGATION
Saturated
Field capacity
Permane
Sprinklers
Trickle or drop
Surface flooding
Low temperature
PHYSICAL METHODS
Cultivation
Drainage
Irrigation
CULIVATION
Produces fine tilth (small
OVER
Breaks down structure
Compacts = poor aeration + drainage
Lime
Fertilisers
DRAINAGE
IMPROVING
POOR
Drains
Raised beds
Tile drains
Mole drains
Surface water
Poor structure
Pugging
High water table
Yellow plants
Foul smell-grey
Mottled subsoil
BIOLOGICAL PROPERTIES OF
SYMBIOTIC ORGANISMS
Rhizobium bacteria in root nodules
Mycorrhizal fungi
SOIL PATHOGENS
Bacteria
Fungi
nemotodes
CONTROL
Soil disinfection → steam
BENEFITS OF HUMUS
Helps soil structure, pore space, water availability, nutrient holding capacity
ORGANIC MATTER
COMPOST
GREEN MANURE
Living organisms & their residues
Dead & decaying Plants & animals
HUMUS
End product of decomposition
Structureless, jelly-like coating on soil particles
Formed by action of earthworms, insects, mites, slugs, snails, fungi,

Soil Formation and Properties

Soil formation

- Soil forming factors
- Soil profile



Soil properties

- Soil components and characteristics
- Soil texture
- Soil structure
- Soil air
- Soil water
- Nutrient retention
- Soil organic matter
- Soil organisms

FACTORS COMMON TO ALL SOILS

SOLIDS

Inorganic Matter
- Gravel
- Sand
- Silt
- Clay

Organic Matter
- Plant remains
- Animal remains
  - Dung
  - Effluent
  - Soil organisms
    - earthworms
    - bacteria
    - fungi

LIQUIDS

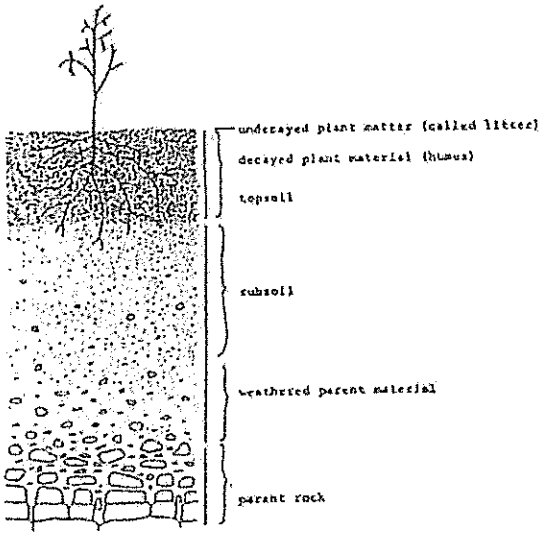
Soil Water
- Oxygen
- Methane
- Ammonium

AIR

- Carbon dioxide

SOIL PROFILES

As you've seen, when the parent rock weathers, layers are formed. (Sometimes these layers are called horizons). Together these layers form what is called a **SOIL PROFILE**. Sometimes you can see these layers in a roadside bank, but the best way to see a soil profile is to dig a pit deep enough to expose the different layers beneath the surface.



At the bottom you can see the **PARENT ROCK**. Above it is the layer where the parent rock has weathered to form the material. Above this layer is the **SUBSOIL**. The particles are smaller than in the parent material layer. Subsoil is not a very good medium for growing plants in, as it lacks organic matter. It is mostly clay.

Above the subsoil is the **TOPSOIL**. This layer is darker than the subsoil because it has had organic matter added. It continually receives organic matter from the litter layer above. It is the layer water can penetrate it most easily.

On the surface of the soil is a layer of undecayed plant material dead leaves, twigs and branches, animal droppings and bodies of dead animals. This is the **LITTER LAYER**. These organic materials in the litter layer gradually decay and add humus to the topsoil. There are also living organisms, eg bacteria, fungi.

Exercise:

1. *Complete the following sentences, using the terms from the list below.*
   weathering *parent rock* *organic addition* *humus* *topography*

   a) *Parent material comes from the breakdown of* _____.
   b) *When dead plant and animal material decays it forms a dark substance called* _____
   c) *Soil is formed from inorganic matter and* _____.
   d) *When rock is broken down into smaller particles by the action of air, water and frost we call the process* _____.
   e) *The shape of the land is its* _____.

2. *Make a mind map of the factors that cause different types of soil to be formed.*

Characteristics of inorganic particles sand and clay

CLAY:- In a clay soil the particles are very small and very close together therefore they have very tiny pore spaces (have a large number of micropores).

DISADVANTAGES	ADVANTAGES
• Poor aeration and drainage unless well structured • Warms up slowly in spring • Difficult to cultivate when too wet or too dry • Cracks in dry conditions • High water holding capacity	• Is rich in plant nutrients • High water holding capacity

Exercise

1. *Describe why clay soils have poor aeration and drainage.*
2. *Clay soils have a high water holding capacity. Explain why this is both an advantage and disadvantage.*
3. *Describe why clay soils warm up slowly in spring and explain how this affects plant growth.*
4. *Describe the management practices a grower could use to improve clay soils.*
5. *Explain how each of these management practices improves clay soils.*

SAND:- In a sandy soil the particles are large, therefore the pore spaces between the particles are large(have a large number of macropores).

DISADVANTAGES	ADVANTAGES
• Is structureless • Contains few plant nutrients • Low water holding capacity • Requires irrigation in dry conditions • Nutrients are easily leached • Organic matter breaks down rapidly	• Good aeration • Good drainage • Warms up quickly in spring • Not affected by wetting and drying

Exercise

1. *Describe what is meant by structureless and explain how this affects the soil.*
2. *Describe why sandy soils are easily leached.*
3. *Describe why sandy soils have good aeration and drainage.*
4. *Describe the management practices a grower could use to improve sandy soils.*
5. *Explain how each of these management practices improves sandy soils.*

SOIL TEXTURE

Soil texture refers to the proportion (percentage) of sand, silt and clay in a soil. Sandy soils are made up mostly of sand sized particles. Clay soils are made up of clay sized particles. Silty soils are made up of silt sized particles. A loam is a mixture of sand, silt and clay particles. Particle size is important, it affects how much air and water the soil will hold.

Soil texture can be determined **three** ways.

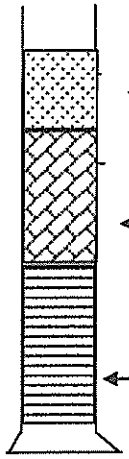
1. Texture by feel analysis
2. Texture triangle
3. Sedimentation

Sedimentation

A measured sample of soil is put into a shaker and mixed with water. It is shaken vigorously until all particles have been separated. The particles are then left to settle and measurements recorded.

Example 1

100mL of soil sample is shaken vigorously and placed in a measuring cylinder.



20mL clay $\frac{20}{100} \times \frac{100}{1} = 20\%$

40mL silt $\frac{40}{100} \times \frac{100}{1} = 40\%$

40mL sand $\frac{40}{100} \times \frac{100}{1} = 40\%$

Using the texture triangle the textural class of the soil can be determined.

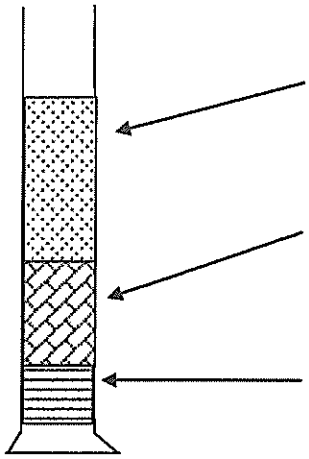
20% clay, 40% silt, 40% sand = loam

NB % must add up to 100%

Exercise

Example 2

50mL of soil sample is shaken vigorously and placed in a measuring cylinder.



25mL clay $\frac{25}{50} \times \frac{100}{1} = 50\%$

15mL silt $\frac{15}{50} \times \frac{100}{1} = 30\%$

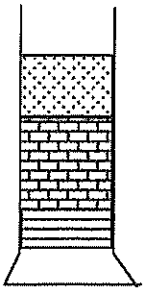
10mL sand $\frac{10}{50} \times \frac{100}{1} = 20\%$

Use the texture triangle to work out the textural class for this soil.

Example 3

50mL of three soil samples are shaken vigorously and placed in measuring cylinders. Work out the textural class for each soil

1

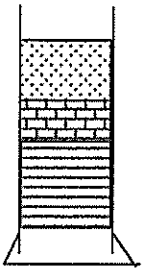


15mL clay

30mL silt

5mL sand

2

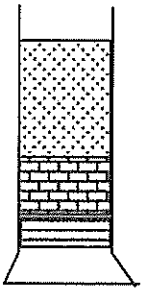


10mL clay

10mL silt

30mL sand

3



30mL clay

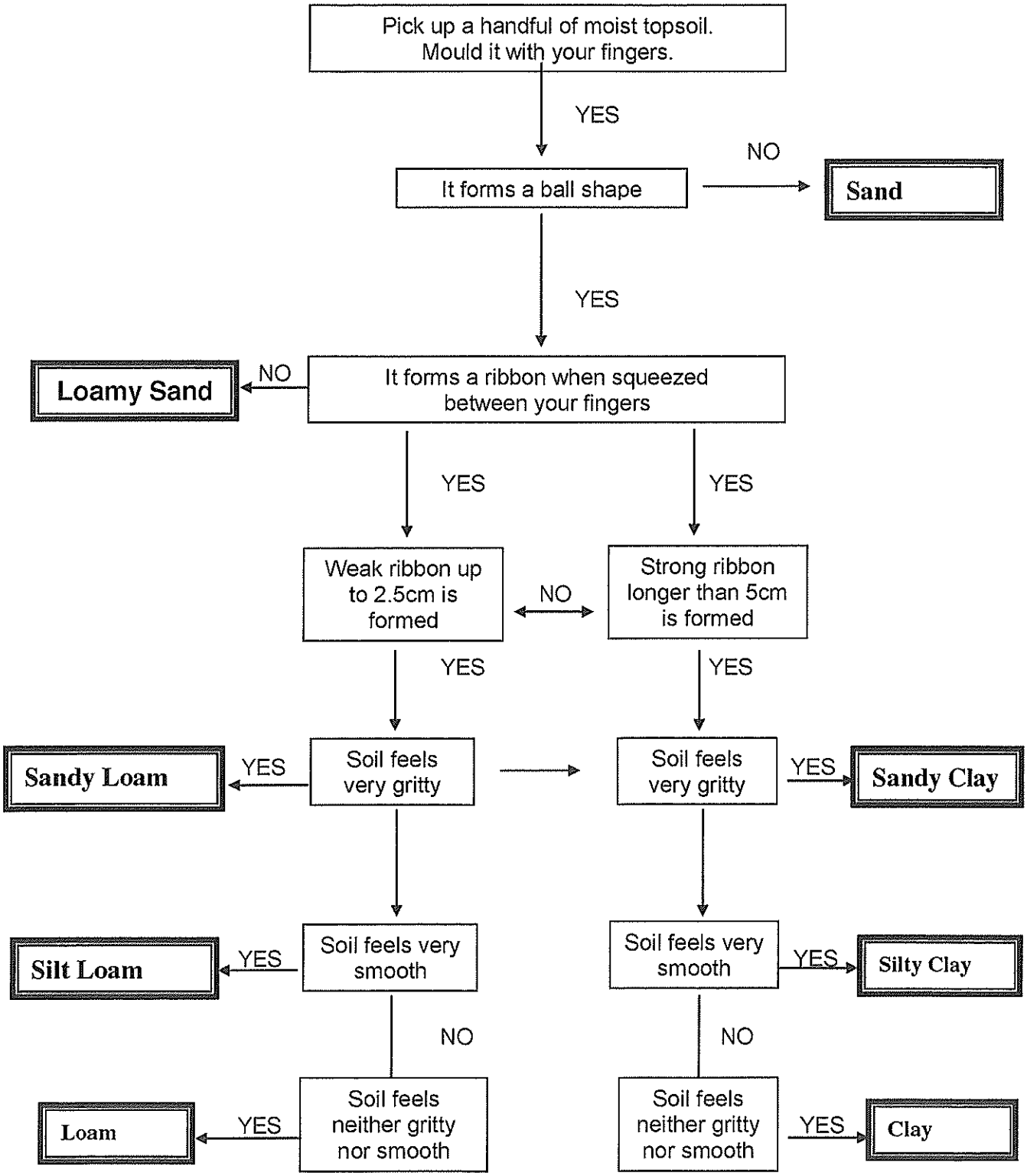
15mL silt

5mL sand

Exercise

1. *Define soil texture.*
2. *Explain how soil texture influences the soil.*
3. *Can soil texture be changed? Explain your answer.*

TEXTURE BY FEEL ANALYSIS KEY



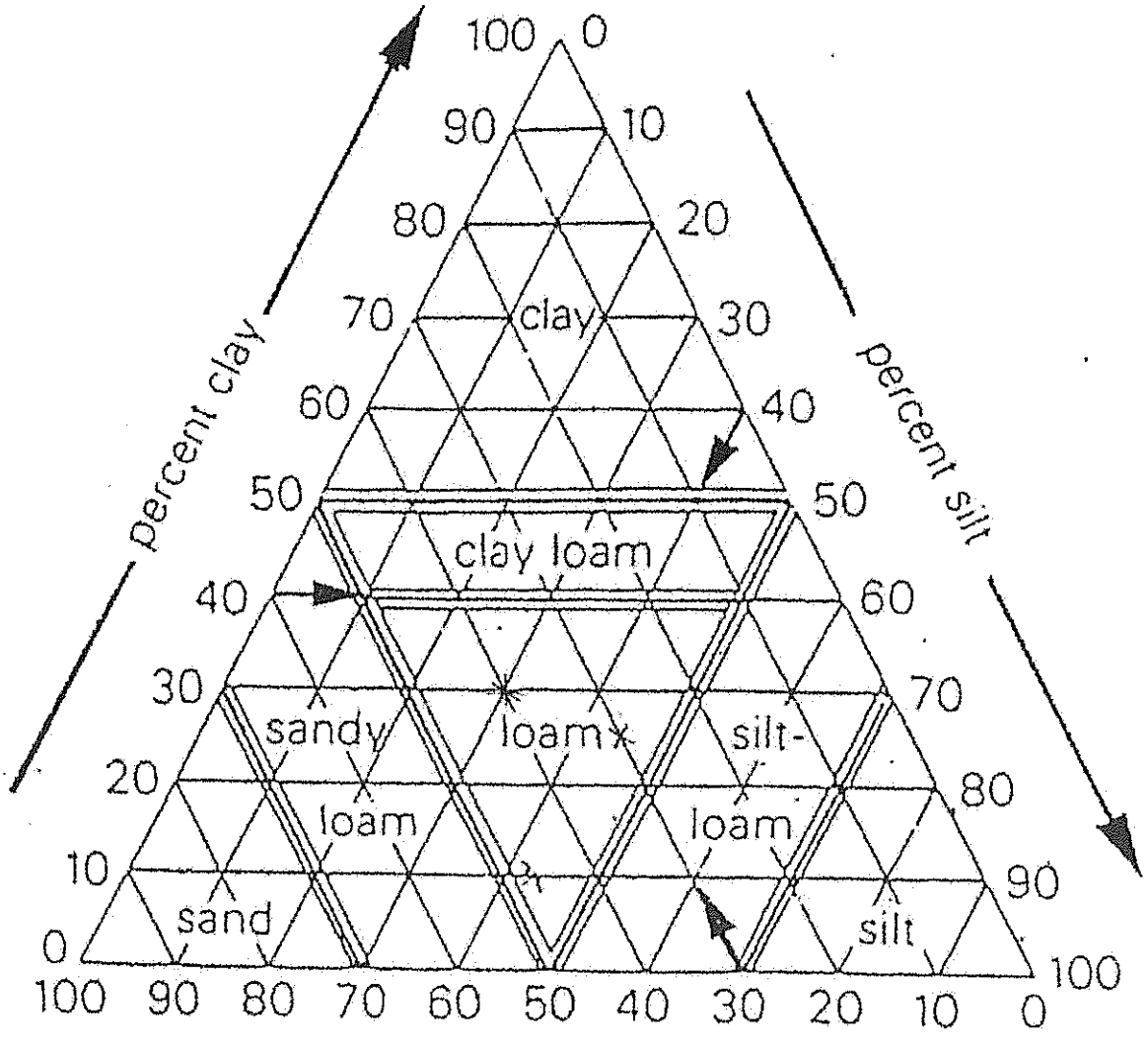
TEXTURE TRIANGLE EXERCISES

1. Given the sand, silt and clay percentages of the following soil determine their textural class.

   a) 30% sand, 45% silt, 25% clay
   b) 15% sand, 50% silt, 35% clay
   c) 55% sand, 5% silt, 40% clay
   d) 40% sand, 25% silt, 35% clay

2. Give three different textural make ups for a soil of the textural name

   a) clay
   b) sandy loam
   c) loam
   d) clay loam
   e) silt



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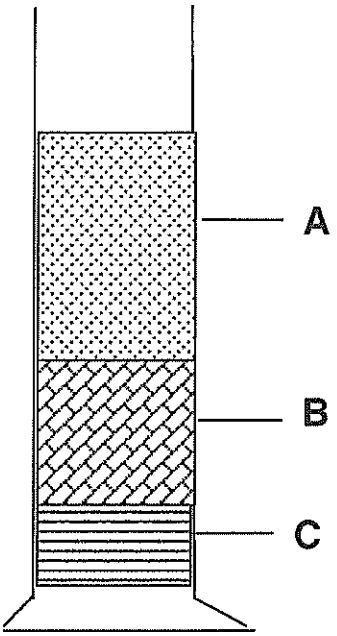
Sand

To find out the texture of a soil an agriculture student put a sample of soil into a measuring cylinder, added water then shook the mixture thoroughly. The mixture is left to settle in the measuring cylinder.



Describe the size of the particles in layers A, B and C and explain how they influence the amount of air and water available to plants

Layer	Description of the size of particles	Explanation of how the particles influence the amount of air and water available to plants.
A		
B		
C		

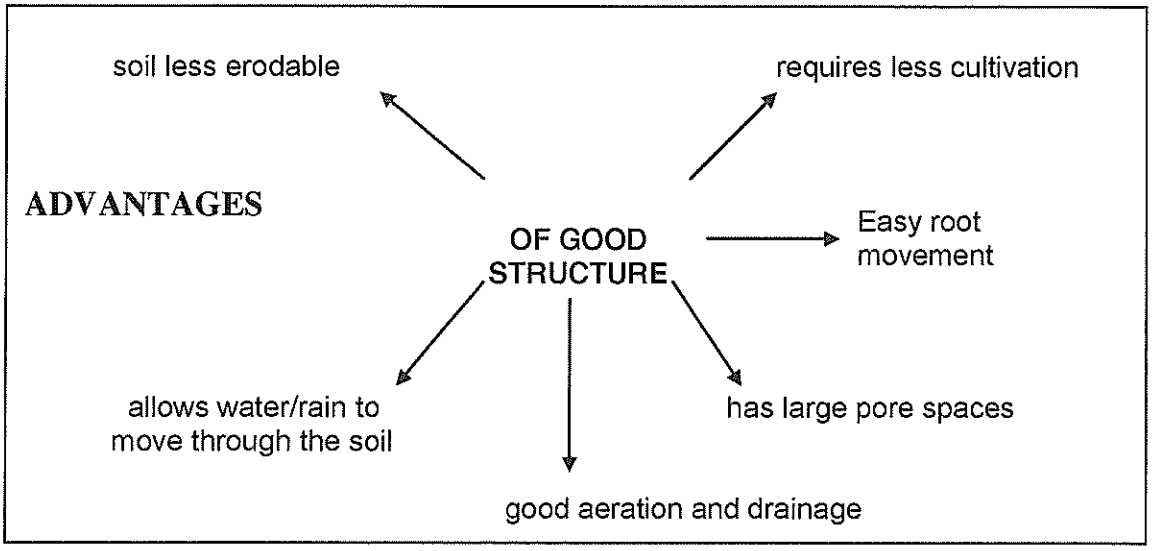
SOIL STRUCTURE

Soil particles usually join together into lumps of soil called **'peds'**.

The way particles are grouped (aggregated) together into peds is called **Soil Structure**.

The size of peds and their resistance to breaking down affects the quality of the soil. Small peds, eg crumbs, have more pore spaces between them for holding water and air and for water to drain through. It is also easier for plant roots to grow between them.

Soil structure can be weak, friable or firm depending on how easily the peds break apart. Friable is the best as the soil is easy to cultivate and for plant roots to grow in. Also the peds are not so likely to fall apart and then form a surface crust or be eroded away by wind or water.



Factors influencing soil structure

1. Inorganic colloids (amount of clay in a soil)
2. Organic colloids (amount of humus in the soil)

Colloids are extremely small particles which have the following characteristics:

1. They absorb water readily and swell
2. They shrink when drying out
3. They have adhesive properties like glues
4. The have the ability to attract positive and negatively charged atoms and hold them

Soil structure can be improved by:

1. Ploughing in crop stubble
2. Planting a green manure crop
3. Spreading effluent
4. Leaving in pasture or returning to pasture

Soil structure can be destroyed by:

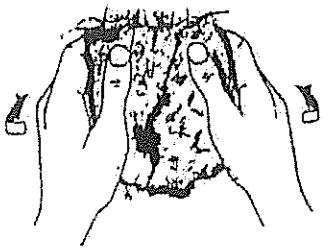
1. Over cultivating a soil
2. Cultivating in the wrong conditions, eg too wet or too dry
3. Over cropping ⟶ decreases OM levels
4. Over stocking on a wet paddock causing pugging
5. Compaction of soil by heavy machinery.

Exercise

1. *Describe soil structure*
2. *Describe a good soil structure*
3. *Explain why a good soil structure is important for plant growth.*
4. *Draw a mind map to show the management practices that a grower could do to improve soil structure.*
5. *Draw a mind map to show the management practices that a grower could do that would breakdown soil structure.*

ASSESSMENT OF STRUCTURE

A *Degree of Development*



1. Take a soil sod. Break open using gentle hand pressure exposing a natural cleavage plane. Observe the number of distinctive peds and the degree of ped separation.
2. Disturb the soil more and observe the proportions of whole and broken aggregates, and unaggregated material

Is there any observable ---

YES → Are there few distinguishable peds initially, and when disturbed a mixture of a few entire peds, many broken peds and much unaggregated material?

NO → Are the peds evident but not prominent initially and when disturbed a mixture of many entire peds, some broken peds, and little unaggregated material?

NO → Are there many prominent peds weakly adhering to one another, and when disturbed mainly entire peds, few broken peds, and little or no unaggregated material?

NO → STRUCTURELESS

YES → WEAKLY DEVELOPED

YES → MODERATELY DEVELOPED

YES → STRONGLY DEVELOPED

B *Form*

Isolate an individual ped and observe its general form

Is it rectangular in form with length approximately >2 times width?

YES → PRISMLIKE → Does the prism have a rounded 'cap' or top?

YES → COLUMNAR

NO → PRISMATIC

NO → Is it cube-like in form or makes up part of a cube?

YES → BLOCKLIKE → Does the block have sharp, angular edges that interlock tightly?

YES → BLOCKY

NO → NUTTY

NO → Is it flattened and layered in form?

YES → PLATELIKE → PLATEY

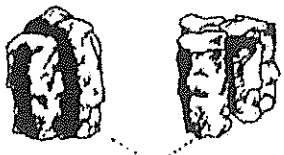
NO → Is the form generally rounded?

YES → SPHEROIDAL → Do the shapes look porous like a breadcrumb?

YES → CRUMB

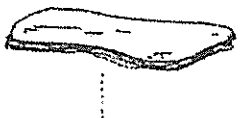
NO → GRANULAR

C *Size*



<10 mm very fine
10 – 20 mm fine
20 – 50 mm medium
50 – 100 mm coarse
> 100 mm very coarse

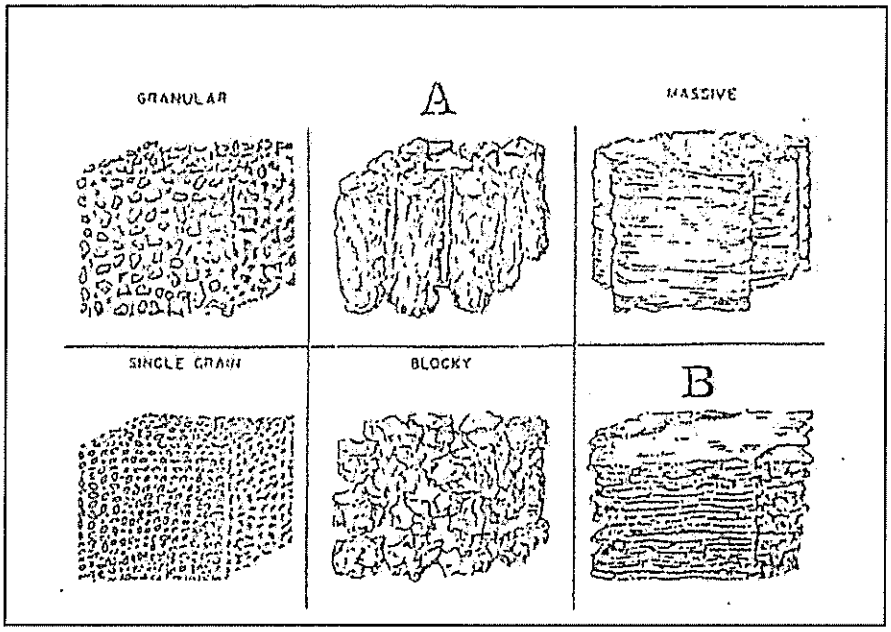
< 5mm very fine
5 – 10 mm fine
10 – 20 mm medium
20 – 50 mm coarse
> 50 mm very coarse



< 1 mm very thin
1 – 2 mm thin
2 – 5 mm medium
5 – 10 mm thick
> 50 mm very coarse

< 1 mm very fine
1 – 2 mm fine
2 – 5 mm medium
* 5 – 10 mm coarse
* > 10 mm very coarse
* Granular only

Exercise
The following diagram shows some common types of soil structures.



1. *In the space provided draw the soil profile represented by the following description.*

   A horizon 0 – 25 cm; dark brown silt loam; **granular** structure; many fine roots at 20cm; no clear boundary between A and B horizon.

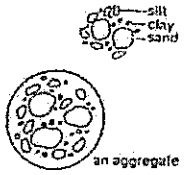
   B horizon 25 – 50 cm; pale brown clay loam; **blocky** structure; clear boundary between B and C horizon.

   C horizon 50 – 70 cm; pale grey clay loam; **platey** structure.

2. Explain the drainage characteristics of the above **soil profile**.

3 How could a farmer improve the soil above?

STRUCTURE OF SOIL



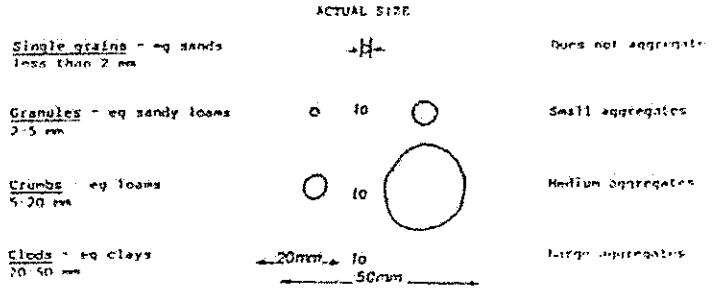
Look at the enlarged diagram on the left. Here we see the soil particles grouped together. Each group contains a mixture of different sized particles. A single group is called an aggregate.

The arrangement of soil particles into aggregates or groups gives the soil its structure.

The soil structure is affected by the size of the aggregations. For convenience the aggregates are placed into 4 classes depending on their size.

Size of Aggregates

SIZE OF AGGREGATES



At one end of this scale we have soils that consist mainly of sand particles which do not aggregate.

At the other end are the clay soils whose particles group together strongly to form large aggregates. This difference in structure gives these properties to sandy and clayey soils.

Sandy Soil

- Drains well
- Dries out
- Warms up quickly
- Easy to cultivate
- May be blown or washed away
- Good aeration

Clayey Soil

- Poor drainage
- Holds excessive moisture
- Slow to warm up
- Hard to cultivate
- Binds other soil particles together
- Poor aeration

A soil with an ideal structure aggregated into crumbs would have properties midway between these two soils.

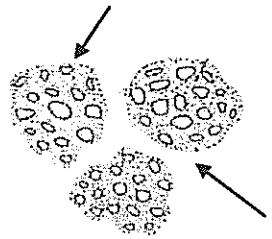
DIAGRAM OF CRUMB AGGREGATES

(Most aggregates 5-20 mm wide)

PORES IN SOIL WITH GOOD CRUMB STRUCTURE

Soil crumbs formed by aggregation of large and small soil particles

Small pores inside soil crumbs which contain water



Large pores between soil crumbs which allow movement of air or water

A soil with a crumb structure has the following properties:

- Drains quite well
- Warms up reasonably quickly
- Has good aeration
- Retains moisture
- Is easy to cultivate
- Has stable aggregates

Exercise: *To sum up: It has an ideal soil structure above, then answer the following questions.*

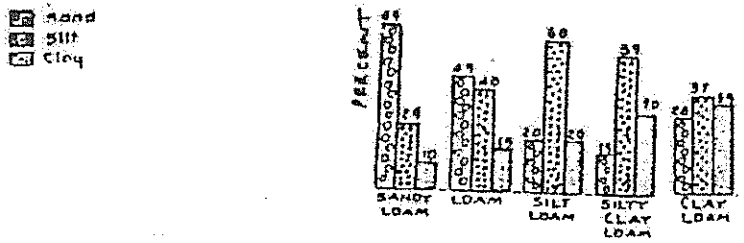
(a) Why do soils with a good crumb structure drain well?
(b) As the water drains from the large pores, what is it replaced by?
(c) Give the names of 3 living things in the soil that need air.
(d) Soils with a good crumb structure hold moisture for plant roots. Explain where this moisture is held.

HUMUS AND SOIL STRUCTURE

Humus improve soil structure by binding the particles with a kind of cement. This keeps the crumb aggregates stable. Without humus aggregates may become unstable and change their size and shape.

SIZE OF PARTICLES AND SOIL STRUCTURE

Some combinations of soil particles more readily produce crumb aggregates than others. Most soils of agricultural importance are some type of loam which contains proportions of particles shown in the graph below of particles shown in the graph below



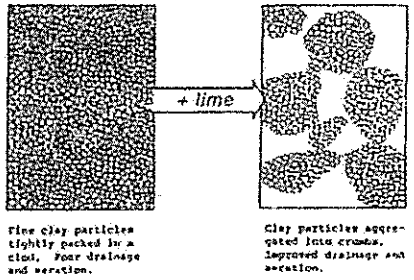
Soils B and C in the diagram above contain combinations of particle sizes that readily form crumb structures. They have a naturally good structure that is easy to handle.

Loam soils containing a high percent of sand, such as soil A, can have their structure improved by the addition of organic matter. Putting the land into pasture for a few years achieve this. Loam solid with between 25-30% clay, eg soil D, could have their structure improved by the addition of Lime.

Clay loams with more than 30% clay would need care if cultivated as their structure is likely to deteriorate. They are mainly in pasture and rarely cultivated.

THE EFFECT OF LIME ON CLAY FLOCCULATION

When lime is added to soil in which the clay particles are aggregated into large clods the particles regroup to form smaller crumb-sized aggregates.



This effect of lime on clay is called **FLOCCULATION**. The crumbs of flocculated clay have a strong stable structure.

MANAGEMENT PRACTICES AND SOIL STRUCTURE

The structure of the soil after we have cultivated it is called the TILTH. The tilth can have a better or worse structure after cultivation depending on how the soil has been managed.

BENEFICIAL PRACTICES

1. Adding organic matter to produce humus.
2. Adding lime, especially on clay loams.

HARMFUL PRACTICES

1. Cultivation of unflocculated clay when too wet or too dry.

(a) If too wet the clods are likely to be pressed together into a structureless sticky mass. Soil that is wet enough to cause tractor wheels to slip should not be cultivated.

(b) If too dry, great clods are turned up which are difficult to work down into a good seedbed.

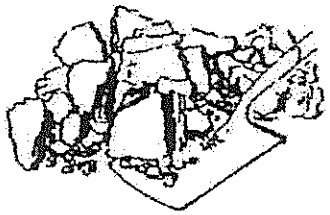
2. Removal of plant cover if soil is exposed to heavy rain.

Heavy rain hitting the surface of aggregates can break them up and leave a fine layer of particles on the surface. This can set hard and prevents air and water from moving into the soil below.

3. Too frequent cultivation

Frequent cultivation of arable land may cause a breakdown of crumb structure especially if organic matter is reduced.

Soil with a good, crumbly structure



Soil with a block-like, lumpy structure that is difficult to break up. Poor management has produced this bad tilth.

SUMMARY

Advantages of a well aggregated soil.

- Surplus water drains away **between** the aggregates
- Soil water is held **inside** the aggregates
- The particles in each aggregate are held together strongly
- It can be easily cultivated into a seedbed
- Aggregates are neither too big for a seedbed nor small enough to be blown away

Exercise: *Read the following paragraph and then answer the questions below.*

Mr Brown is a farmer. He has a paddock with soil that contains inorganic particles in the following preparations: 29% sand, 39% silt and 32% clay.

One fine morning, after a week of rain, he took his tractor into the paddock. The wheels spun a bit but he persevered and ploughed his paddock. Later, after harrowing, he was disappointed to find that his seedbed had a very lumpy tilth.

(a) What type of soil is in Mr Brown's paddock?

(b) How could he have avoided getting such a poor tilth?

(c) (i) What could be added to this soil to improve its structure?

(ii) Explain how this improves the structure.

Exercise: *Why does humus make crumb aggregates stable?*

(a) How would you increase the amount of humus in a sandy loam paddock?

SOIL STRUCTURE REVISION

1. *What is meant by soil structure?*
2. ***"Aggregate"*** *What does it mean in soil science?*
3. *Explain why soil structure is affected by the size of the aggregates?*
4. *List the properties of sandy and clayey soils.*
5. *List the properties of a soil with a good crumb structure.*
6. ***"Humus"*** *What is it?*
   Why is it an important soil component?
7. *List the ways in which soil structure can be improved.*

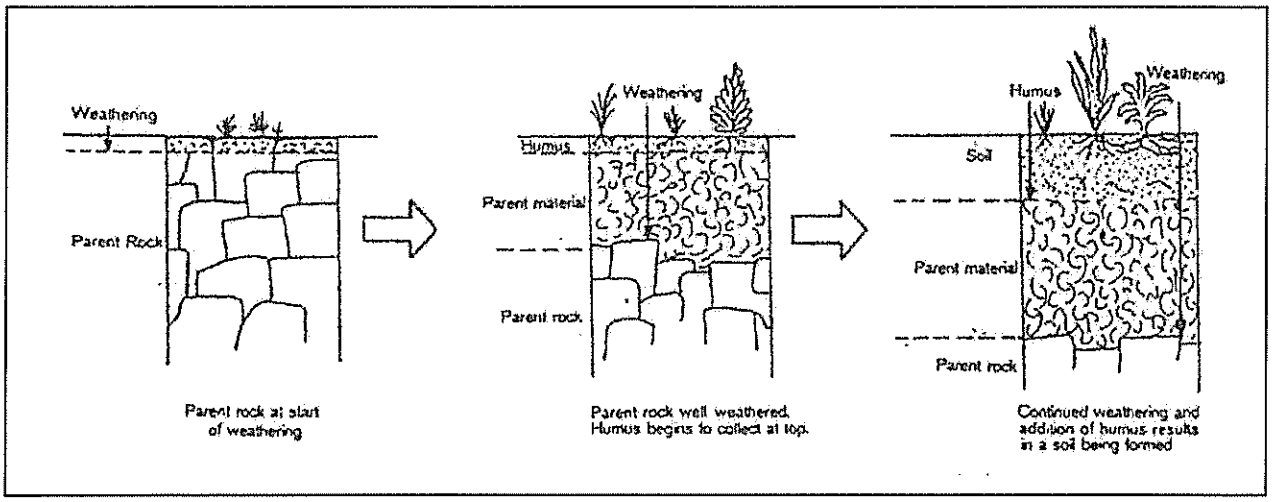
HOW DO SOILS FORM?

The Earth, the planet we live on, is made of rock. At the surface, where the rock is exposed to air and rain, a process called 'weathering' takes place. This process is the first stage in making soils.

The rock from which a soil is formed is called the ***parent rock*** of that soil. Many things help to turn parent rock into a soil.

When a rock ***weathers,*** the top layer turns firstly into a softer matter, known as ***parent material***, in which small plants can take root. Then, as the weathering goes on, more and bigger plants take root and the soft part gets darker as ***organic matter*** or ***humus*** (matter from the breakdown of dead leaves, etc.) builds up. Once this dark layer can be seen, even if it is quite thin, then we have a ***soil*** (Figure 1).

Figure 1



The kind of soil that is formed in a particular place depends on the kind of rock that it comes from, and also on all the things that affect it as it forms (Figure 2). Some of the main things which help to make a soil, and which go on changing it afterwards, are:

CLIMATE

The weather or climate in any place affects the soil directly and causes the process that we call ***weathering***. This results from repeated heating by the sun and wetting by the rain. Weathering causes the parent rock to be slowly softened and changed, and broken up into smaller and smaller particles.

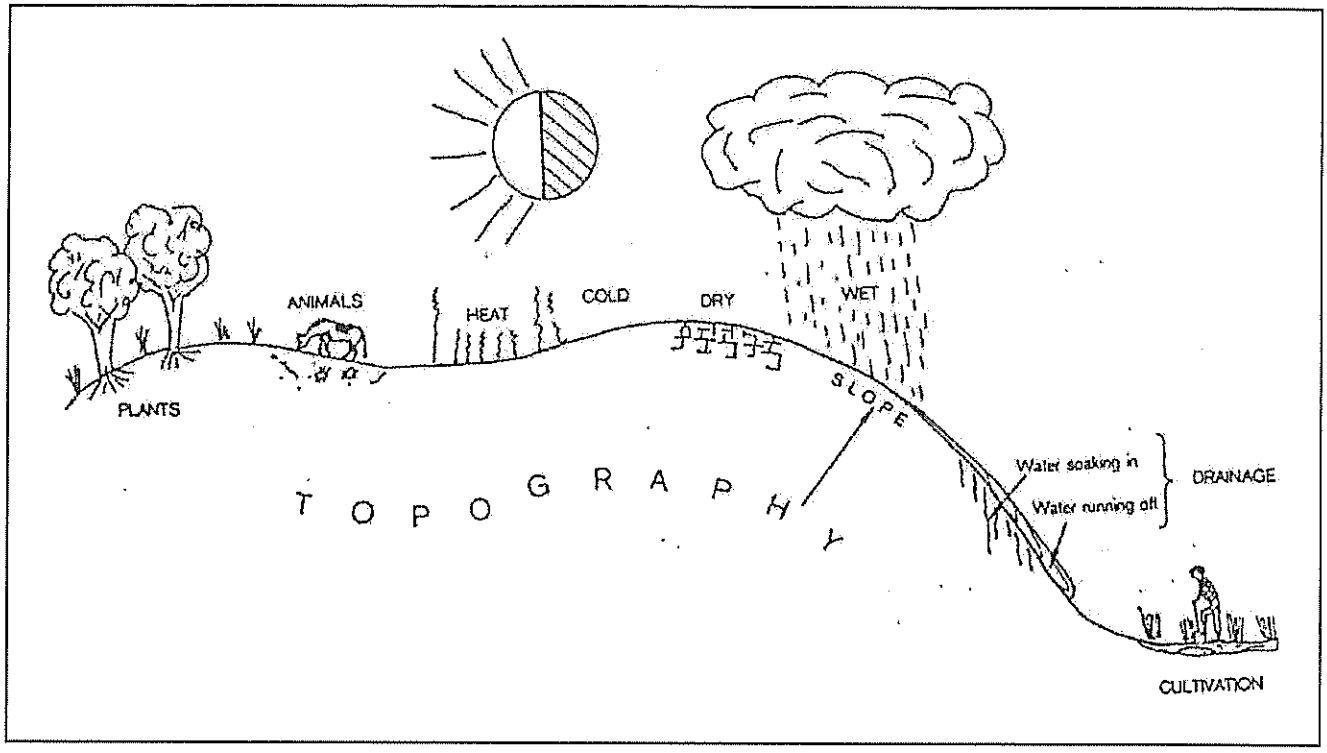
Climate also affects the soil by controlling the kinds of plants that can grow and the speed with which dead plants and animals decay (break down) and return to the soil as humus.

Weathering is faster in warm damp climates than in cool dry ones.

THE SHAPE OF THE LAND

The shape of the land (its ***topography***) and, in particular, its slope or steepness can have a big effect on soils. In flat places the soil is often deep while in steep places it is likely to be thin because the top layers slide downwards or get washed down hill.

Figure 2



DRAINAGE

When rain falls, some of the water soaks into the soil and some runs off. Water soaking in is called ***infiltration*** while water flowing away on the surface is called ***runoff.***

Infiltration

Many important nutrients or plant foods that are needed by crop plants are washed downwards in the soil by water. The speed with which this happens depends on the amount of rain and how easily it soaks through the soil. Once these nutrients go too deep in the soil plant roots cannot reach them.

Runoff

This does not affect the soil unless there is enough to actually wash the top part of the soil away. This, when it happens, is called ***soil erosion***, and must be stopped if a soil is to go on growing crops.

LIVING THINGS

Plants

Plants protect the top layers of the soil against erosion. Their roots go into the soil and make many small channels down which water can soak into the deeper layers. At the same time they shade the soil from the sun's heat and stop the rain from evaporating back into the air to quickly. Lastly, their dead leaves, twigs, roots, etc., which we call ***plant litter***, break down and add to the organic matter in the soil.

Animals

Soil is affected by the animals that live in it (such as earthworms and beetles as well as those that live on it (such as sheep). Animals within the soil speed up the breakdown of dead plant matter and mix it with the rest of the soil. Animals living on top of the soil affect it in other ways; for example, sheep may make

it muddy by trampling on it. They also help to make the soil richer by returning organic matter to it as droppings.

Micro-organisms

The very smallest living things in a soil ("micro-organisms") cannot be seen by eye, but they also help in the breakdown of dead plants and animals to humus and then into ***nutrients*** that living plants can use again.

CULTIVATION

If a soil is cultivated for crops, changes occur. For example, deep ploughing mixes up the top and lower soil layers. This usually, but not always, has good results. Also, fertiliser can greatly change the soil. When a soil has been cultivated for a long time it may become quite different from what it was like previously.

TIME

Time is important to all of the soil-forming processes. The amount by which a soil has developed or changed depends on how long the soil-forming processes have been working.

WHAT DOES SOIL LOOK LIKE?

Usually a soil is formed on top of its parent rock, but sometimes it is formed from rocky or sandy material (alluvium) brought down by streams from the hills. Either way, the development of a soil results in the appearance of layers which we call ***horizons.*** These horizons can easily be seen by looking at soil in a roadside bank, ditch or pit. The soil face exposed by such a cut is called a soil ***profile.***

The soil profile extends from the ground surface down to the parent material. Old soils that have been weathering for a long time may be very deep. In young soils where there has been only a short time for weathering the parent material may be close to the surface and the soil very thin.

From the profile the ***physical properties*** can be seen. These include:

SOIL COLOUR

The colour of a soil tells us about the conditions under which it has formed, as well as about the parent material. For example, ***topsoils*** are dark coloured because of the humus in them and usually the darker they are the more humus is present. The amount of humus, in turn, depends on the climate and the plant growing in the soil. Grey colours in a horizon can mean that the horizon is wet all through the year or that the plant nutrients have been washed out of that horizon. Red colours in a soil often show that the soil is old and weathered and probably rich in iron.

SOIL TEXTURE

The ***mineral*** part of a soil (that is, the part that comes from rock and not from plants) is formed as the parent material breaks down. ***Soil texture*** is a way of describing the sizes of the particles formed and the amount of humus present. The texture is worked out by rubbing the moist soil between finger and thumb and estimating the amounts of ***sand, silt*** and ***clay*** present. Sands feel gritty, silts are smooth, and most clays are sticky and "plastic" (can be pressed into different shapes).

SOIL CONSISTENCE

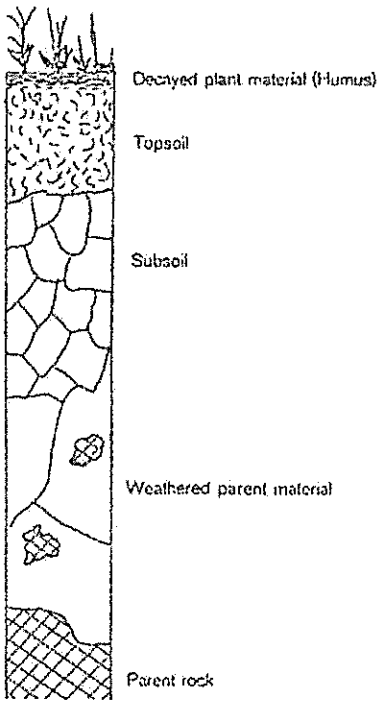
Soil consistence tells us how well the soil holds together, or how hard it is to break up and crush. If the soil is ***"loose"*** it will fall apart easily with little or no pressure. If a small amount of pressure is needed the soil is ***"friable"***, while if a lot of pressure is needed it is ***"firm"*** or ***"very firm"***. A very firm soil will crush only under very strong pressure. Friable soils are usually best for plants, strong enough to support them but not too firm to stop the roots from growing.

SOIL STRUCTURE

The way in which soil mineral particles and organic matter are arranged together, leaving spaces between them, is called the ***soil structure***. Lumps of small particles stuck together are called ***peds*** or ***aggregates***. They are described by their size (fine, medium or coarse), their shape, and how strongly they are formed (weakly, moderately or strongly).

The shapes of peds are important because spaces are left between them and within them. These spaces are very necessary for roots to grow and for water and air to move within the soil. Unless a soil has a good structure, crop yields will be low and erosion of the soil may occur. The structure of many soils can be damaged by too much cropping or by the movement of machinery (such as tractors and spraying equipment) over the soil when it is too wet.

Figure 3 is a drawing of a soil profile in which different horizons can be seen.



At the surface is the dark-coloured ***topsoil.*** This horizon is the most workable because the soil structure is better developed, and the peds are smaller and more easily parted from each other than in the lower horizons. Underneath the topsoil is the ***subsoil.*** It is usually a paler colour and has larger structure, but it is not so well developed. It is also sticky when wet because it usually contains more clay. At the bottom the subsoil mixes gradually into the parent material and, below this again, the parent rock may be found. Each soil horizon has physical properties of colour, texture, consistence and structure that occur only in that horizon and are often quite different from the properties of the horizons above and below it. By examining the whole profile, and not just the topsoil, the soil scientist is able to learn a lot about the soil and how it might best be used.

Exercise ***SOILS REVISION***

Using your own notes and the worksheet 'How Do Soils Form', answer the following questions.

1. *The rock from which a soil is formed is called?*
2. *When do we have a soil?*
3. *How does the climate affect soil formation?*
4. *What is topography?*
5. *How does topography affect the soil?*
6. *Explain the terms –Infiltration and Runoff*
7. *How does infiltration and runoff affect the soil?*
8. *Explain the role that plants play in soil formation.*
9. *In what ways is the soil affected by micro-organisms, man and animals?*
10. *Time is an important soil-forming factor. Why?*
11. *List the soil forming factors.*
12. *What is alluvium?*
13. *Explain what is meant by a soil profile.*
14. *What does the colour of a soil tell us?*
15. *Explain the difference between soil texture and soil structure.*
16. *Briefly explain how soil texture is worked out.*
17. *What does the consistency of the soil tell us?*
18. *Is soil structure important? Explain your answer.*
19. *Soil structure can be easily destroyed. List three ways that this can occur.*
20. *Draw a diagram of a soil profile –*
    - *a Describe each layer*
    - *b Briefly describe how each layer is different*
    - *c Explain why a soil scientist would examine a whole profile rather than just the top layers*

Soil Investigations

All investigations follow a plan so that fair and accurate data can be gathered. This data can then be processed and conclusions made.

Investigation Plan

Aim: The purpose of the investigation (testable question)

***Hypothesis*:** Prediction of what could happen. This can be proved right or wrong.

Variables

There are three types of variables that should be considered when developing an investigation:

- **Independent variable** – the only factor that is changed during the investigation.
- **Dependant variable** – the factor that is measured as a result of changing the independent variable
- **Controlled variable** – the factors that are kept constant during an investigation to ensure the reliability and validity of the results.

Method

This is a step by step plan of what needs to be carried out and how it should be carried out to ensure the results are valid and reliable.

- Have all of the variables that could affect the results been identified and controlled
- Could the step-by-step methods be easily understood and followed by somebody else and still produce reliable and valid results?

Results

Raw data

- **Raw data needs to be recorded in table or another way which is easy to follow**

Processed data

- Process your raw data (results) so that you can show the trend (or lack of) or pattern in your data. This will usually involve some calculations (e.g. averages) and/or a graph.

Interpret results (trends patterns)

- Record the relevant trend or pattern; this is your interpretation.

Conclusion

- Make sure that the conclusions link the results with the aim and/or hypothesis. That is relate the trend or pattern to your purpose/aim/hypothesis

Evaluation

- Explain why certain parts of the method may be done differently in future investigations (ie sources of possible error).
- List any limitations of the investigation and its conclusions. Try to explain how they could be investigated further.
- Logically discuss any unusual or unexpected findings in terms of their biological significance to the aims of the investigation.
- Discuss the results in relation to the aims of the investigation and how they link with the scientific agricultural ideas behind the investigation.

Air in Soil

Experiment Soil Air

Aim: To find out how much air is in different types of soil.

Independent variable: _____

Dependant variable: _____

Controlled variables: _____

_____

_____

_____

_____

Method:

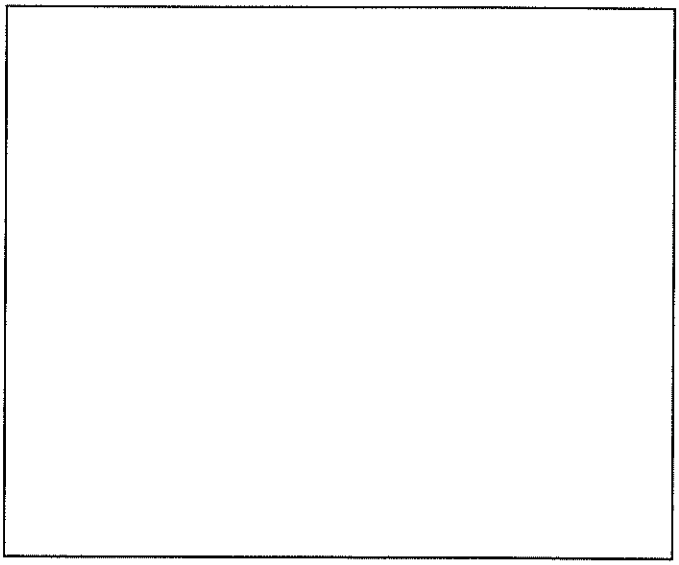
1 Place 50mL of each soil in a measuring cylinder.

2 Add 50mL of water

3 Shake well, but do not let water escape.

4 Let the mixture settle and read the volume.

5 Calculate the volume of air in the sample by subtracting the final volume from 100. This will be a percentage.



Results

Interpret results

Conclusion

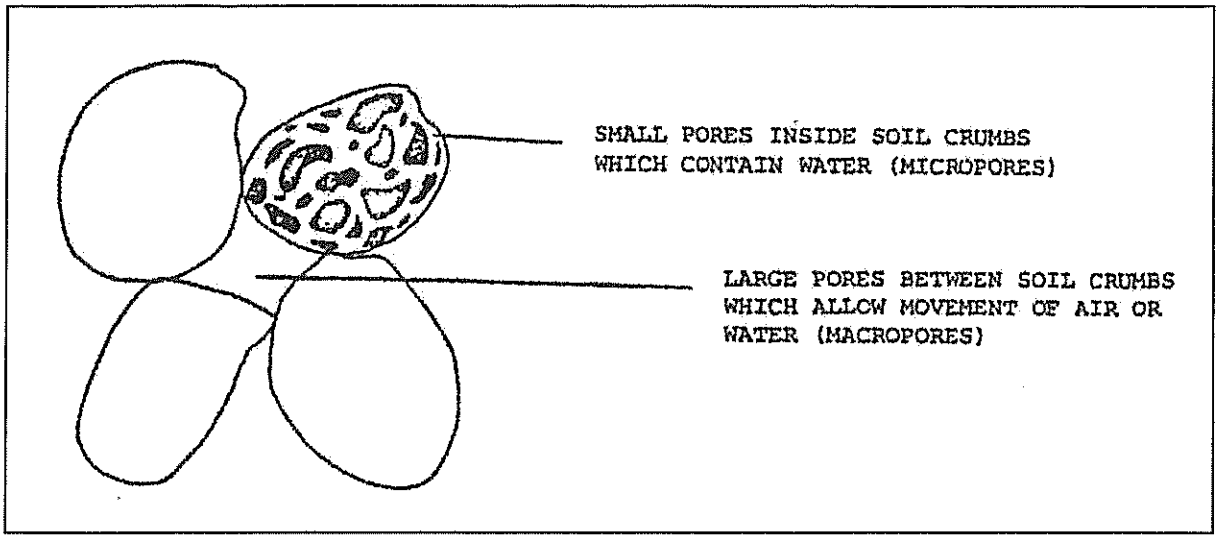
Evaluation

Exercise

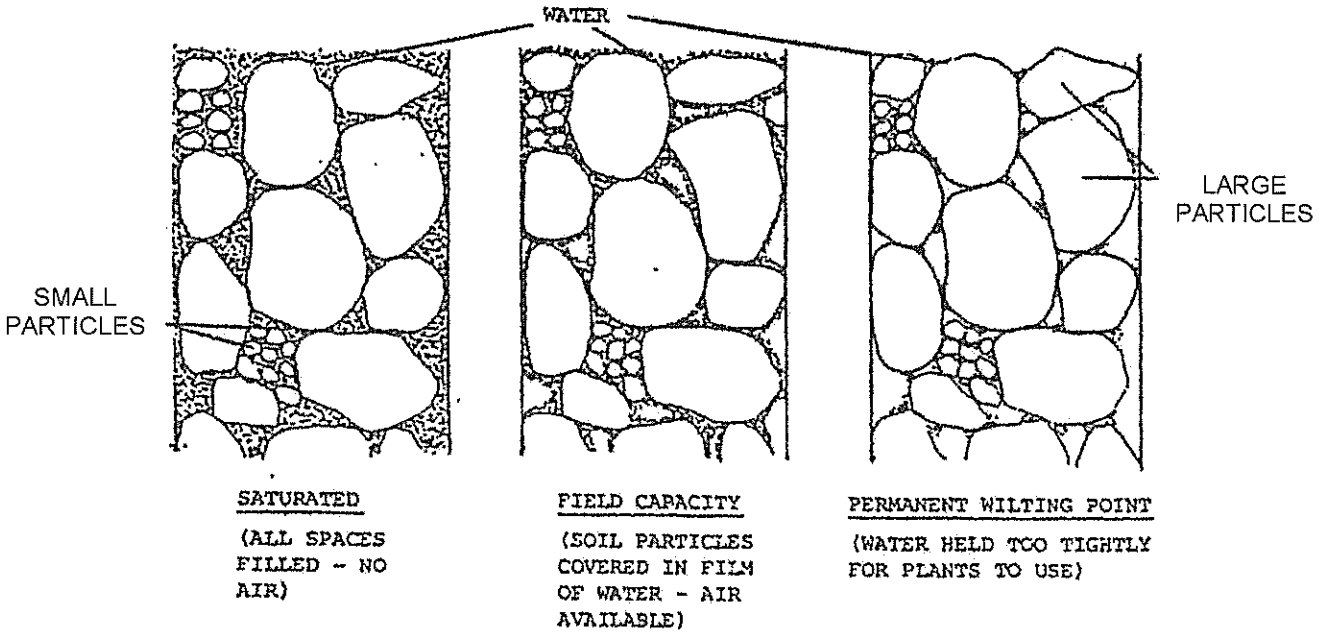
1. *List the reasons why soil air is important.*
2. *Describe the factors that affect the amount of air in a soil*
3. *Explain the affect of poor aeration on plant growth.*
4. *Describe management practices a grower could use to improve soil aeration*

Soil Water

PORES IN A SOIL WITH GOOD CRUMB STRUCTURE



HOW WATER IS HELD IN SOIL



WATER MOVEMENT THROUGH DIFFERENT SOIL TYPES

INTRODUCTION

Water enters the soil by percolation of rainfall or irrigation water. The rate at which percolation occurs (drainage) depends upon the pore spaces within the soil which in turn is dependent on the soil texture.

Aim: To recognise the relationship between pore size and rate of drainage.

Independent variable: _____

Dependant variable: _____

Controlled variables: _____

_____

_____

_____

_____

Method

1. Weigh equal amount of each different soil and place in the funnel
2. Pour 40mL of water slowly in to each of the three funnels.
3. Time how long the water takes to run through from the moment of pouring to the moment the water begins dripping out of the funnel.

Diagram

Results

	Loam	Silt	Clay loam	Sand
Time taken for first drop to fall				

Interpretation

Conclusion

Evaluation

Exercise

1 List the reasons why water is important in a soil.

2 Describe the factors that affect the amount of water held in a soil.

3 Describe what affects the drainage rate of a soil.

4. Explain the affect of poor drainage on plant growth.

5. Describe management practices a grower could use to improve the drainage rate of a soil.

WATER CONTENT OF SOIL

Aim To find out the percentage of water different soils can hold.

Independent variable: _____

Dependant variable: _____

Controlled variables: _____

_____

_____

_____

_____

Method

1 Weigh a sample of three different wet soils.

2 Oven dry the soil samples at 105° C until no further weight loss.

3 Weigh oven dried samples.

4 Calculate the

(a) amount of water in the soil sample.
(wet weight - dry wet)

(b) percentage of water in the soil sample.

$$\frac{\text{amount of water held in soil}}{\text{initial weight of soil}} \times \frac{100}{1}$$

Results

Interpretation

Conclusion

Evaluation

Exercise *Water % Calculations*

For each of the following examples calculate the

1 *amount of water held in the soil and*

2 *percentage of water found in the soil.*

(a) *A sample of soil weighed 90g it was oven dried until no further weight loss then re-weighed. The weight of the oven-dried soil was 76g.*

(b) *A sample of soil weighed 105g it was oven dried until no further weight loss then re-weighed. The weight of the oven-dried soil was 82g.*

(c) *A sample of soil weighed 78g it was oven dried until no further weight loss then re-weighed. The weight of the oven-dried soil was 56g.*

(d) *List the factors that affect the amount of water held in a soil.*

(e) *Discuss what a farmer could do to improve the water holding capacity of a sandy soil.*

(f) *Explain why too much water is harmful to plant growth.*

(g) *List ways a farmer could improve the problem of too much water in the soil.*

MEASURING ORGANIC MATTER

INTRODUCTION

Organic matter is defined as material derived from plants and animals, may be alive of dead. It is of major importance to soil as products of its decay form nutrients for further plant growth.

AIM: To calculate the percentage of organic matter and inorganic matter in a given sample of soil.

METHOD

1 Weight a sample of oven dried soil

2 Strongly heat the oven dried soil over a bunsen burner of in a hot oven (200°C) until no further weight loss

RESULTS

Initial weight of oven dried soil	
Weight of strongly heated soil	
Change in weight	

CALCULATIONS

1 % of organic Matter = $\frac{\text{change in weight}}{\text{initial weight of dry soil}} \times \frac{100}{}$

2 % inorganic matter in the sample

100 - organic matter % = inorganic %

CONCLUSION

Exercise

1 How does the organic matter content of your soil compare with that in the pie diagram?

2 If it was lower than in the pie diagram, what sorts of action (management practices) could the producer use to increase the soils organic matter?

Exercise MEASURING ORGANIC MATTER CALCULATIONS

For each of the following examples calculate the percentage of organic matter in a soil.

1. *An oven-dried soil weighed 50g. It was strongly heated until no further weight loss. It weighed 46g.*
2. *An oven-dried soil weighed 61g. It was strongly heated until no further weight loss. It weighed 58g.*
3. *An oven-dried soil weighed 43g. It was strongly heated until no further weight loss. It weighed 42g.*
4. *An oven-dried soil weighed 77g. It was strongly heated until no further weight loss. It weighed 75g.*

Answer the following questions

5. *List **three** ways organic matter improves the soil.*
6. *List **two** ways a farmer could improve the organic matter content of the soil.*
7. *List **three** ways organic matter can be lost from the soil.*
8. *How can farmer prevent loss of organic matter from the soil?*

A student collected a sample of soil from a paddock and weighed it. It weighed 110g. The student oven dried the soil sample until no further weight loss and weighed it. It weighed 85g. The student then heated the oven dried soil sample strongly over a bunsen until no further weight loss. It weighed 82g.

9. *Calculate the amount of water in the soils sample.*
   a) *Calculate the percentage of water in the soil sample.*
   b) *Calculate the percentage of organic matter in the soil sample.*

Soil Temperature

Soil temperature has a significant affect on germination, plant growth and soil microbial activity. Both soil texture and structure affect soil temperature as they affect soil water holding capacity, drainage rate and aeration.

Exercise

1 *List the factors that affect soil temperature and describe how they affect it?*

2 *How does soil temperature affect germination and plant growth?*

3 *Soil temperature varies throughout the year. Give reasons why?*

4 *Describe the effect of temperature on the breakdown of organic matter and explain why.*

5 *Describe the effect of soil temperature on clover growth and nitrogen fixation.*

6 *When soil temperatures are low how do dairy farmers boost pasture growth and explain why?*

7 *Describe management practices a grower could carry out to improve soil temperature.*

SOIL ORGANISMS - FLORA AND FAUNA.

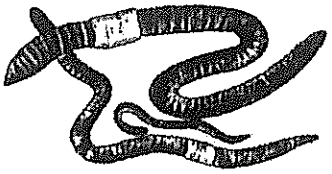
(Flora - Latin word for plants. Fauna - Latin word for animals).

Classification of Soil Organisms

Macro - organism - those which can be seen by the naked eye.

Micro - organisms - those which need a microscope to be seen.

Plants	Bacteria	important in decomposing wastes
	Fungi	feed off dead or living organic matter.
	Algae	
Animals	Micro	Nematodes (eelworms)
		Protozoa
	Macro	Worms
		Insects



Bacteria Are present in very large numbers (several million per gram of soil).
'Aerobic' bacteria are those which obtain their oxygen from air and require it to live.
'Anaerobic' bacteria live in the absence of air, eg in water logged soils.
Most of the anaerobic bacteria are harmful. But most of the bacteria in the soil are useful. As well as decaying organic matter, some bacteria are particularly useful because they make nitrogen available to the soil.

Fungi Are very important in decaying organic matter but they cannot make nitrogen available to soils. Fungi prefer a more acidic soil than do bacteria. Several fungi cause plant diseases, eg clubroot, rusts, mildews. These are 'parasitic' fungi (live on living things), but most soil fungi are 'saprophytic' (feed on dead organic matter, eg mushrooms).

Nematodes Are sometimes called 'eelworms'. Many of these are parasitic on the roots of crops and so reduce yields, eg in wheat, potatoes.

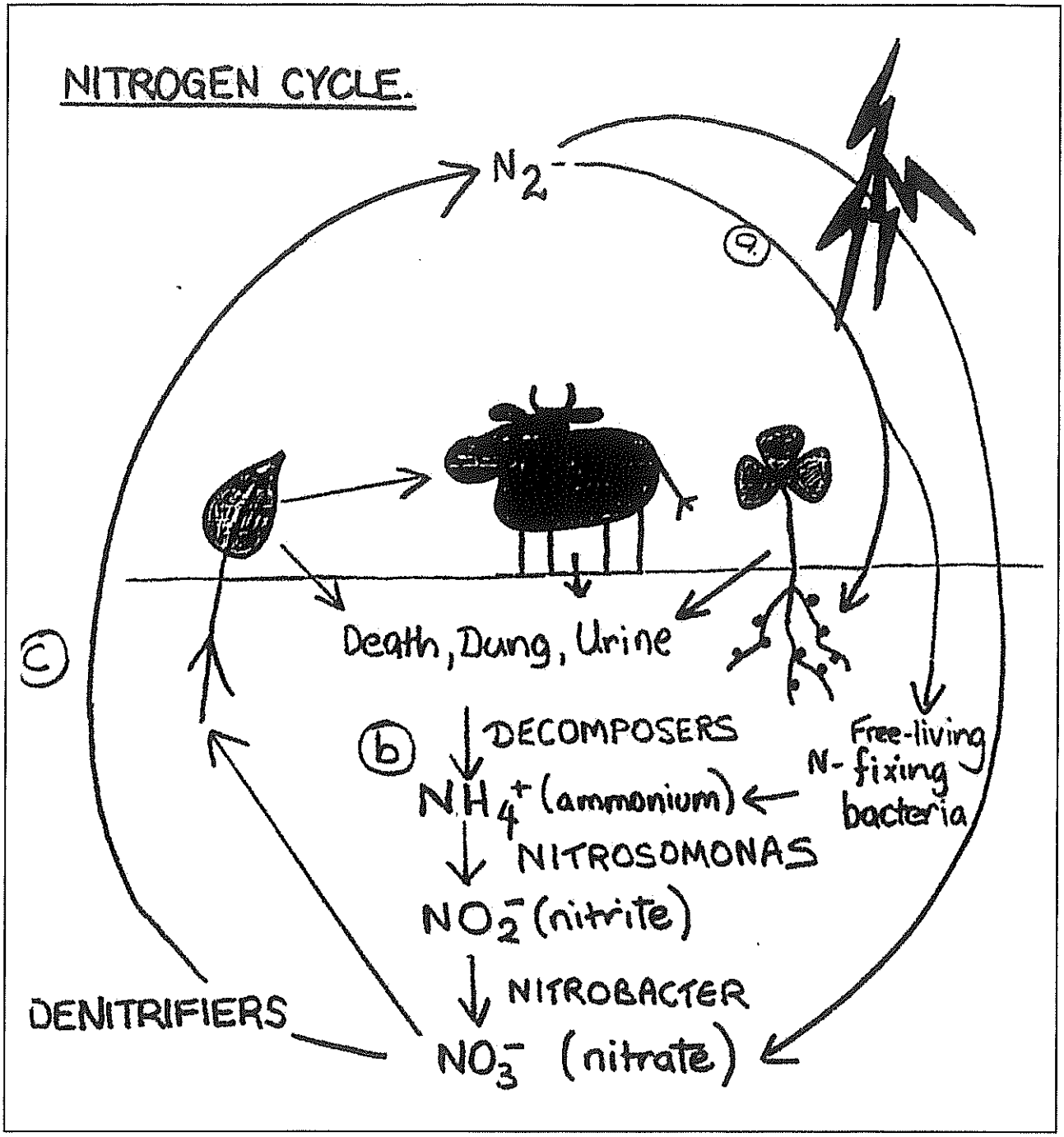
Algae Very simple plants which help in the decay of organic matter. They contain chlorophyll so can make their own food.

Earthworms Aerate the soil and mix organic matter through the soil. The population of earthworms is increased by adding organic matter and by liming.

Insects Spiders, snails and grubs spend some of their lives in the soil. They may be useful in aerating the soil and breaking down plant remains, but some are harmful to crops, eg grass grub.

Exercise

1. *Into your books draw up a table to list soil organisms and describe their advantages and disadvantages.*
2. *What environmental factors do soil organisms need to survive?*



Exercise

1. *What are the three processes represented by the letters a, b and c?*
2. *Explain how nitrogen fixation is carried out.*
3. *Describe the soil conditions needed for nitrogen fixation and nitrification.*
4. *What is denitrification?*
5. *Describe the soil factors which could increase denitrification.*

WORKSHEET ON THE NITROGEN CYCLE

A NITROGEN FIXATION

1. Refers to the process in which certain bacteria can absorb nitrogen gas from the atmosphere and convert it into _____ compounds in their body _____.
2. Some of these _____ live freely in the soil. These are called _____
3. Some of these nitrogen-fixing bacteria live in nodules on the roots of legume plants. These are called 'symbiotic' bacteria.

   What does symbiotic mean?

   _____

   _____

   What is a 'legume'? Give two examples

   _____

   _____
4. The nitrogen which these bacteria 'fix' becomes available to other plants when the bacteria and plants die and are_____.
5. Lightning also oxidises N2 (g) and forms Nitrogen _____which are carried into the soil by rainwater.

(B) NITRIFICATION:-

1. Animal wastes together with the protein of dead plants and animals are broken down by _____ to _____
2. This substance is further oxidised to the Nitrite ion (_____) by the bacteria called _____which live in the soil. This is oxidised to the _____(_____) by the bacteria _____.
3. These _____ ions are then available for use by _____.

Exercise:

1. *Why is the nitrogen cycle important to NZ agriculture?*
2. *Explain why white clover is an important pasture plant.*
3. *Explain how white clover lowers the cost of production for NZ farmers.*

Soil Science Exercise

1 Describe the following physical properties of a sandy loam soil and explain how they affect plant growth.

Physical property	Describe the physical properties of a sandy loam and explain how these properties affects plant growth
Drainage and aeration	
Water holding capacity	
Temperature in spring	

2 Describe the following physical properties of a clay loam soil and explain how they affect plant growth.

Physical property	Describe the physical properties of a clay loam and explain how these properties affects plant growth
Drainage and aeration	
Water holding capacity	
Temperature in spring	

3 Describe the following chemical properties of a clay loam soil and explain how they affect plant growth.

Chemical property	Explain how these properties affects plant growth
Nutrient retention/status	
Soil pH	

Soil Management

- Cultivation
- Drainage
- Irrigation
- Adding organic matter
  - Green manuring
  - Effluent
  - Manure
- Liming
- Fertilizer application
- Crop rotations
- Erosion control

Soil Management

- Cultivation
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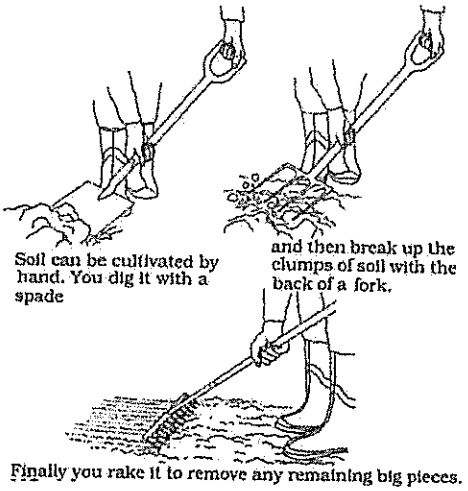
CULTIVATION

Cultivating breaks the soil structure into smaller pieces. The more you cultivate soil the more you break it up. Finely broken soil is called tilth. Cultivation provides a more suitable environment for seed germination and plant growth.

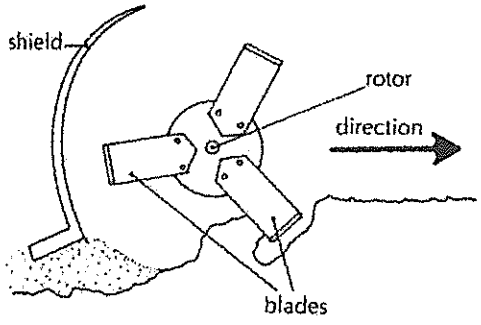
Reasons for cultivating soil include

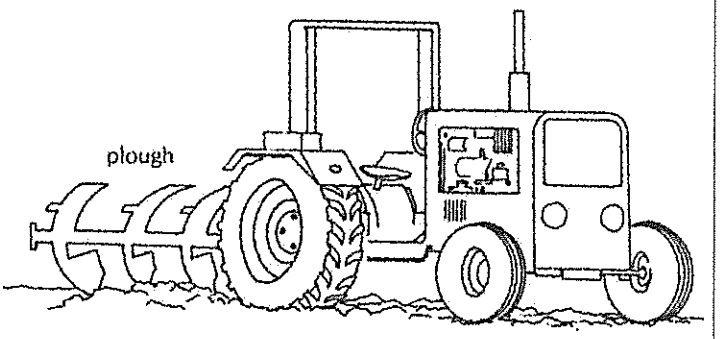
- It is easier to plant plants and sow seeds in loose soil.
- The soil is fine enough to be in contact with the roots.
- Fertiliser can be mixed into the soil.
- It gets rid of weeds or other existing vegetation.
- It can improve aeration and drainage.



Methods of cultivation

- Digging soil over with a spade, fork and rake.
- Rotary hoe
- Plough
- Minimum tillage





Minimum tillage

Minimum tillage involves spraying off the existing vegetation with a herbicide then directly sowing seeds or seedlings into the soil. This method of cultivation reduces damage to the soil structure as well as minimising the loss of water and organic matter.

Exercise

1 *List the benefits of cultivation.*

2 *Describe minimum tillage.*

3 *What type of soil would minimum tillage be commonly used on and why?*

4 *For each of the above methods of cultivation draw a table to state their advantages and disadvantages.*

5 Describe the effects on soil properties of no cultivation and excessive cultivation, and explain how these effects influence plant growth.

	Effect on soil properties	Influence on plant growth
No cultivation:		
Excessive cultivation:		

6 A dairy farmer wishes to grow a crop of maize for silage. There are several options to consider before sowing the crop.

- The soil temperature needs to be 10^0C for good germination.
- The earlier the crop is sown the higher the yield.
- There are two types of soil on the flat areas of the farm a, weakly structured sandy loam and a heavy clay loam.
- The farmer has the equipment to either plough or rotary hoe the soil to prepare the seedbed. Another method the farmer could consider using is minimum tillage.
- If the weather is dry irrigation is available but is expensive.

a. *Why would a dairy farmer want to grow a crop of silage?*

b. *What is meant by yield?*

c. *Which soil type would you recommend the farmer use? Explain why.*

d. *Taking into consideration your answer to question* ***c*** *which method of cultivation would you recommend. Give reasons for your answer in terms of*

- *effect on soil structure*
- *yield..*

DRAINAGE

The main objective of drainage

The main objective of drainage is to get rid of excessive moisture from the soil. Excessive wetness is the limiting factor to higher production of much land in New Zealand.

Benefits of good drainage?

1. Thorough aeration of the soil.
2. Speeds up the breakdown of organic matter - nutrients are returned faster.
3. Enables plant roots to enter to a greater depth (to the depth of the drain in most cases), therefore they have a greater feeding area and are much more drought resistant.
4. The soil stays at a uniform temperature.
5. The removal of moisture from the surface enables the soil to be worked earlier after rain.
6. Many diseases, eg leaf-spot in lucerne and clovers; rust in cereals and footrot in sheep, are prevented.
7. Improved drainage of pasture land results in greater growth of the more nutritious grasses.

Recognition of poor drainage

There are lots of clues to tell you that land is poorly drained:

1. After rain, water _____ on the surface of the ground.
2. The soil's surface is _____.
3. The soil smells _____ if you dig it.
4. Wet loving plants grow. eg _____
5. Diseases associated with wet conditions eg _____

Poorly drained soils cause problems to farmers because stock and vehicle movement is restricted, otherwise, pugging and pasture damage occurs, especially in gateways. Pasture quality is poorer because of _____. The amount of pasture feed produced is less because wet soils are colder and lack _____ so the pasture, plants, grow slower. Cropping can not be done on wet soils and more stock and health problems occur

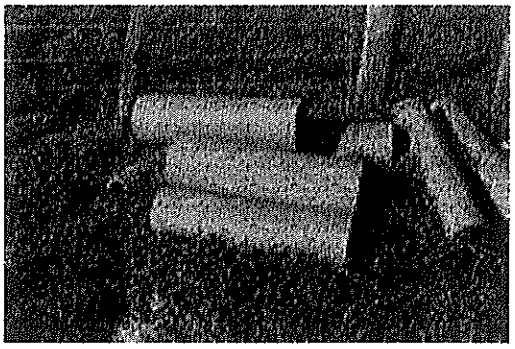
Methods to improve drainage

- Drainage can be improved by
- Adding organic matter
- Deep ripping soil pans
- Raised garden beds
- Adding lime to clay soil (flocculation of clay particles)
- Open ditches
- Subsurface drainage

Subsurface Drains.

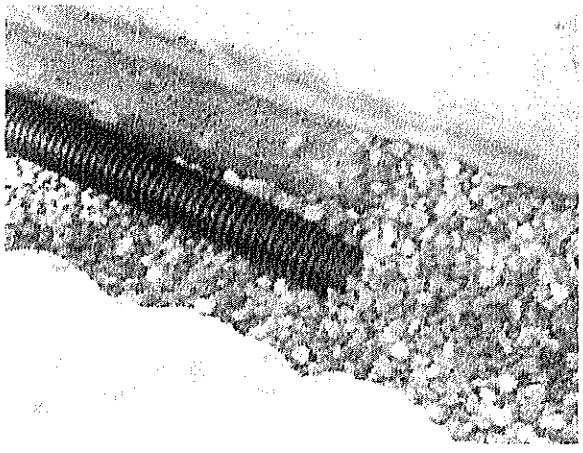
Clay tiles

Water enters the drain through the gaps between pipes and some soaks through the pipes themselves.



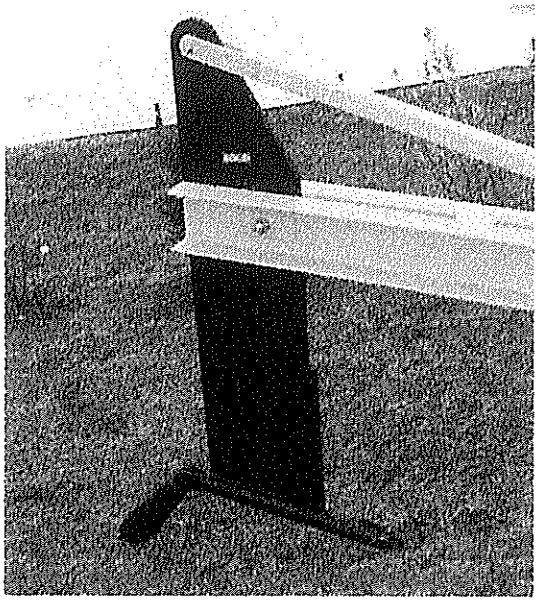
Plastic pipes

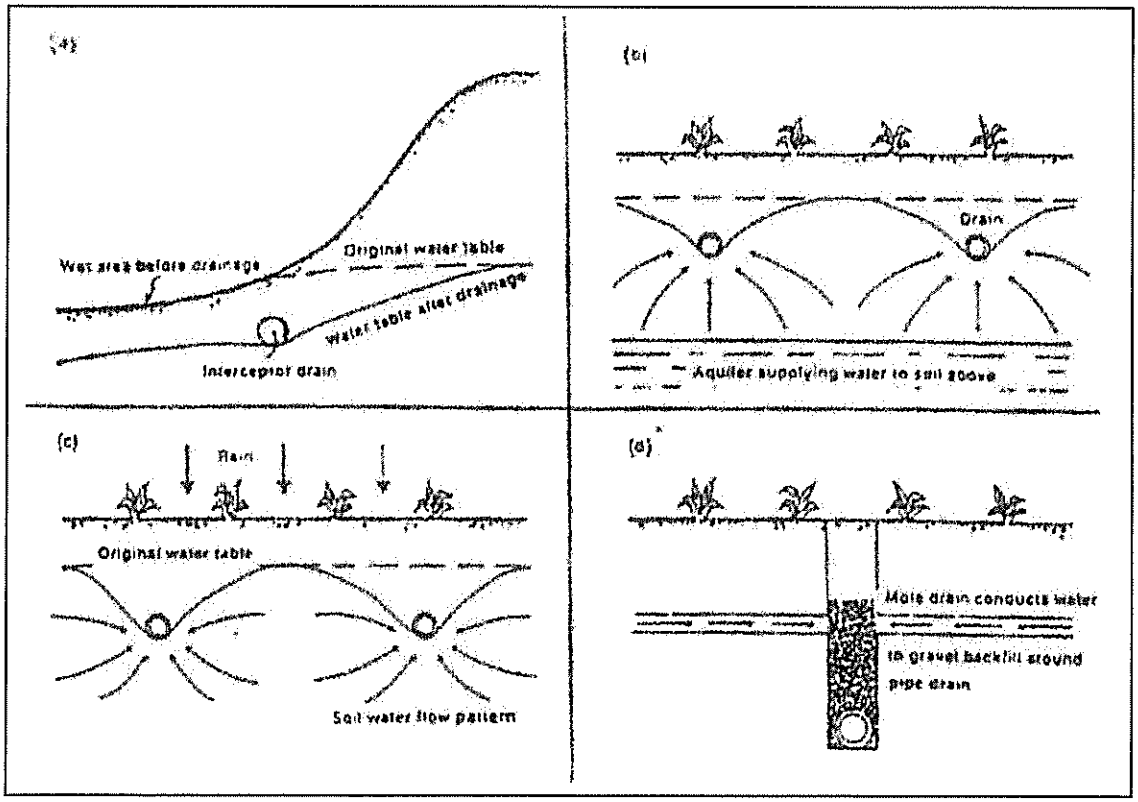
Plastic pipes can have either smooth or corrugated sides, with holes in them through which water enters the drain.



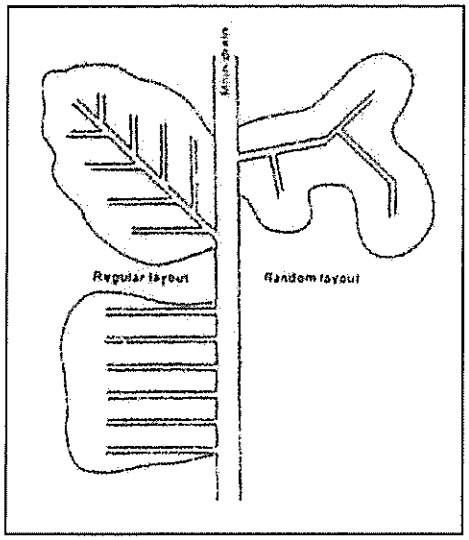
Mole Drains

Mole drains are common in soils with high clay content. A mole plough is drawn through the soil, forming a little tube-like channel. As the plough moves through the soil the soil it shatters forming cracks down which water can move into the mole drain. Mole drains are usually formed 1.5 - 2m apart and feed the water into another type of drain (eg tile drain).

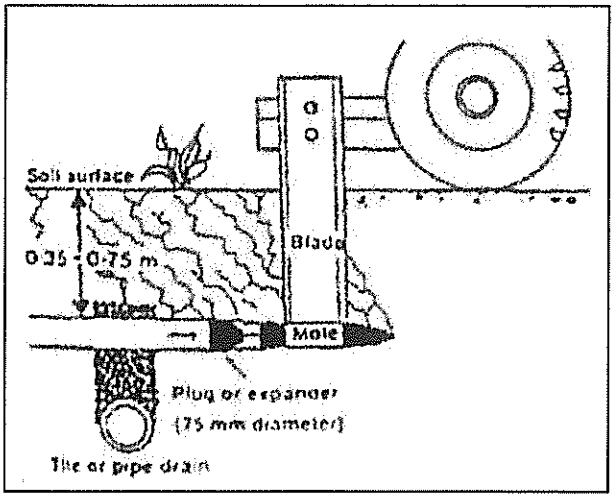




Typical drainage problems and the types of subsurface drains used: (a) Interceptor drain to lower the water table produced by seepage from upslope; (b) Relief drain to reduce the pressure of water from an underground aquifer; (c) Relief drain to remove water which accumulates in soil because of an excess of rainfall over evapotranspiration; (d) Mole drains to connect pipe drains in soils with low permeability (adapted from Bidwell, 1978)



Regular and random layout of subsurface drains.



Mole plough design and effect on soil

Exercise

1 *Draw a mind map of the benefits of draining soil.*

2 *How does poor soil drainage affect the root system of plants and plant growth.*

3 *Describe four methods a grower could use to improve soil drainage. For each method list advantages and disadvantages.*

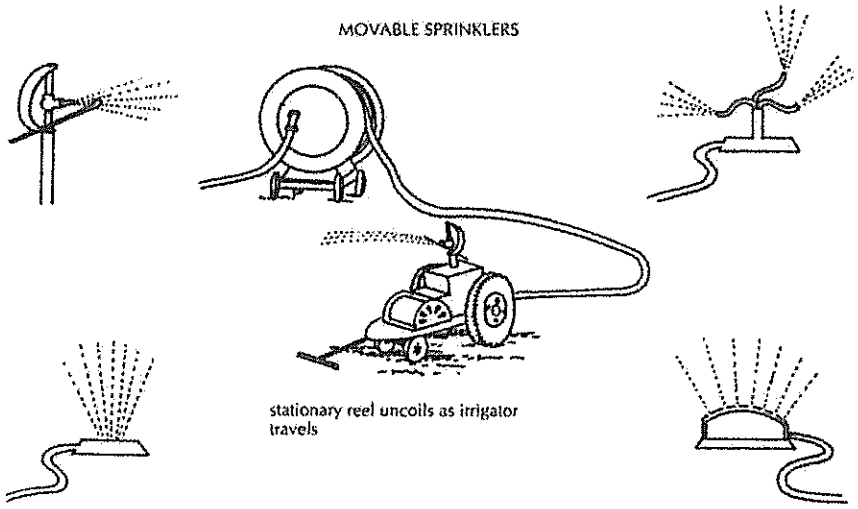
4 *Name two weeds which grow well in poorly drained soils.*

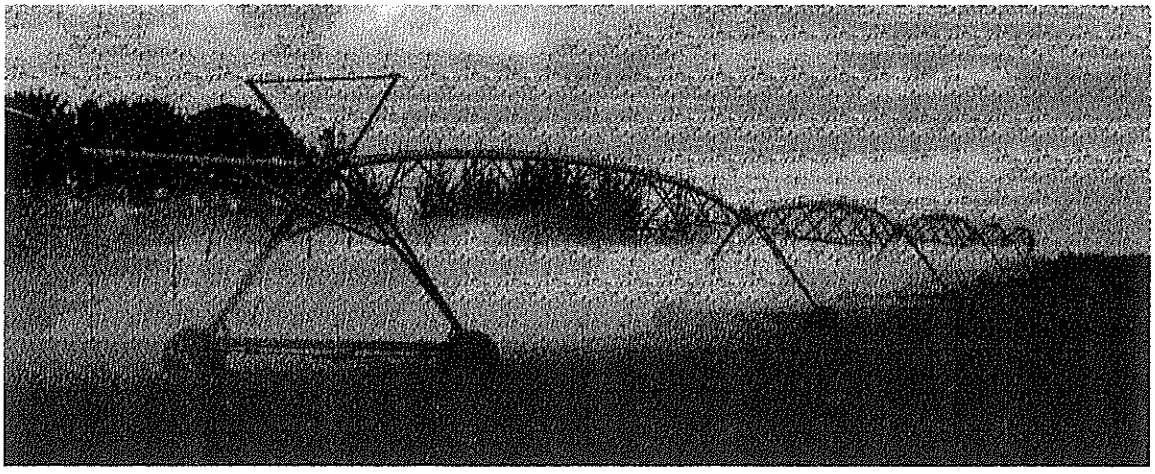
Irrigation (Watering Systems)

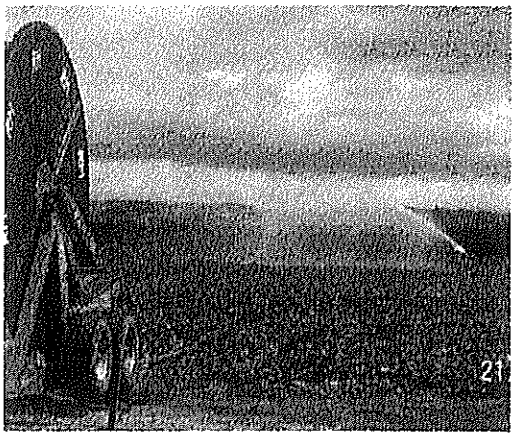
Water is being continually lost from the soil. If rainfall is insufficient some form of irrigation is needed.

Methods of irrigation include;

- Sprinklers
- Surface flooding
- Trickle or drip
- Rotorainer
- Center pivot
- K-line







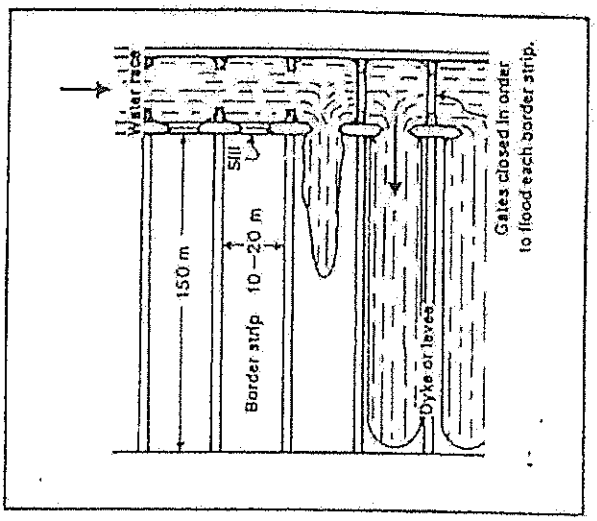


Figure 9.1: Border-dyke irrigation scheme.

Exercise

1 *When is irrigation necessary?*

2 *Describe the benefits of irrigation for plant growth.*

3 *Describe the soil types that would benefit most from irrigation.*

4 *Draw a table to list the types of irrigation. For each method discuss*

- *Type of agriculture/ horticulture suitable for.*
- *State advantages and disadvantages.*

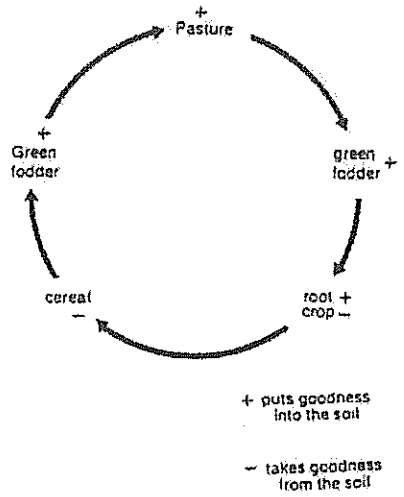
5 *On what types of farms in New Zealand is irrigation mostly used and why?*

6 *With the increase conversions of sheep farms to dairy farms the demand for irrigation has increasde. Discuss why and explain the environmental issues associated with this increase demand for irrigation.*

7 *Explain the effects of irrigation on a sandy loam soil and explain how this affects plant growth.*

MIXED LIVESTOCK FARMING AND CROP ROTATIONS

Mixed livestock-crop farming is a system of agriculture which involves a variety of livestock and crops. Some crops, such as wheat, take large amounts of fertility from the soil. Other crops, such as clover or peas and livestock put some fertility back in the soil. The fertility of the soil will be kept high if a farmer carefully manages the livestock and crops on the farm. This is done by rotations. In a rotation a crop which takes goodness from the soil is followed by one which puts it back. A good crop rotation will also maintain high production from the soil. As soils and their fertility vary from place to place, so the rotation of crops and livestock vary.



Principles behind a simple crop rotation

Pasture

↓

Ploughing for green fodder crop

↓

Root crop

↓

Cereal crop

↓

Green fodder crop

↓

Pasture

Clover, which puts nitrates into the soil, is sown in autumn. Sheep graze on the land in spring. They are then removed and the clover is allowed to grow for harvesting as a seed crop.

Eventually weeds in the pasture grow to such an extent that the pasture must be ploughed for a green fodder crop such as rape or kale.

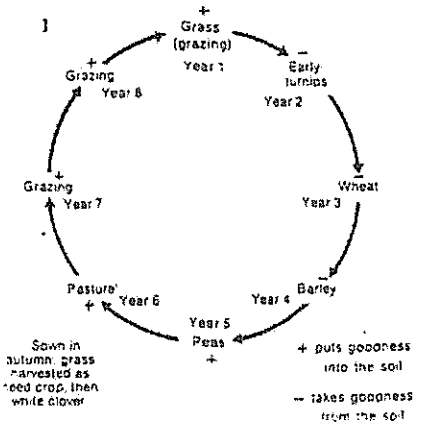
Peas or potatoes are grown. They help break up the soil. Peas add nitrates to the soil.

Wheat or barley use up the nitrates in the soil.

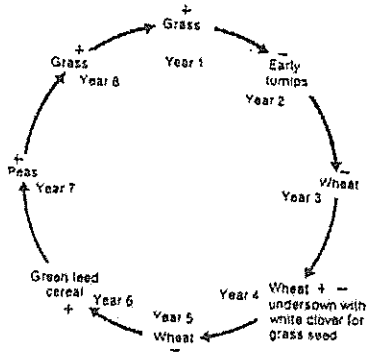
The crop is used for fodder and/or ploughed into the soil to act as a form of compost.

Examples of crop rotations

1



2



Exercise

1. *Explain in your own words the advantages of using crop rotations.*
2. *Complete the table below by listing restorative and depletive crops.*

Restorative crops	***Depletive crops***

3. *Which crop rotation do you think is the best? Give a reason for your answer.*
4. *What do you think could happen to the yield of wheat in year 5 in crop rotation 2? Explain your answer.*
5. *Explain why livestock are an important part of a crop rotation.*
6. *Explain the following terms:*
   - *Forage crop*
   - *Fodder crop*
   - *Cash crop*

   *Give **two** examples of each.*
7. *What is meant by a green manure crop and how does it benefit the soil?*
8. *Name an example of a green manure crop.*
9. *Explain the term yield.*
10. *Describe the physical conditions needed for mixed farming.*
11. *A farmer has cropped wheat in the same paddock for the last five years and has noticed that his yield has decreased despite using fertilizer and lime.*

    From the list below, select the management practice that you consider the farmer should use to overcome the drop in crop yield.

    Management practices
    - *Irrigation*
    - *Crop rotation*

    Management practice _____

    Justify your selected management practice by explaining why it is better that the other management practice listed

A dairy farmer grows a maize crop for silage each year in the same paddock because the paddock is close to the silage pit. The soil in this paddock is a clay loam. The farmer has noticed that the silage yield has decreased over the years. This year the maize seeds did not germinate well. This was because the surface of the soil packed down and became crusty after rain.

The maize plants when they grew were pale yellow green in colour and did not grow as big and leafy as they should.

The farmer asked for advice from two other local farmers about how he could improve his maize silage crop.

Farmer 1: told him to add fertiliser and to irrigate more
Farmer 2: told him to change the paddock he grew the maize in each year.

12 Explain why the farmers' maize silage crop was not growing well in terms of the physical, biological, and chemical properties of the soil.

- Physical properties:
- Chemical properties:
- Biological properties:

13 Which farmer gave the best advice on how to improve the growth of the maize crop compared to the other farmer? Give reasons for your choice of in terms of

- soil structure
- nutrient and disease status
- financial returns

Green Manure Crops

Green manure crops are crops which are grown to be ploughed back into the soil to improve organic matter levels. Crops can be legume crops such as mustard which also increase soil nitrogen levels through nitrogen fixation. However they can be crops such as annual ryegrass which absorb soil nitrogen and prevent it from leaching. When cultivated back into the soil the nitrogen is release again through nitrification for plants to take up.

Exercise

1 List the benefits of a green manure crop

Maintaining organic matter levels in soil is important to growers. Market gardeners often grow a green manure crop which they plough in, while farmers rely on the return of animal dung.

2 Explain one effect the addition of organic matter has on a soil's physical properties and why plants benefit from the effect.

3 Explain one effect the addition of organic matter has on a soil's biological properties and why plants benefit from the effect.

4. An arable farmer growing grain crops noticed the wheat yield from a paddock usually producing high grain yields is lower than other years.

There are **two** management practices the farmer is considering to improve crop yield these are:-

- crop rotation
- growing a green manure crop

Select the management practice you consider will be best to improve crop yield

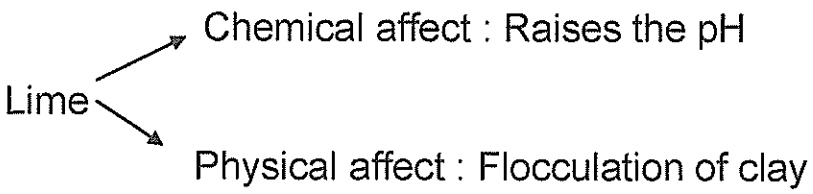
Selected management practice:_____

Give reasons why the selected management practice is better than the other management practice in terms of:-

- use of chemicals
- soil fertility
- disease status
- improving yield(increasing financial returns)

Lime: The soil conditioner

When lime is added to soil it has a chemical and physical affect on clay.



Physical affect

When lime is added to soils with a high clay content the clay particles flocculate together to form crumb sized aggregates improving the soil structure. As the aggregates are larger there are bigger pore spaces therefore aeration and drainage is improved.

This effect of lime is called flocculation.

Investigation: The effect of lime on clay soil

Aim: To find out the physical affect of lime on clay soils

Method

a) Play equal samples of the same clay into a test tube.

b) To one test tube add limewater and to the other just the same quantity of water.

c) Shake each test tube and leave to settle

Diagram

Results

Conclusion

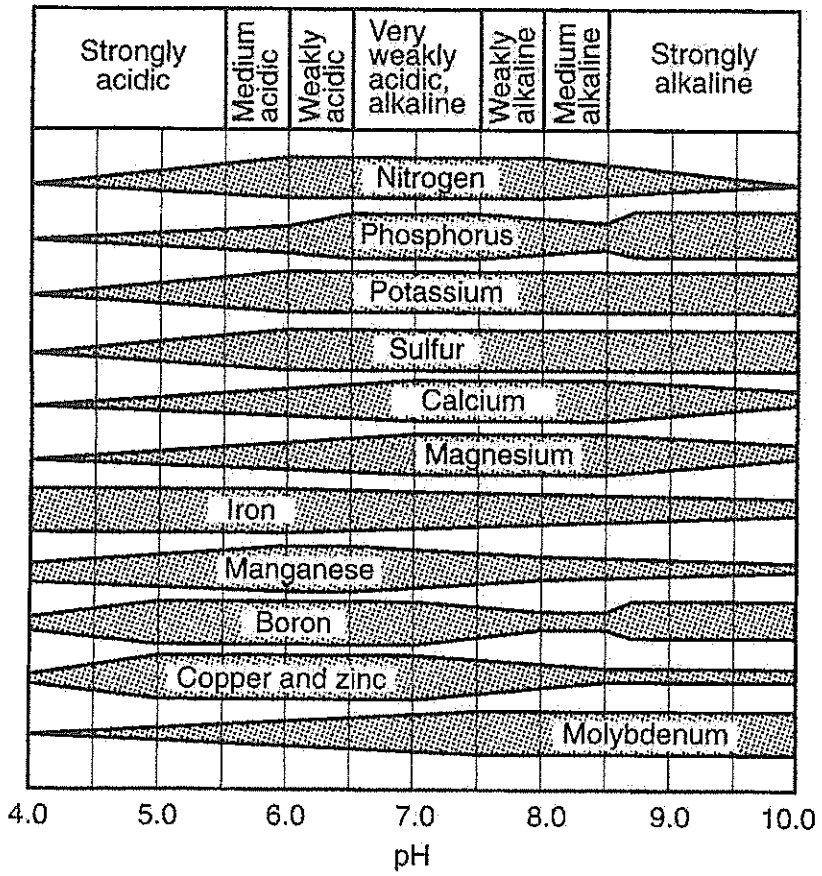
Exercise

1 Explain the effects of adding lime to a clay loam soil and explain how this affects plant growth.

Chemical effect of lime

Lime raises the pH of soil. Soil pH affects nutrient availability.

The availability of nutrients is influenced by the pH of the soil. The optimum pH, where the majority of nutrients are most available is between 6.0 – 6.5.



Exercise

1. *All these nutrients are needed by plants to grow, and by the stock that eat the pasture. Which soil pH is best for pasture? Why?*
2. *If the soil pH was 5.5, what could you do to improve it?*
3. *Describe the chemical effect of lime on soil.*
4. *What is the relationship between lime and molybdenum availability to plants?*
5. *Phosphorus, sulphur, and molybdenum are the most important nutrients for clover growth. Why would clover growth be poorer in acidic soils?*
6. *Too much manganese, iron or copper can be toxic or hinder plant growth. How can adding lime to acid soils help this problem?*
7. *Do you think it's possible to "over lime" a soil? Why?*

SOIL ACIDITY AND LIME

A soil may be acidic or it may be alkaline. It is important to know which you have you may need to alter the degree of acidity in order that the soil may be more fertile. The reasons for this are:

1. Micro-organisms that help convert organic material into humus are affected by the degree of acidity of the soil.
2. Plant nutrients are more available or less available depending on the acidity of the soil.

MEASUREMENT OF ACIDITY

The amount of acid or alkali in a soil is measured on a scale called the pH scale. (p = power; H = hydrogen ion. pH is a concentration of hydrogen).

pH 1 is extremely acid

pH 7 is neutral

pH 14 is extremely alkaline

Nearly all soil are between pH 4 and pH 8. At pH 4 a soil is strongly acid and at pH 8 a soil is alkaline. Usually the aim is to have a soil pH of about 6 which is slightly acid. At pH 6 to 7 the important element phosphorus is most available at pH 6. (These are elements necessary for growth, needed in very small amounts).

To measure the pH of a soil chemical an indicator can be used. An indicator changes colour at different pH levels. The simplest is litmus, and you have been supplied with some pink and/or blue litmus paper. Litmus is coloured pink at pH's below 7 and blue at pH's above 7.

HOW THE FARMER DETERMINES SOIL ACIDITY

To find out the pH of soils on his farm, the farmer can have the soil tested by the Ministry of Agriculture and Fisheries or a commercial firm. The test result is usually handled by a farm adviser who will make any necessary recommendations.

Exercise

(a) Draw a line to represent the pH scale and on it place the following:
pH 0, pH 7, pH 14, pH 6, acid, alkaline

(b) What soil pH is best for pasture and crop growth? Explain why?

LIME

The acidity of soil is decreased by adding lime. Most of the lime applied to soil on our farms is calcium carbonate which occurs as limestone in deposits throughout the country. The limestone is excavated and

ground to a suitable fineness and sold as lime. Most of it is applied by trucks that are fitted out with spinners to spread lime. (Other kinds of lime are used in horticulture but limestone is plentiful and the cheapest.)

CALCIUM

As well as helping to reduce acidity calcium is an element essential for growth, so most soils grow better plants when lime is applied.

Calcium is essential because it gives rigidity to cell walls and so is needed by green plants to reach maturity. It also helps new plant tissue grow. While limestone is plentiful in deposits scattered throughout the country most soils do not have a lot of calcium in them.

BENEFITS OF LIME ADDED TO SOIL

1. Reduces acidity - elements in the soil are most available to plants in a slightly acid to neutral soil and decay is rapid.

1. Improved soil structure because it
(a) encourages earthworms
(b) flocculates clay - brings clay particles together into "flocks" making the clay less sticky and friable, easier to cultivate, easier for roots to grow in. Supplies the element calcium.
2. Clover nodule bacteria are more active in less acid soil.

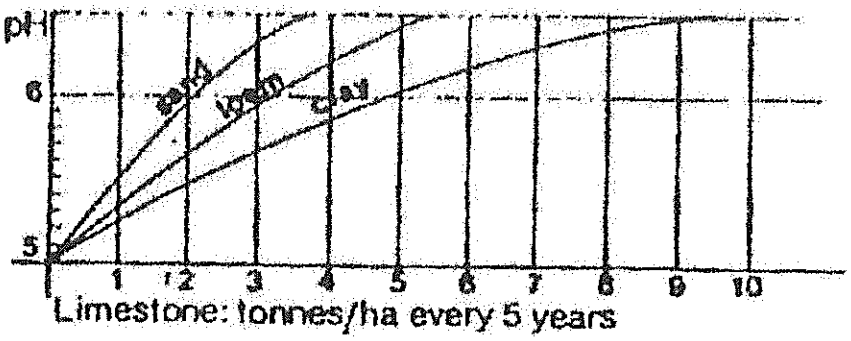
In summary the addition of lime can greatly improve growing conditions for plants

AMOUNT OF LIME TO APPLY TO SOILS

The amount of lime required is the amount needed to raise the pH of the soil to the level that results in the greatest production from the crop to be grown in that soil.

A clay soil will need more limestone to reduce acidity than a sand. The graph below shows the lime required for three soils each with the same initial pH of 5.0. Note that it is usual to apply lime about every 3 to 5 years rather than each year. This is just as effective and less costly than applying it more often.

To "read" the graph you need to know that the present pH is 5.0 and also decide what pH is desirable. If you have sand at pH 5 and want to increase the pH to 5.5 first find 5.5 on the upright (vertical) axis at the left. Next draw a line from the 5.5 mark parallel to the bottom line (the horizontal axis) to meet the curve marked "sand". This meeting point tells you how much lime to apply. The amount is below the meeting point on the bottom line and in this case is 1 tonne per hectare every 5 years.



The amount of lime to apply should be checked by taking pH readings of the soil every few years.

SOIL ACIDITY AND LIME

Largely due to high rainfall a great majority of NZ soils are highly acidic. Most NZ soils are in the range of pH 5-6.5. Soils of pH greater than 7 (ie alkaline) are found in regions of low rainfall and high temperatures.

Exercise

Read the handout ***"SOIL ACIDITY AND LIME"*** *and answer the following questions.*

1. *Why is it important to know the pH of a soil?*
2. *List reasons why soil pH should be between pH 6 and pH 7.*
3. *Explain how soil pH is measured.*
4. *How does a farmer determine how acid or alkaline the soil is?*
5. *How is soil acidity reduced?*
6. ***"Lime"*** *What is it?*
   Where does it come from?
7. *List the benefits of adding lime to a soil.*
8. *Explain why different soils require different amounts of lime to reduce acidity.*

Soil Fertility/Nutrients

There are a number of elements needed for good plant growth.

Macro nutrients: Nutrients needed in large quantities

C H O N P S K Ca Mg

Micro nutrients: Nutrients needed in small quantities

B Zn Cu Mo Cl Fe Mn Co Se

These elements are supplied in natural circumstances by the weathering of parent material and the gradual decomposition of plant and animal remains by bacterial and fungal activity. However man's activities eg cropping, harvesting hay and silage, and removal of animal products can deplete these nutrients and therefore supplements may be needed. Some soils can be naturally deficient in one or more of these nutrients eg Cobalt and Selenium.

Some functions of elements taken-up by plants

Element	Approximate contribution to dry weight of plant	Some Functions
Macronutrients		
Nitrogen	1 – 3%	Forms part of the structure of amino acids, proteins, nucleic acids and chlorophyll.
Potassium	0.3 – 6%	Takes part in enzyme, amino acid and protein synthesis. Forms part of cell membranes.
Calcium	0.1 – 3.5%	Forms part of cell walls and enzymes. Affects cell permeability.
Phosphorus	0.05 – 1%	Takes part in energy transfer processes. Forms part of nucleic acids, enzymes and phospholipids
Magnesium	0.05 – 0.7%	Forms part of chlorophyll and activates many enzymes.
Sulphur	0.05 – 0.7%	Forms part of some amino acids and proteins.
Micronutrients		
=Iron	10 – 1,500 ppm (parts per million)	Takes part in chlorophyll synthesis. Forms part of pigments.
Chlorine	100 – 300 ppm	Affects osmosis and ion balance. Takes part in photosynthesis.
Copper	2 – 75 ppm	Activation of some enzymes.
Manganese	5 – 1,500 ppm	
Zinc	3 – 150 ppm	
Molybdenum	Trace	Affects nitrogen metabolism.
Boron	2 – 75 ppm	Influences calcium uptake and possible involved in carbohydrate transport.

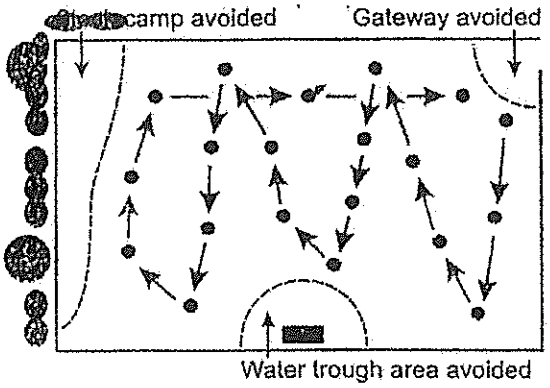
SOIL FERTILITY

Summary

1. The correct soil fertility is critical for best pasture and crop growth.
2. Soil test prior to sowing to check soil fertility.

SOIL SAMPLING

Do not sample within three months of applying fertiliser or lime.

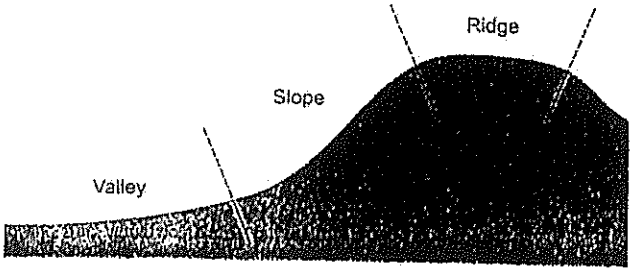


How to sample pasture

- Collect 15-20 cores per paddock
- Core to 7.5cm depth
- Avoid troughs, gates, trees and abnormal areas
- Do not sample immediately after grazing

Hill Country Sampling

- If areas of different aspects are large enough, sample them separately.



Exercise Soil Fertility

1. *Explain why soil fertility is critical to achieve the best pasture and crop growth?*
2. *Explain the reason for soil testing.*
3. *State the pH level at which improved pasture plants such as perennial ryegrass grow best and explain why?*
4. *Why should a grower avoid collecting soil samples?*
   a) *three months after applying fertiliser*
   b) *from stock camp areas, gateways, water troughs and high traffic areas.*
   c) *immediately after grazing.*
5. *Explain how soil samples should be taken.*
6. *Discuss why areas of different aspects should be sampled separately.*

Exercise ***Soil Test Information Worksheet***

Using the data on the next page answer the following questions.

1. *Explain the difference between macro and micro nutrients.*
2. *Why would you recommend to farmers that they should have soil tests carried out on their farm.*
3. *When carrying out soil tests why should farmers take soil samples from the whole farm?*

Using the information on the worksheet answer the following questions.

4. *Which soils would you recommend a farmer lime?*
5. *List **three** benefits that can be gained from liming these soils.*
6. *List the biological optimal for the following nutrients.*

   P Phosphorus

   K Potassium

   S Sulphur
7. *Which soils need fertiliser and why?*
8. *There are several fertilisers listed below. Which one would you recommend the farmer use? Explain why?*

A	26	0	0	14
B	12	5	14	8
C	12	10	10	0
D	0	10	0	11
E	0	0	42	18

9 A dairy farmer farming on a sandy loam soil is considering two management practices to improve soil fertility. These are:-

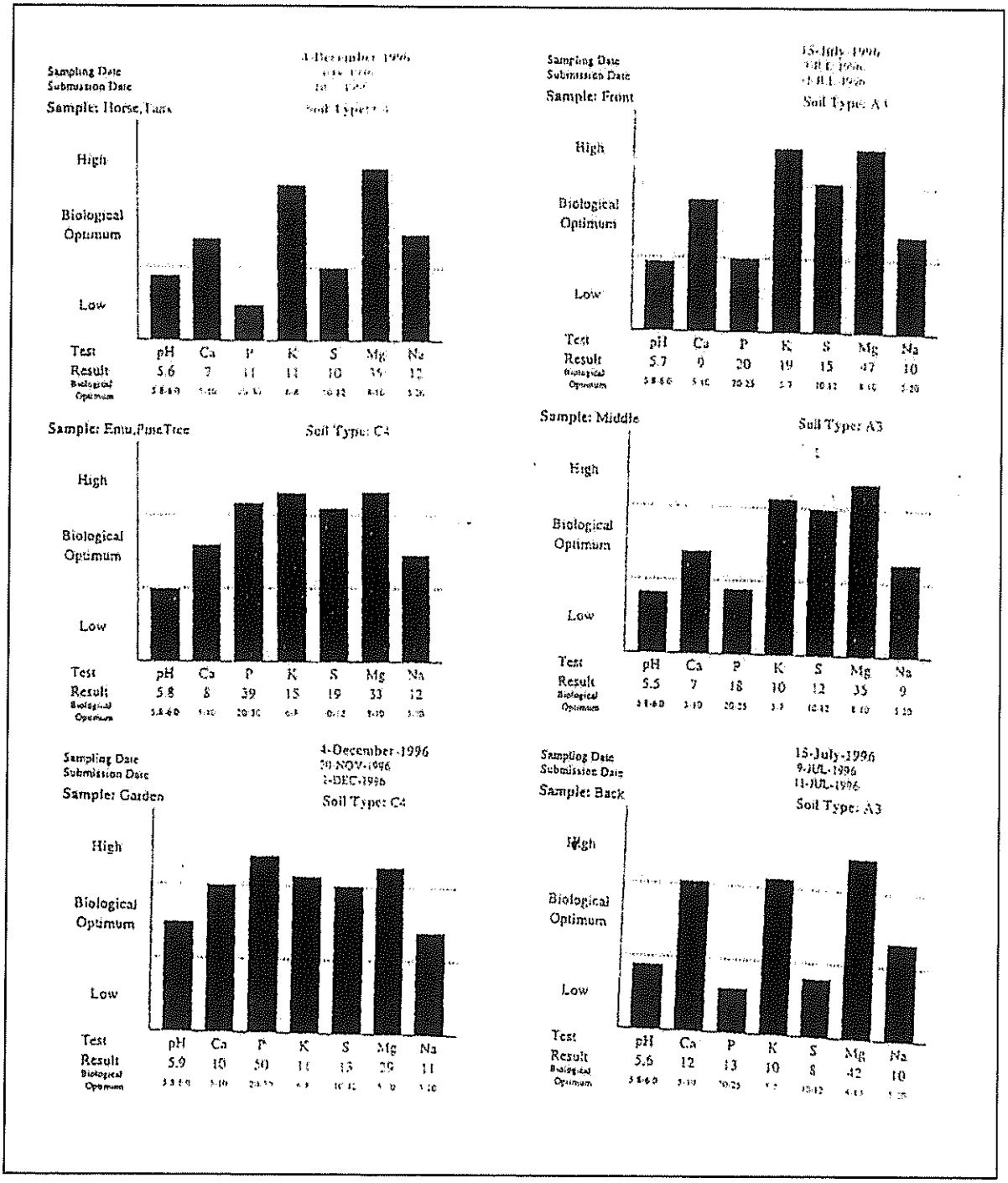
- applying fertilizer
- land applying effluent from the dairy shed

Select the management practice you consider will be best to improve soil fertility without having a negative effect on the environment.

Selected management practice: _____

Give reasons why the selected management practice is better than the other management practice in terms of:-

- impact on the environment
- farm financial returns



Sample	pH	Ca	P	K	S	Mg
Front	5.7	9	20	19	15	47
Middle	5.5	7	18	10	12	35
Back	5.6	12	13	10	8	42
Optimum levels	5.8 – 6.0	10 – 20	20 – 25	8 – 10	12 – 15	8+

FERTILISERS

There is a wide range of fertilisers in New Zealand. Some are single (ie only contain one element eg sulphur) while some are compound fertilisers containing a number of nutrients in chemical combinations eg N.P.K.S.

Types of Fertiliser

Standard Fertilisers

There are four elements that are needed most by plants for growth.

N Nitrogen

P Phosphorus

K Potassium or Potash

S Sulphur

Standard fertilisers contain large amounts of these elements.

Nitrogen	urea, sulphate of ammonia
Phosphorus	superphosphate
Potassium	muriate of potash, sulphate of potash
Sulphur	superphosphate, elemental sulphur

N.P.K.S. refers to the percentage of each element in the fertiliser.

Sometimes two or more of the standard fertilisers are physically mixed together to give fertiliser with different proportions of N.P.K. and S.

Nitrogen Fertilisers

Clover in pastures in New Zealand produces most of the nitrogen required for pasture growth but substantial responses to fertiliser nitrogen will occur in the following circumstances.

a) Newly sown pastures, before clover plants have begun to supply sufficient nitrogen for growth.

b) Winter pastures where temperatures are sufficient for grass growth but are too low for nitrogen fixing in clovers to be happening.

c) Spring pastures in all parts of New Zealand. The available of soil nitrogen in spring restricts spring growth when moisture and temperature are otherwise adequate.

d) Late spring/early summer pasture for the production of hay or silage crop

Organic Fertilisers

Organic fertilisers are manufactured from freezing works by-products and animal manures. Eg:

- blood and bone
- dried blood
- bone dust
- garden galore

Fertiliser Solutions

Fertiliser solutions are fertilisers dissolved in water. These are often used in the horticulture industry in irrigation systems or hydroponics. They have the advantages of a more even and accurate application and can be used to target specific growth stages of the plant.

Exercise

1. *What information should a grower find on a fertiliser bag?*
2. *Describe the difference between inorganic and organic fertilisers.*
3. *Describe an advantage and a disadvantage of each type of fertiliser.*
4. *For each for the following situations:- how would you apply fertiliser and explain why?*
    - *1ha of broccoli that was transplanted 4 weeks ago.*
    - *2ha of sweetcorn 1m high*
    - *A 10ha kiwifruit orchard in December when the fruit are growing.*
    - *A 5ha paddock being cultivated to sow potatoes in.*
    - *Nitrogen to a 5ha paddock on a dairy farm*
    - *Superphosphate onto a 3000ha hill country sheep and beef farm*
    - *DAP fertiliser to 40ha of flat land*

SOIL EROSION

Erosion is the removal of topsoil by;

1. Weathering (this occurs over a period of time).
2. Corrosive action (wind, rain).
3. Removal and interferences by man.

Accelerated Erosion: is when erosion in increased (speed up because of man's activities) for example

- indiscriminate burning.
- overgrazing.
- liberation of pests (rabbits, opossums, deer).
- felling of steep forest country.

New Zealand had a high potential for erosion because

- the fragile soft rocks (especially in mountain areas) are easily eroded.
- the shallow soil in many areas of New Zealand.
- activities by man in producing animals and crops and removing vegetation.

Causes of erosion

- burning and clearing vegetation or bush.
- over grazing of pastures.
- pests
- bull-dozing steep hill sides.
- over cultivation

Effects of erosion

- Erosion leads to a decrease in the total land area suitable for use.
- Decreases the productivity of land.

Methods of erosion control in New Zealand

1. By good pasture management
   - choice of pasture plants
   - controlled grazing
2. Subdivision
   - to control grazing
   - fence off areas susceptible to erosion
3. Plant trees in susceptible areas, also as shelter belts
4. Plant trees to remove excess water.
5. Do not over cultivate
6. Pest control

Exercise

1. *What is erosion?*
2. *Draw a star diagram of the causes of soil erosion.*
3. *Describe three methods that a grower could do to reduce or prevent soil erosion.*
4. *For each method described above explain how it would reduce or prevent erosion.*
5. A farmer has a bad erosion problem on the hill country. The farmer is considering using a combination of **two** management practices:-
   - fencing off step parts and planting trees on the effected areas
   - reducing stocking rate.

   a. Explain how erosion has a negative impact on the environment

   b. Give reasons why a combination of these **two** management practices is important to reduce the negative impact on the environment.