Growing Plants Two

Growing Plants Two is the companion to the popular third and fourth form text, *Growing Plants One*. It contains many of the distinctive features that made *Growing Plants One* so successful, and some additions reflecting feedback from teachers —

- well-explained notes using targeted language
- clear line drawings and photographs
- practical and useful exam-oriented exercises throughout
- question panels to reinforce key points
- a summary of relevant work covered in *Growing Plants One* beginning relevant chapters
- practical activities to conclude each chapter

Growing Plants Two comprehensively fills the resource gap at this level and, with *Growing Plants One*, provides a very close correlation to the fifth form prescription.

Glennis Moriarty is an experienced teacher. Her horticultural text books are an extension of her teaching at Hastings Girls' High School and St John's College, Hastings. She is now working in Quality Publications for ENZA New Zealand (International).

Heinemann

ISBN 0-8686-3128-0
9 780868 631288

Growing Plants Two

G.K. Moriarty

H

Growing Plants

G.K. MORIARTY

Two

Yates

C. MATHIESON

C.D. MATHIESON
WRIGHT'S BUSH RD
R.D. 4 PH 2352653
INVERCARGILL

Growing Plants Two

G.K. MORIARTY

Heinemann

Published by Heinemann Education, a division of Reed Publishing (NZ) Ltd, 39 Rawene Road, Birkenhead, Auckland. Associated companies, branches and representatives throughout the world.

ISBN 0 86863 128 0

© 1995 G. K. Moriarty
First published 1995
Reprinted 1996
Printed in New Zealand

The author and publishers wish to thank Yates New Zealand Ltd for their financial assistance. Also the New Zealand Qualifications Authority for permission to reproduce copyright material.

Illustrations by Lisë Knowles.
Typeset by Graeme Leather.
Cover photograph by David Hollander, Lincoln University.

Contents

Author's note

Growing Plants Two is intended to be used in conjunction with *Growing Plants One* to completely cover the School Certificate Horticulture prescription. Where a connection between the two books exists, a summary of the material already covered in *Growing Plants One* is provided at the beginning of the chapter.

Section One

The Plant World

1 Plants

SUMMARY

Horticulture is the science which deals with growing plants successfully. In New Zealand, horticulture is important for food production, export earnings, employment and aesthetic reasons. Plants are used for many purposes including food, fibre, building materials, erosion control, medicines, industrial chemicals, fuels and recreation.

Plants are different from animals because green plants are able to make their own food by the process of photosynthesis. As well, plants carry out basic life processes; respiration, water uptake and transpiration, transport of nutrients, excretion, growth, and dispersal.

The structure of a green plant is related to its life processes. The form of root, stem, leaf, flower and fruit enables each to carry out its particular function.

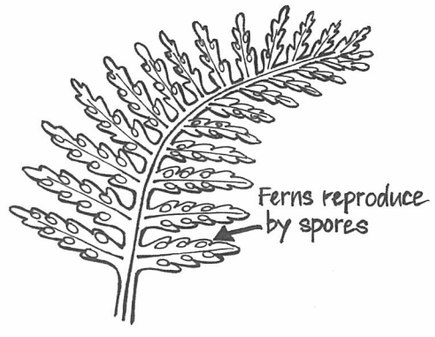
A plant grows well when it has all the things it needs, in the right amounts. The main factors affecting growth are water, air, light, nutrients, temperature, wind, humidity and pests and diseases.

Plant variety

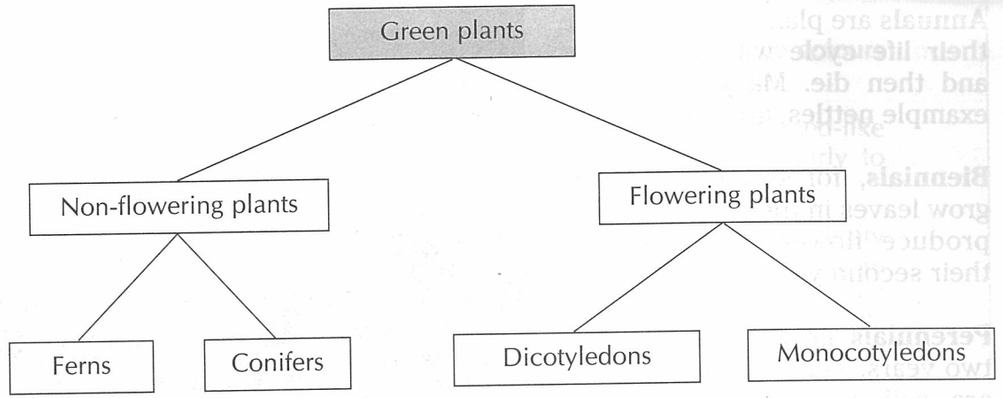
There is great variation in the plant kingdom, with each group of plants having its own way of life and its own special needs.

The plant kingdom can be divided into two major groups: plants that never have flowers and plants that do have flowers.

The non-flowering plants include ferns and conifers. Ferns reproduce by spores which form beneath their fronds. Conifers have cones instead of flowers.



The flowering plants can be divided into two major groups; monocotyledons, which have long thin leaves with parallel veins, and dicotyledons, which have leaves arranged in a branching pattern.



Questions

1 What are the two major groups in the plant kingdom?
2 How do ferns reproduce?
3 What do conifers have instead of flowers?
4 How do monocotyledon leaves differ from those of dicotyledons?

Exercise

Read the story about Bill Smith's garden. Then make a list of the plants in Bill's garden. Beside each plant write the name of the group (fern, conifer, monocotyledon or dicotyledon) to which the plant belongs.

Bill Smith got up early to work in his garden. He walked over the grass to pick some grapes from the grape vine. On the way he stopped to see if the sweetcorn seeds had sprouted through the soil. He noticed that some fronds from the punga had blown off in the wind and the pine tree had shed a lot of its needles. Fortunately the roses were undamaged. There were some dandelion plants in the cracks in the path.

"Must get rid of those," thought Bill. His potatoes and beans were doing well. The flax bush gave them good shelter from the wind. He picked some flowers to take inside — a bunch of sweet peas and some lilies. The clover in the lawn was attracting the bees.

"They will help to pollinate the peach tree," Bill said to himself.

Other plant groups

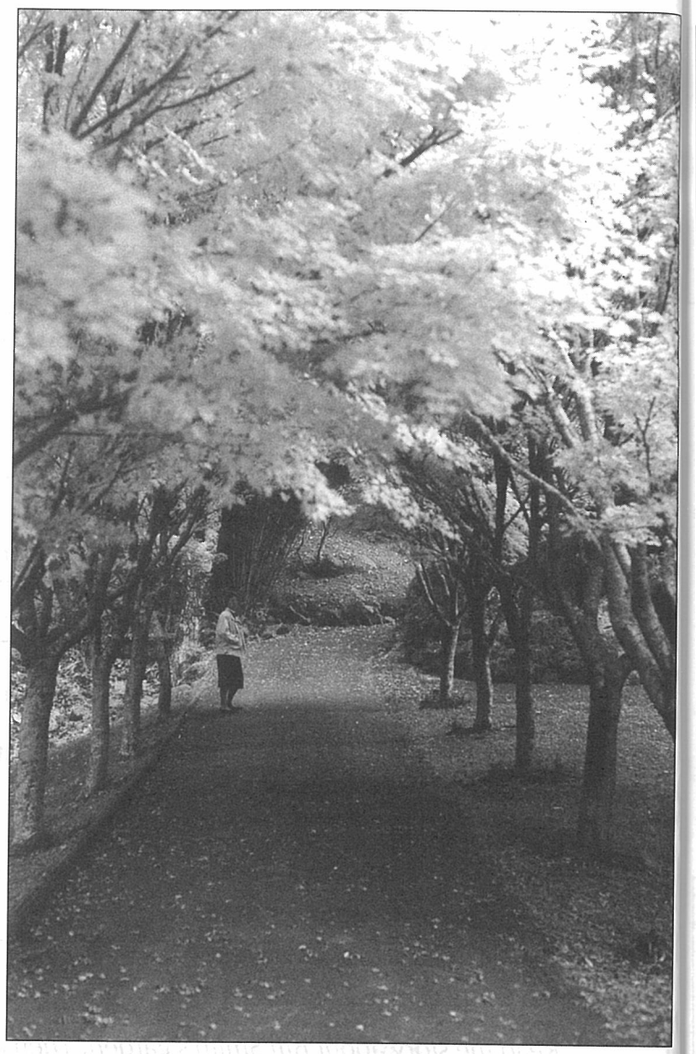
Plants can also be grouped according to how they grow and how long they live.

Annuals are plants that complete their life cycle within one year and then die. Many weeds, for example nettles, are annuals.

Biennials, for example parsley, grow leaves in their first year and produce flowers and seeds in their second year.

Perennials grow for more than two years. Those with soft stems are called **herbaceous perennials**, for example chrysanthemums. Those with tough stems and branches are called **woody perennials**. Shrubs and trees are woody perennials. Shrubs are bushy and less than three metres high. Trees are taller and have one single main trunk.

Trees and shrubs that do not lose all their leaves in winter are called evergreens, for example camellias. Those that lose their leaves are said to be deciduous, for example apple trees.



Deciduous trees

Questions

1 Give an example of an annual weed.
2 What sort of growth do biennials make in their first year?
3 What is the difference between herbaceous and woody perennials?
4 What is a word that means "losing its leaves in winter"?
5 Give an example of an evergreen tree.

Exercise

Use the information given below to say whether each plant is an annual, biennial, perennial, or deciduous or evergreen shrub or tree AND give a reason for each answer.

1 SILVER BIRCH Distinctive silvery bark, fast-growing tree. Foliage colours to yellow in autumn, bare in winter. Will grow in most soil types.

2 SPANISH BROOM Bushy, up to three metres high with green reed-like almost leafless stems and brilliant yellow flowers. Cut back yearly to maintain its shape.

3 SNAPDRAGON Plants vary in height from twenty-five to ninety centimetres. Long attractive spikes are useful as cut flowers. Time from sowing seed to flowering is up to five months. Will self-sow if seed is not allowed to dry out once the plant has died.

4 GERANIUM Versatile and easy to grow in most soils from cuttings taken from soft stems. Vary in size up to about two metres. Hardy plants which will give a steady supply of flowers for years if kept slightly dry.

5 FOXGLOVE Will grow in sun or light shade. Produces soft green leaves in the first year, then spikes of tall flowers provide a good garden accent in the second summer. Sow seed in spring.

The physical environment

The members of any one group of plants can vary in response to their physical environment, so that they appear different from each other even though they are closely related.

Plants growing in shady areas often have larger leaves than their relatives in sunny places, to make use of all available light.

Where water is limited plants may appear small and stunted. Leaves will be tough and flowers and fruit reduced in size.

In a windy position there will be fewer leaves on the windy side. Trees may develop a permanent 'lean' away from the prevailing wind.

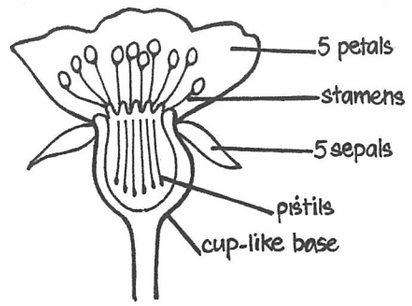
Minerals in the soil can affect plant colour, as can temperature. Many roses, for example, have flowers of a different shade in spring from those they produce in autumn.

Questions

1 Why do plants growing in shady areas often have larger leaves than their relatives in sunny places?
2 How may plants look if water is limited?
3 What effect may limited water have on flowers and fruit?
4 Give two physical factors that can affect plant colour.

Naming plants

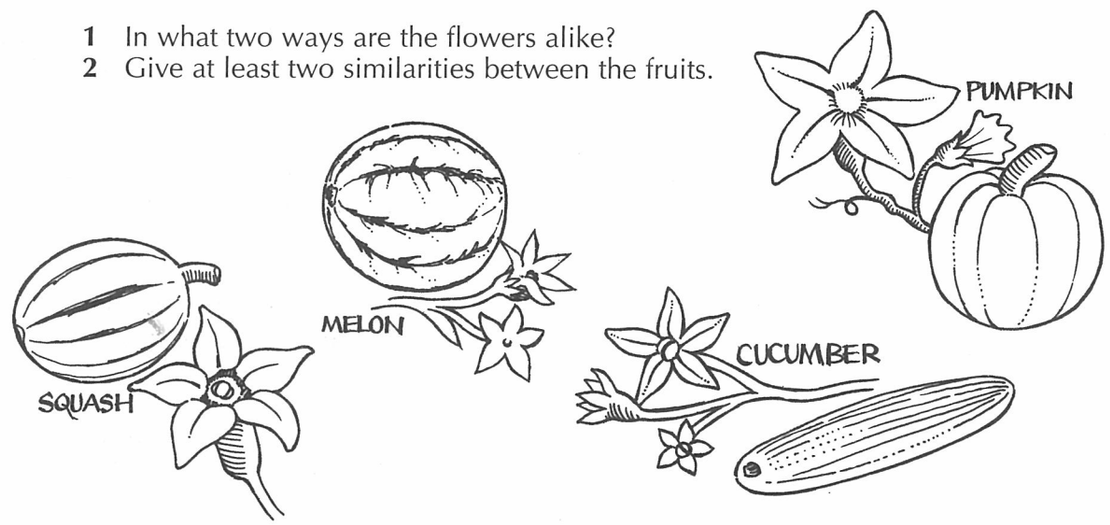
Within their larger groups or types, plants are grouped into families which share similar characteristics. Flowering plants have been divided into families chiefly on the basis of the various differences in flowers. Relationships within a family are best seen when you look inside flowers and fruits. For example, all members of the rose family (Rosaceae) have flowers with five petals or multiples of five petals. The base of each flower is turned up like a cup around the pistils. Stamens, petals and sepals are attached to this cup. As well as roses, apples and pears are members of the Rosaceae.



Exercise

Study the diagram showing several members of the pumpkin family (Cucurbitae). Then answer the questions.

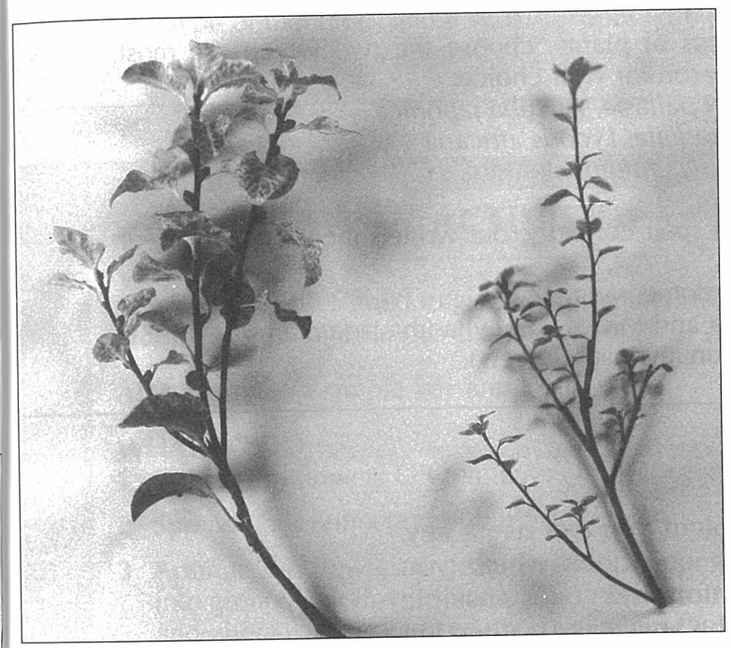
1 In what two ways are the flowers alike?
2 Give at least two similarities between the fruits.



Genus and species

Every species of plant has a two–part scientific name. These names are often in Latin or Greek because these are the languages understood internationally by plant growers. The second name is that of the species itself while the first name is that of the genus in which it is classified. A genus group is a group of very similar species within a family.

As an example, the New Zealand native trees *Pittosporum eugenoides* (the Tarata) and *Pittosporum crassifolium* (Karo) are both members of the family Pittosporaceae. They belong to the same genus — *Pittosporum* — but are different species. They are classified like this:



Two *Pittosporum* cultivars

Family: Pittosporaceae

Genus: *Pittosporum*

Species: *P. eugenoides*, *P. crassifolium*

Sometimes a third name is added. This is the sub-species or variety.

If a new variety, or cultivar, has been grown by a plant breeder it is given a modern name that usually describes its characteristics. An example is *Pittosporum tenuifolium* 'Purpureum' which has deep bronze to purple leaves.

The names of genus and species should be written in italics or underlined. The name of the genus is given a capital letter but the species name is not. The cultivar name is written in ordinary type and is not underlined. It is usually put in single inverted commas. When the name of the genus has been written in full once, you can just use its initial for the rest of a piece of writing. For example, *Pittosporum crassifolium* can be written as *P. crassifolium*.

Two plants which belong to the same genus and species are more closely related to each other than those which belong to different species, no matter what they look like.

Questions

1 On what basis have flowering plants been divided into families?
2 What do all members of the Rosaceae have in common?
3 Why are scientific names often written in Greek or Latin?
4 What is a genus group?
5 How are cultivars usually named?
6 Explain how to write the names of genus and species.

Exercise

1 From the following groups of plants, choose the two which are most closely related. Give a reason for your choice.
   a *Aulax cnerifolia, Aulax pallasia, Aucuba japonica*
   b *Lycoris radiata, Pinus radiata, Lycoris africana*
   c *Colchicum autumnale, C. autumnale* 'Alba', *C. byzantium*

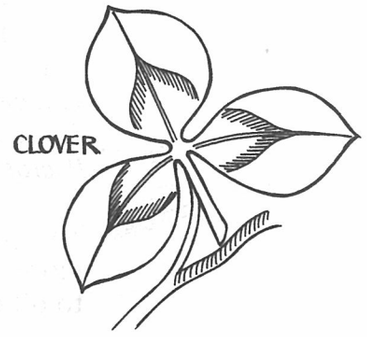
2 The following names are spelt correctly, but written incorrectly. Correct them.
   a punica Granatum (the pomegranate)
   b Macadamia Integrifolia and Mac. tetraphylla (macadamia nuts)
   c persea americana Bacon (avocado variety)

Using a key

To find the name of an unknown plant you can use a key. The most useful sort of key has questions which you answer one by one. Each question has two possible answers. When you have chosen the answer to a question for your unknown plant the key leads you to the next pair of questions and, finally, to the identity of the plant.

Exercise

Here is a diagram of a clover leaf. Use the key on the opposite page to identify this type of clover.



Key to identify clovers

1	Number of leaflets on leaf:		3 . . . go to 2 4 . . . Shamrock
2	Narrow leaflets:		go to 3
	Broad leaflets:		go to 4
3	End of leaflet:	pointed	Narrow leafed clover; *Trifolium angustifolium*
		rounded	Haresfoot trefoil; *Trifolium arvense*
4	Leaflets:	plain	Horned oxalis; *Oxalis corniculata*
		with markings	go to 5
5	Type of marking:	central spot	Spotted burr medick; *Medicago arabica*
		v shaped	White clover; *Trifolium repens*

ACTIVITY

This activity is designed to give you practice in sorting plants into groups which have similar characteristics.

AIM: To make a simple key and use it.

WHAT TO DO:
1 Collect ten flowers OR ten leaves from different plants.
2 Spread your collection out in front of you.
3 Arrange the flowers or leaves which are similar in some way into groups. For flowers, look at symmetry, count petal numbers and check where stamens and pistils join the stem. For leaves, look at the vein patterns and leaf outlines. Try not to use colour for grouping. You should end up with three or four groups. Label each group A,B,C,D.
4 For each group write down its main characteristic, for example, 'Group A leaves all have parallel veins'.
5 Make a two-choice key so that another person could put a plant in its group.
6 Test your key by giving it and a leaf or flower to a partner. See if he or she can say which group the plant came from.

REPORT:
Write a report of this activity and copy your key into your notes.

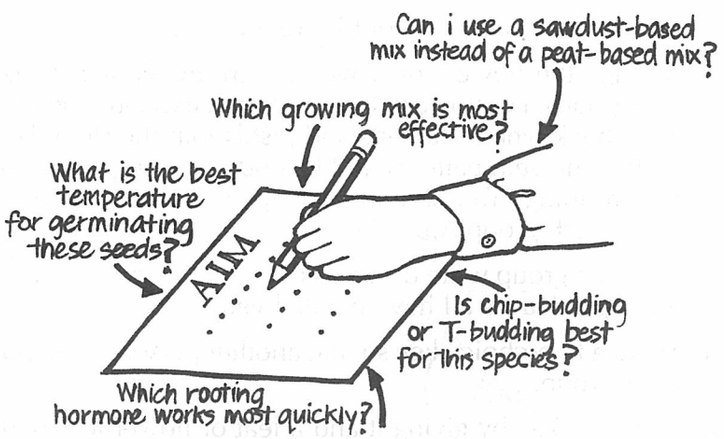
2 Experiments with plants

There are many reasons why a grower might want to run small-scale experiments. The grower might want to try out a new fertiliser or potting mix, or be considering new methods of budding or grafting. There might be a need to try new cutting or rooting hormones, or new methods of weed control. Whatever the reason, the same important principles of good experimental design will apply. It is necessary to set objectives, use a control, use a sufficiently large sample to get reliable results, and to avoid bias. There should be some method of recording precise results so that conclusions can be made.

Setting objectives

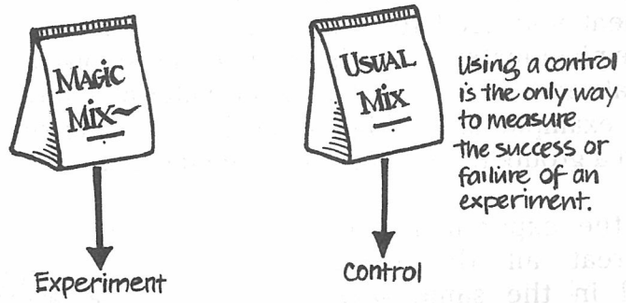
Before starting an experiment you must know what the **aim** of the experiment is. Then you can more easily set up the experiment, because you know what you are trying to find out. It helps to write the aim down.

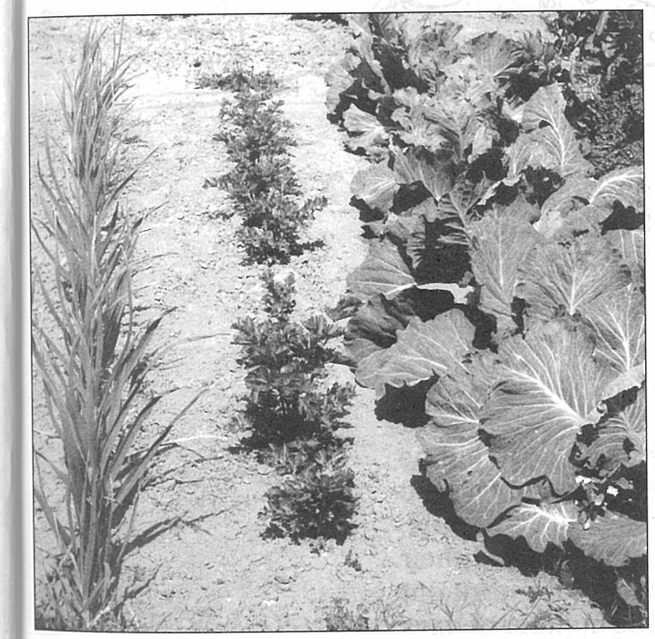
In any experiment it is important to test only **one** method or material at a time. For example, you may test which temperature is most suitable **or** which seed-raising mix is best for germinating seeds, but you should not test both these factors in the same experiment because you will not know which factor has given you the results you get.



Using a control

When you are carrying out an experiment you must have something to compare it with. So you set up **two** trials, one with the new method or materials you want to test, and the other with the method or materials you normally use. The comparison experiment is called the "control". Since you already know the results it should give, you can use it to check that the results of the whole experiment are reliable. For example, if you want to test a new potting mix you would set up one trial using the new mix and another trial, the control, using your usual potting mix as a comparison.





Plants vary in size and shape in any batch

Sample size

In any batch of plants, the plants will vary in size and shape. If you use only one plant in an experiment you cannot be sure if the way it grows is due to the treatment you give it or natural variation. You must use a number of plants, so that individual differences average out and you get reliable results.

The number of replicates to use depends on such factors as how many are available, and what space, time and labour is available. For a small-scale experiment, ten is a suitable number of replicates to use, although in large-scale nursery trials hundreds of replicates will be used.

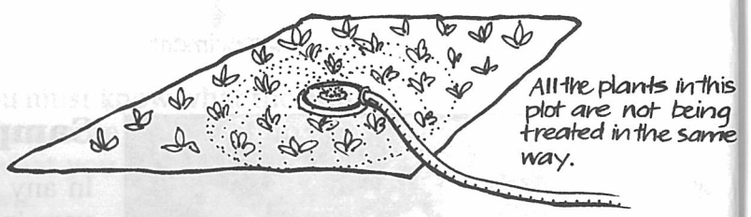
Questions

1 Suggest two reasons why a grower might want to run small-scale experiments.
2 What should you write down before starting an experiment?
3 Why should you test only one method or material at a time?
4 Explain how to use a control and give an example.
5 Why should you always use more than one plant in an experiment?

Avoiding bias

So that you can make valid conclusions about an experiment you need to avoid bias from start to finish. First, the plant material (seeds, cuttings and so on) must be chosen at random. If you select plant material in any other way, for example all the biggest seeds, or all the smallest plants in a group, then you are introducing bias.

During the experiment you must treat all the plant material in the same way. Conditions such as watering, spraying, temperature and light must be the same for all the replicates so that the factor being investigated is the **only** thing that is different between the experimental plants and the control plants. Then you can be sure the results you get are not caused by some other factor than the one you are investigating.



Results

Although general observations are often useful they are not a very good way of comparing the effects of materials or methods on plants. Some sort of precise results should be recorded. These will depend on the kind of experiment you are carrying out. For a potting trial, for example, measurements could include the height of plants and their stem diameter. For a propagation trial you could work out the percentage of cuttings that root and the number of days they take to root.

When the results have been taken you work out an average result for both the experimental plants and the control plants so a comparison can be made.

Example of a small scale experiment

AIM:
To compare the flower size on disbudded carnations with those that have not been disbudded.

METHOD:
Use twenty similar carnations in bud.
Remove all buds except the central bud of ten plants.
Do not disbud the other ten plants at all (the control).
Grow all twenty plants in identical conditions.
When the plants have flowered measure the diameter of all flowers.

RESULTS: (It is easiest to show results on a table.)

Average flower diameter for each plant (mm)

Plant number	1	2	3	4	5	6	7	8	9	10	Total
Disbudded	22	35	30	41	28	33	36	24	30	31	310
Control	11	25	17	26	18	12	20	24	19	18	190

Average diameter for disbudded plants = 310/10 = 31mm
Average diameter for control plants = 190/10 = 19mm

(You get the average for each set of plants by dividing the total by the number of plants — in this case, ten.)

CONCLUSION:
Flowers grow larger on carnations that are disbudded.

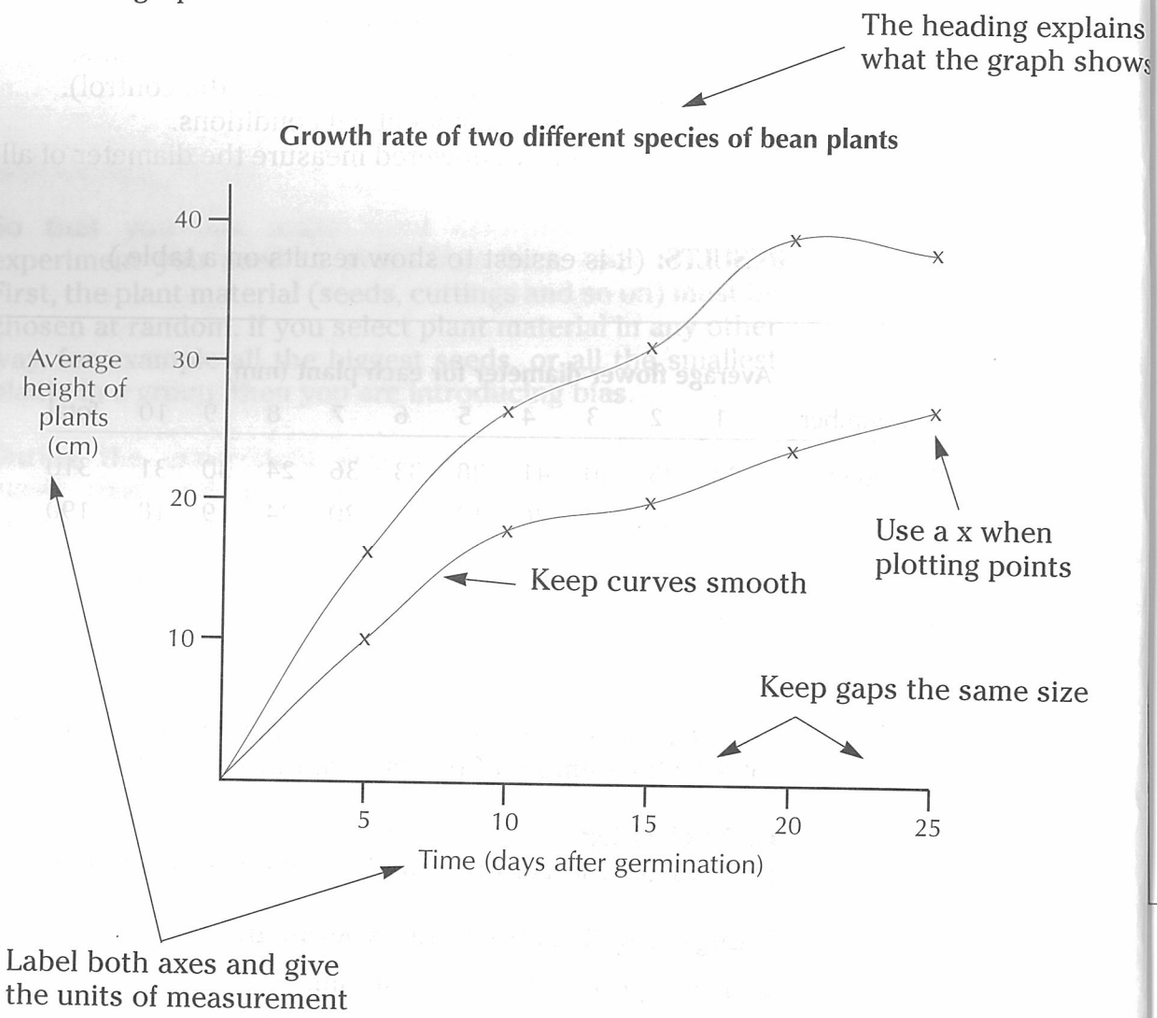
Things to notice about this experiment:

- The experiment has a clear aim.
- A suitable number of plants is used.
- There is a control.
- All plants are treated exactly the same, except for disbudding.
- Measurements are taken to give precise results.
- The average measurements enable a conclusion to be made.

Graphs

Sometimes it is useful to turn tables of results into graphs so that the results are easier to see and comparisons can be made more easily.

Rules for graphs:



Questions

1 Why must you always avoid bias in an experiment?
2 Give two ways you can try to avoid bias.
3 What is meant by 'precise results'? Give an example.
4 How do you calculate an average result?
5 Copy the "Rules for graphs" diagram into your notes and label it fully.

Exercise

The effects of weedkillers
The effect of some weedkillers lasts longer in the soil than others.

Three students were asked to trial three new weedkillers on an area of wasteland. Each weedkiller was sprayed on three square metres of wasteland which was cleared after the weeds had died. Every eight weeks radishes were sown in a section of each sprayed area.

The percentage of radishes which germinated after two weeks was calculated. The table shows the results:

% Germination of radish seeds

Time of sowing in weeks after weedkiller application	Weedkiller A	Weedkiller B	Weedkiller C
8	60	0	0
16	70	0	0
24	95	3	2
32	No reading	18	5
40	No reading	No reading	No reading
48	No reading	60	15

What to do:
1 Graph these data. Plot three lines, one for each weedkiller.
2 No sowing was made at 40 weeks. From your graph work out the possible percentage germination of the radishes sown at 40 weeks for Weedkiller B.
3 Why were readings for Weedkiller A discontinued at 32 weeks?
4 Which weedkiller lasted longest in the soil?
5 Suggest a suitable CONCLUSION for this experiment.

ACTIVITY

Choose **one** of the questions on the following page. Design an experiment that will attempt to answer the question. Keep your proposed experiment as simple as possible and follow the rules discussed in this chapter. Say what measurements you would make and how you would present your results. If time is available, carry out your experiment.

1 What is the best temperature for germinating bean sprouts?

2 Does coloured light affect the growth rate of radish plants?

3 Are F1 hybrid plants really bigger and better than normal plants?

4 Does a little lime in soil encourage earthworms?

5 What is the best depth to sow pea seeds?

Section Two

Growing Media

3 Soil

SUMMARY

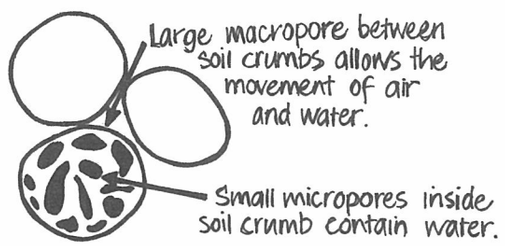
Soil is a complex mixture of organic matter, mineral substances, soil organisms, water and air. It provides air, warmth, water, nutrients and mechanical support for the plants that grow in it. Plant roots and soil organisms are found in the dark top layer of soil, the topsoil. Below the topsoil is the subsoil and then hard parent rock. Soil texture refers to the proportions of sand, silt and clay particles in the soil. Soils can be classified into sandy, clay or loam soils. Sandy soils have large particles and big air spaces. They drain easily and nutrients often leach out of them. Clay soils have tiny particles closely packed together. They stay cold and can become waterlogged. Loam soils are a mixture of sand and clay. They are best for growing most crops. Soil structure depends on how the mineral particles group together in the soil. The best soil for horticulture has a crumb structure. Soil structure can break down because of cultivation, compaction and water drop action. It can be improved by the addition of organic material.

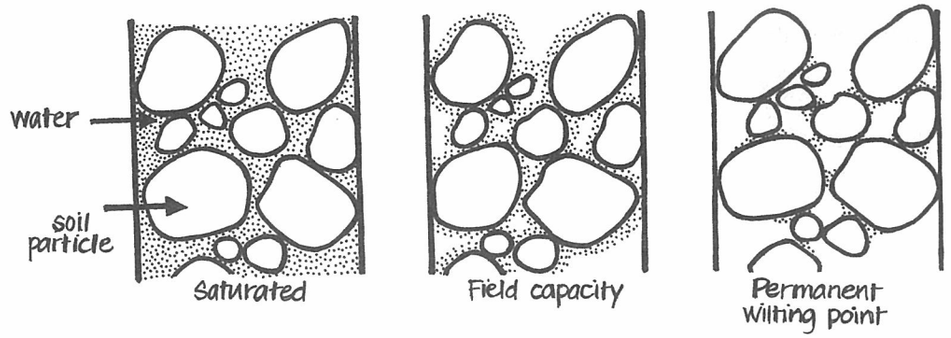
Soil contents

Water and air

Water is held in soil both inside and outside the soil particles.

In an ideal soil, pore spaces should occupy half the volume of the soil. In good growing conditions each pore space is filled half with water and half with air. This condition is called 'field capacity'. If there is too much water in the soil the pore spaces are filled with it and no air is present. The soil is 'saturated'. If there is not enough water there will be plenty of air available but the small amount of water will be held too tightly by the soil particles for plants to use. This condition is called 'permanent wilting point'.





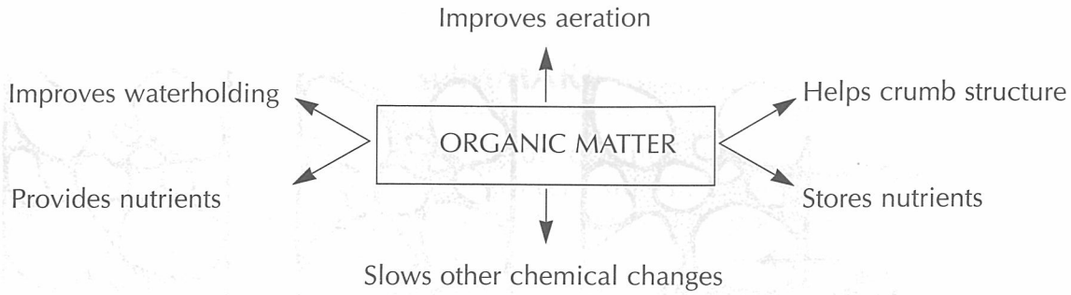
Rushes indicate that this soil is often waterlogged

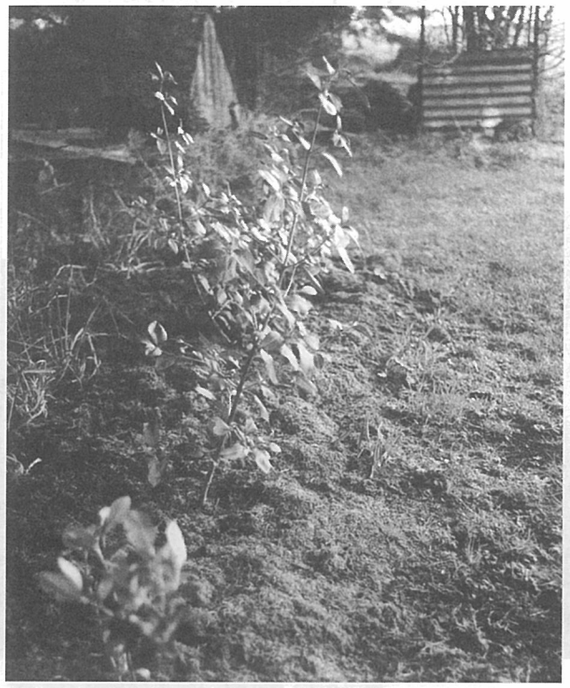
Organic matter

Organic matter, that is, non-living plant and animal material, has a big influence on the chemical and physical properties of the soil.

Organic material added to clay soil will improve both its drainage and its aeration because the organic material separates the soil particles. In a sandy soil it will prevent nutrients from being easily washed away because it helps the sandy soil to hold more water. Because it decomposes to form humus, organic matter helps the development of good crumb structure. Humus also helps to store and

provide the nutrients needed by growing plants and it slows the chemical changes that occur when lime and fertilisers are added.





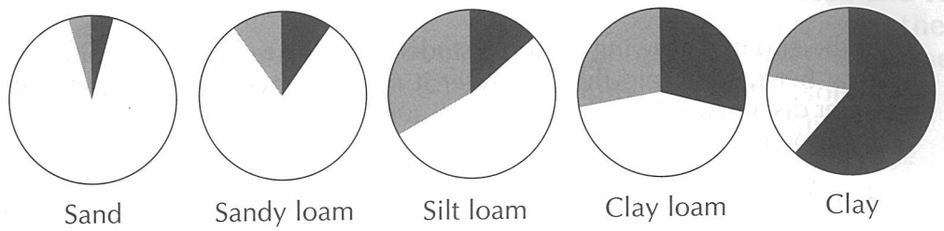
Organic matter as a mulch around young trees

Questions

1 Draw a diagram to show how water is held inside and outside soil particles.
2 Explain what is meant by 'field capacity', 'saturated' and 'permanent wilting point' in soil.
3 What is 'organic matter'?
4 How does organic matter improve a clay soil?
5 What effect does organic matter have on a sandy soil?

Exercise

1 The pie graphs show the proportion of sand, silt and clay in soils commonly found in New Zealand. The table gives the characteristics of sand and clay. Use the graphs and the table to answer the questions that follow them.



Characteristic	Sand	Clay
Water retention	Low	High
Drainage	High	Low
Fertility	Low	Higher
Rate of warming	High	Low
Cultivation ease	Easy	Difficult
Improvement	Hard	Easier

a Which soil would be the most free-draining?
b Would clay loam or clay be colder in winter?
c Which two soils would need additional nutrients?
d Which soil would be most difficult to cultivate?
e Which two soils would be most suitable for horticulture?

2 Three students were testing the TEXTURE of their home garden soils. Each put about 300mL of the soil into a measuring cylinder and then filled the cylinder with water. This was shaken vigorously and allowed to settle over a period of three days. The proportions of different particle sizes were measured and percentages calculated. These are shown in the table.

a Copy and complete the table of results by naming the soil texture. Give ONE characteristic of each soil texture other than particle size.

Student	% clay	% sand	% silt	% stones	Name of texture	Characteristic
A	76	20	4	0		
B	48	45	7	0		
C	12	68	8	12		

b Which student would have the most difficulty in growing vegetables in the garden in winter?
c Explain how the texture could be improved to overcome this problem of winter growth.
d Which student would have to water the soil most in summer?
e Which student would have the best natural balance of air and water in the soil?

3 At the end of a growing season a student dug the remaining organic matter from her garden into the soil. After it rained heavily she noticed that the water disappeared off the garden soil surface much more quickly than from a soil path nearby.

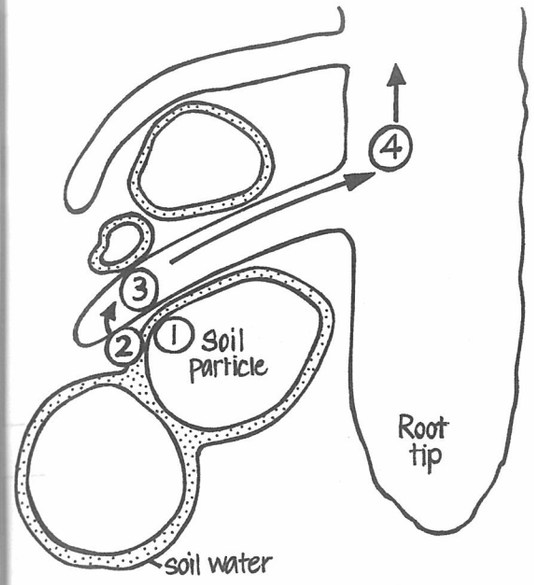
a What effect did the organic matter that she dug in have on the soil particles?
b Explain how this helped improve the drainage.
c State one other way that the organic material might improve the soil STRUCTURE.

Plant nutrients

Plant nutrients are the chemical elements that plants need for growth. There are sixteen essential elements. Some, called macronutrients, are needed in large amounts by plants. Others, called micronutrients or trace elements, are only needed in small amounts.

Macronutrients	Chemical symbol	Micronutrients	Chemical symbol
carbon	C	iron	Fe
hydrogen	H	manganese	Mn
oxygen	O	boron	B
nitrogen	N	molybdenum	Mo
phosphorus	P	copper	Cu
sulphur	S	zinc	Zn
potassium	K	chlorine	Cl
calcium	Ca		
magnesium	Mg		

Plants get these nutrients from the soil water. As the plants take up the nutrients they must be replaced in the soil water. Often nutrients are strongly attracted to soil particles. For example, phosphorus is held strongly by clay particles. Then these nutrients are not available to plants until they become dissolved in the soil water. Clay soils hold on to nutrients more strongly than sandy soils.

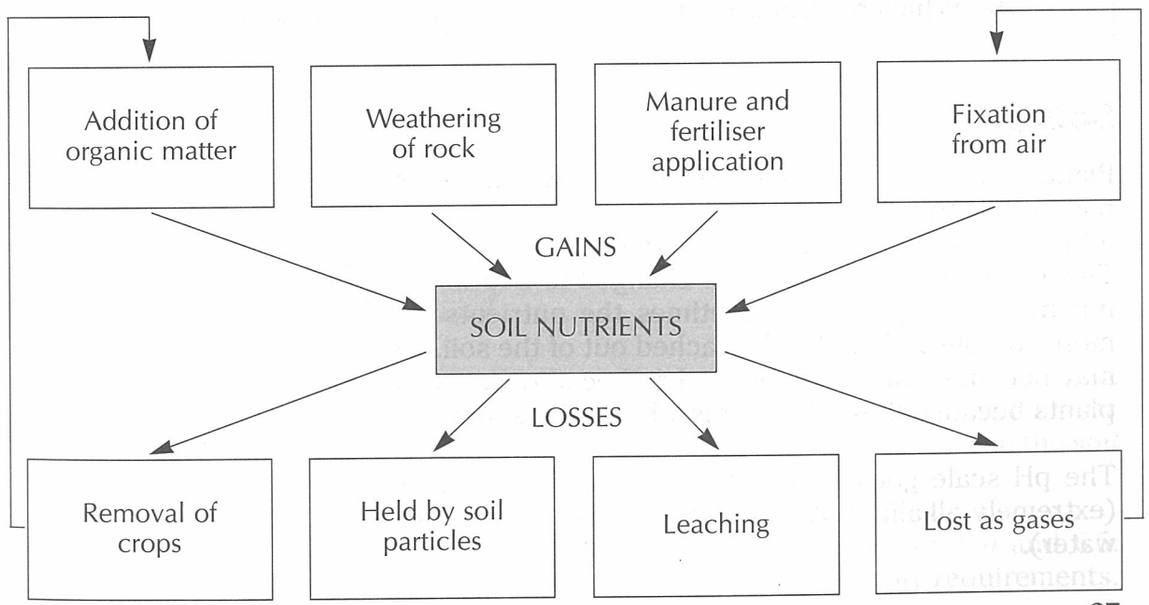


1 Nutrient held by soil particle
2 Nutrient in soil water
3 Nutrient passes into root hair
4 Nutrient moves up into plant

When you add organic matter to soil it is broken down to humus by bacteria and fungi. Nutrients are released from it that are either attracted to clay or humus particles or are dissolved in the soil water.

When plants are harvested and removed from the soil the nutrients they have taken up are removed with them. We return nutrients to the soil in the form of natural or artificial fertilisers.

The flow diagram summarises the movement of nutrients in and out of the soil:

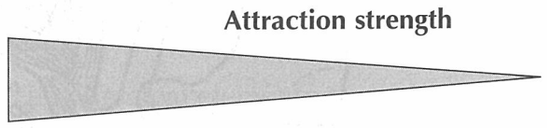


Questions

1 What is meant by "plant nutrients"?
2 What is the difference between macronutrients and trace elements?
3 Give the names and symbols of three macronutrients and three micronutrients needed by plants.
4 Copy the diagram showing how a nutrient moves into a plant.
5 What happens to organic matter when it is added to soil?
6 Why may plants find it hard to get nutrients from clay soils?
7 What effect does harvesting have on nutrient levels in the soil?
8 How do we return nutrients to the soil?

Exercise

Copy the diagram showing the attraction between soil particles and some nutrients and then answer the questions.



STRONG ——— MODERATE ——— WEAK

Phosphorus Calcium Magnesium Sulphur Potassium Ammonium Nitrate

a Which nutrient is held most strongly by soil particles?
b Which nutrient is most likely to be leached out of sandy soils?

Soil pH

Plant nutrients in the soil are not always in forms that plants can use. The soil pH (how acid or alkaline it is) influences the chemical reactions that take place in the soil. This can cause nutrients to be changed to a form that can not be used by plants. Sometimes the nutrients become more soluble and are easily leached out of the soil. Or they may become more insoluble and so become unavailable to plants because they will not dissolve in the soil water.

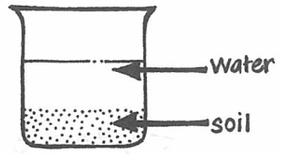
The pH scale goes from pH 1 (extremely acid) to pH 14 (extremely alkaline). A soil with pH 7 is neutral (like pure water).

Soil pH value	Term
9.0	Very strongly alkaline
	Strongly alkaline
8.0	Alkaline
7.0	Neutral
6.0	Acid
5.0	Strongly acid
4.0	Very strongly acid

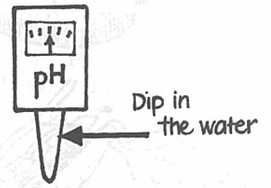
It is useful for growers to be able to measure soil pH so that they can alter it if they need to, in order to suit the crop they are growing.

You can check the pH of your soil using pH paper or a pH meter.

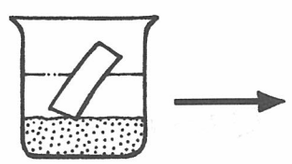
1 Shake one part of soil with 2.5 parts of distilled water and allow it to settle for several hours.

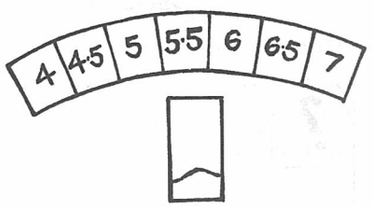


2 Measure pH by dipping the pH meter in the water.



3 Or measure pH by dipping pH paper in the water and then comparing the colour of the paper to the colours on the pH paper chart.



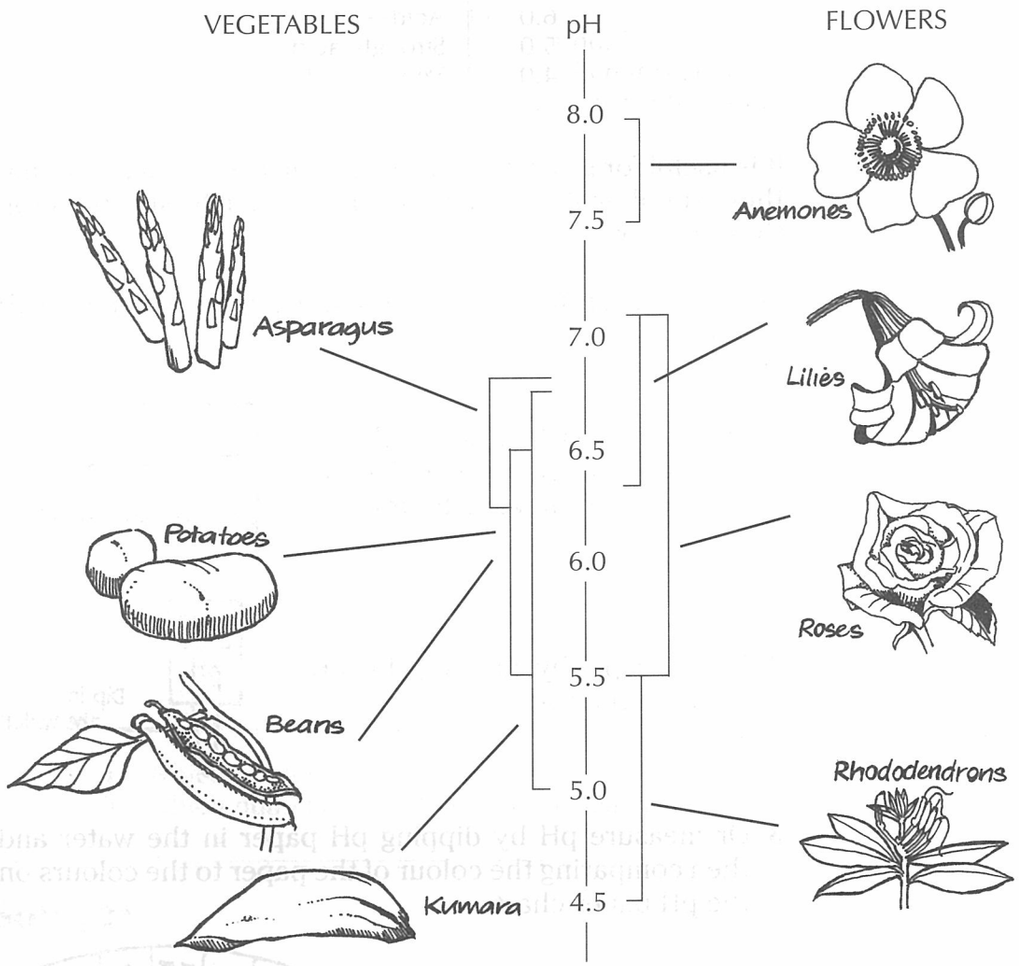


As well as affecting nutrients in the soil pH can also affect soil bacteria. Below pH 4.5 the activity of soil bacteria stops. Since bacteria are important decomposers in the soil this is an important effect.

For most crops the best soil pH is between 6.0 and 6.5. However, different plants have different pH requirements.

Some plants, for example the blueberry, need a very acid soil for healthy growth. You must know the optimum pH range for the plants you want to grow.

Optimum pH range for some crops

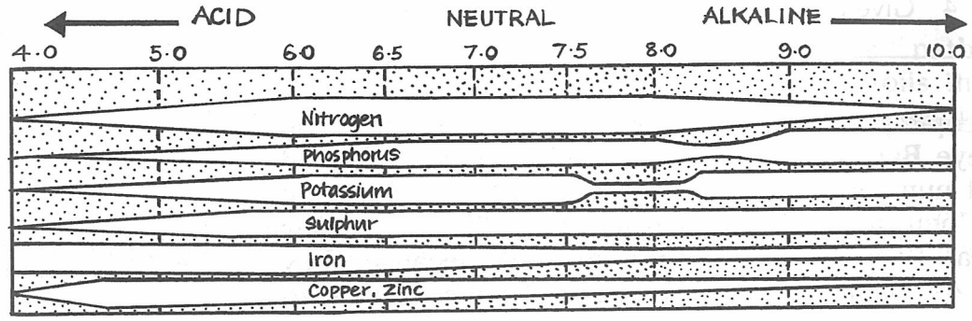


Questions

1. What is meant by "the pH of a soil"?
2. Give two ways plant nutrients may be affected by pH.
3. Why is it useful for growers to be able to measure pH?
4. Describe one method of measuring pH.
5. At what pH level does bacterial activity stop in soil?
6. What is the best pH for most crops?
7. Give an example of a plant that grows well in alkaline soil conditions.
8. Give an example of a plant that gows well when the soil pH is low.

Exercise

Copy the table showing the effects of pH on nutrient availability and then answer the questions.

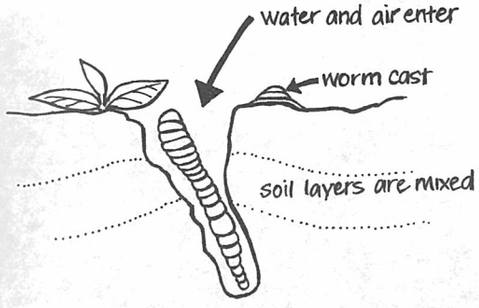


a At which soil pH are all nutrients freely available?
b What happens to the trace elements at high pH values?
c Are nutrients freely available in very acid soils?

Soil organisms

Many different plants and animals live in the soil. Most are found in the topsoil where there is warmth, oxygen, food and moisture. Some soil organisms help plant growth. Others do not. Soil must be managed so that only the helpful organisms survive.

Some soil organisms are visible to the naked eye while others are not. The ones you can see easily are called macroscopic plants and animals. **Earthworms** are very useful macroscopic animals. They improve soil aeration and drainage by their tunnelling. Their feeding activities help form and improve soil structure. They break down organic matter and so improve the physical condition of the soil for decay organisms. And they mix soil layers as they tunnel, which helps spread organic matter, lime and fertilisers through the topsoil. Earthworms flourish in soil that is warm, moist, well-aerated, and which contains organic matter and lime.

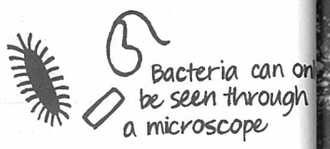


Plant roots are important in the soil. The roots from previous crops provide soil with organic matter and as they decay they leave channels which help aeration and drainage.

Questions

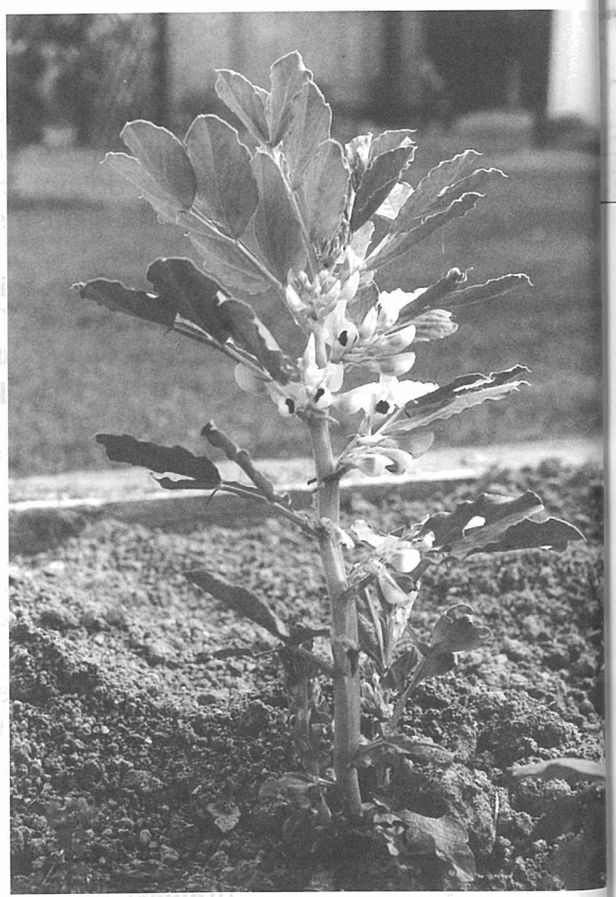
1 In which part of the soil are most plants and animals found?
2 Give three ways in which earthworms improve soil.
3 State four soil conditions that help earthworms to flourish.
4 Give two reasons why plant roots are important in soil.

Microscopic plants and animals cannot be seen with the naked eye. **Bacteria** are small single-celled organisms found in great numbers in fertile soil. They prefer warm, moist soils of neutral pH. Sandy and infertile soils contain few bacteria. Bacteria are very important because they decompose organic matter and make nutrients available to plants.



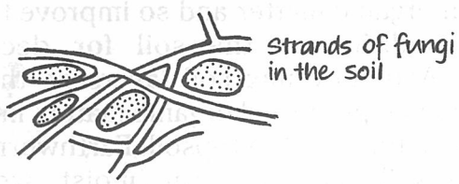
They also convert nutrients into a form that plants can use. For example, some bacteria (called 'nitrogen-fixing' bacteria) can turn nitrogen from the air into nitrates, which plant roots are able to absorb. *Rhizobium* bacteria, which live in the root nodules of legumes such as peas, beans and clover, are nitrogen-fixing bacteria.

Nitrogen-fixing bacteria live in broad-bean root nodules

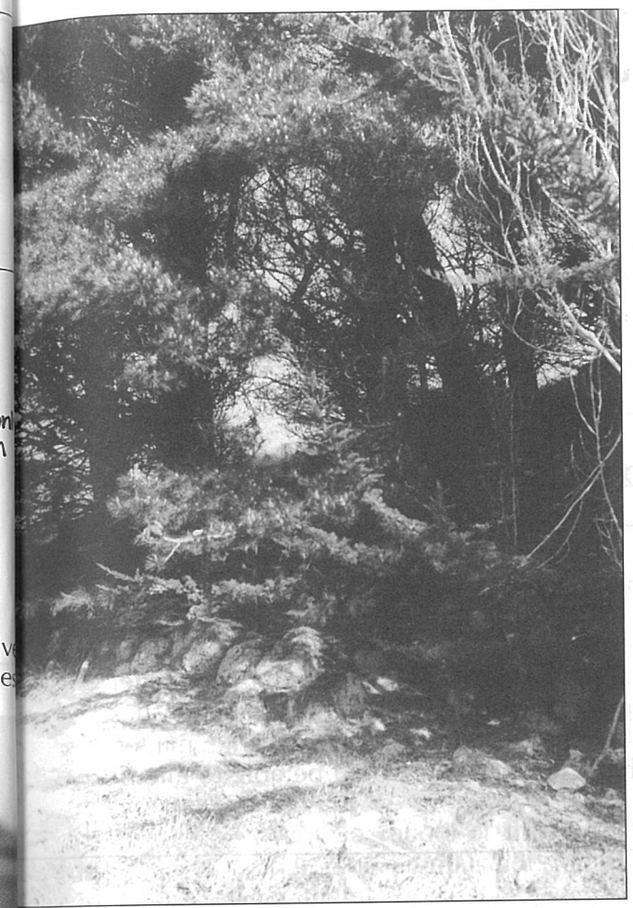


Some soil bacteria are harmful to plants. They can cause diseases such as galls and root rots. Disease-causing organisms are known as pathogens.

Fungi are a large and varied group of soil organisms. Like bacteria their main role is decomposing organic matter.



Some fungi live in a symbiotic relationship in the roots of plants. In this relationship both the fungus and the plant benefit. These mycorrhizal fungi can help the host plant take up nutrients, especially phosphorus. They



Pine trees and their roots

are necessary for many cultivated crops. For example, young pine tree seedlings will not become established if the right fungus to form mycorrhiza is not present in the soil in which they are raised.

Some soil fungi are pathogens. Especially in very wet soils they can cause problems such as damping off and wilting.

Other organisms that play a large part in soil fertility include algae and nematodes. Algae are tiny green plants which thrive in damp places. Nematodes are small worms, sometimes called eelworms. Some of them eat the roots of plants. Larger soil animals that feed on dead (and sometimes living) organic material and so help to break it down include slugs, snails, mites, slaters, millipedes and many soil insects.

Humus

When the decomposed remains of plants and animals have completely lost their structure they are called humus. Humus is a jelly-like coating on the soil particles.

Humus is formed by the combined activity of all the organisms in the soil. It is very valuable because:

1 It binds soil particles into stable crumbs and so helps to provide good soil structure.

2 The improved structure means there will be more pore spaces and so better soil aeration. Water will move more easily through the soil.

3 More water is held in the soil when humus is present. This is important in sandy soils.

4 Humus holds on to nutrients so they cannot be leached from the soil. It is also a source of nutrients for plants.

Questions

1 What sort of soils do bacteria prefer?
2 Why are bacteria very important in soil?
3 How do *Rhizobium* bacteria help the growth of peas and beans?
4 What do 'pathogens' cause?
5 What is one problem that may be caused by fungi?
6 Explain how humus is formed and where it is found.
7 State four reasons why humus is so valuable in soil.

Exercise

Choose ONE of the following. Answer in about half a page of clear writing.

a "Soil is not just dirt". Explain this statement.

or

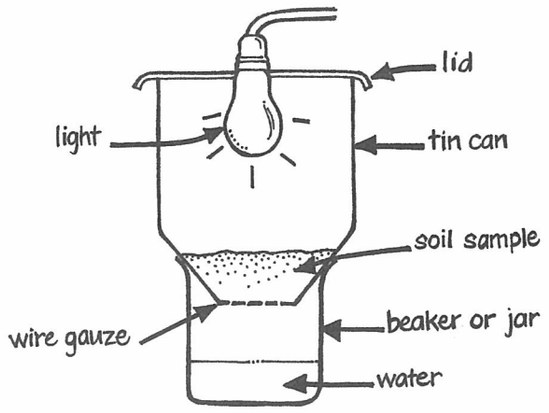
b Imagine you intend to buy some land to grow plants. Write a short letter to a friend describing what crop you intend to grow, what characteristics you will look for in the soil (texture, structure, pH, organic matter, organisms, water) and which characteristics you would be able to alter if necessary.

ACTIVITY

This activity is designed to help you see some of the many animals which are found in soil.

AIM:
To set up and use a Berlese funnel.

WHAT TO DO:
1 Use a large tin or other suitable container with a lid.
2 Cut a section out of the bottom and insert a piece of wire gauze as shown in the diagram. Put your soil sample on the wire gauze.
3 Cut a hole in the lid big enough for a low wattage light to go through.
4 Stand the apparatus over a container of water and turn on the light.



5 Leave overnight in a safe place. The soil animals will try to escape from the light and fall into the water where you will be able to see them.
6 Use a paintbrush to remove the tiny animals from the water and look at them with a hand lens.

REPORT:
Write a report of this activity into your notes. Say how many different animals you found and try to provide a drawing of two of them.

4 Soil modification

SUMMARY

Soils in different areas differ from each other. Even in any one area soil does not always stay the same. It is changed by climate and the plants that grow in it. Soil can be modified, or changed, so that it becomes suitable for growing plants.

Cultivating breaks soil into smaller crumbs. This fine tilth provides a medium that is easy to plant, makes good contact with roots, and allows air and water movement to take place. Digging, hoeing, forking, raking and the use of a rotary cultivator are all methods of soil cultivation.

Over-cultivation can lead to poor soil structure.

Fertilising soil adds the nutrients needed for growth.

Organic matter added to soil improves its structure and adds nutrients. Organic matter can be added as compost, through planting legumes, in organic fertilisers or as mulches.

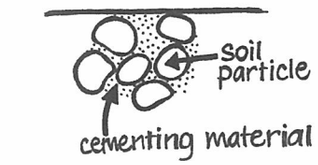
Lime is added to soil to make it less acid and encourage earthworms.

Water is continually being lost from the soil. Irrigation systems return water to the soil if rainfall is insufficient. Methods include sprinklers, sprays, trickle and drip irrigation systems. Each method has advantages and disadvantages.

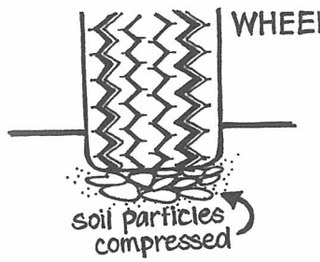
Over-cultivation

Though cultivation by breaking up the soil may be necessary for soil improvement, it is possible to over-cultivate soil.

It is most important to manage your soil so you do not lose topsoil. You should cultivate with the shape of the land, not up and down a slope, so that heavy rain does not wash away the soil. And soil should never be cultivated to the point where it is so fine that it is easily blown away by the wind. For this reason, cultivation should not be carried out when soil is very dry. Similarly, when soil is very wet you should stay off it and leave it alone. Cultivation of wet soil, especially using heavy machinery, can compress the soil particles and ruin its structure.



Poor soil structure leads to drainage problems.

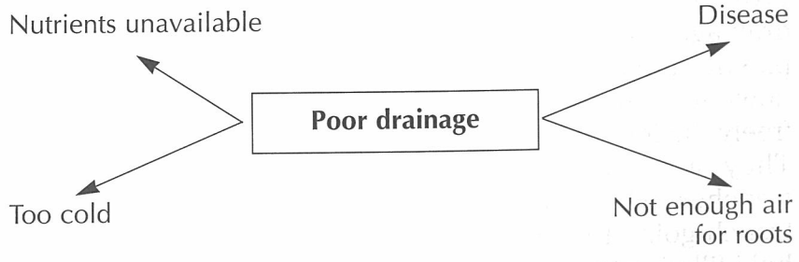


Drainage

Soils which contain a lot of clay do not drain well. Sometimes a hard 'pan' or layer beneath the surface of the soil stops water escaping. Such a layer may be produced if the soil is mechanically cultivated at the same depth for a number of seasons. This compresses the lower soil layers.

Soils which need draining are easy to recognise. There will often be water lying on the surface after heavy rain and there may be an unpleasant smell associated with the sub-soil. The smell is caused by sulphur-forming bacteria which are present while useful bacteria are destroyed. The soil will become pugged and sticky if it is walked on while it is wet, and plants growing in it will often have yellow leaves.

If excess water is held in the soil there is less air available for plant roots. Soil temperatures remain low because of the cooling effect of the water and this slows down plant growth. It also becomes more difficult for plants to take in nutrients from the soil. Waterlogged soils cause roots to rot because disease organisms flourish in soil that is too wet. Plants growing in poorly drained soil are therefore at risk.



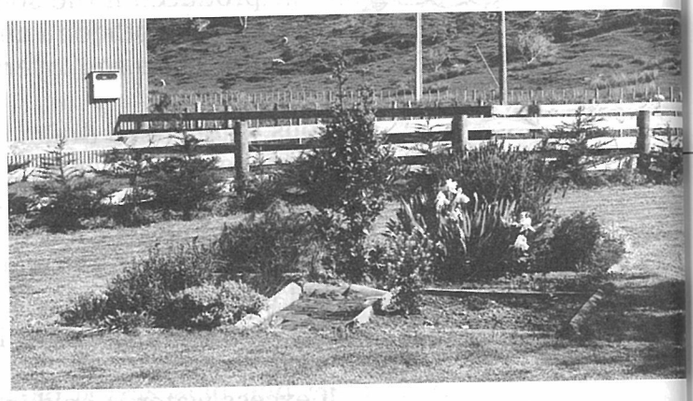
Questions

1 In what direction should sloping land be cultivated?
2 Why should very dry soil not be cultivated?
3 Why should you stay off very wet soil?
4 What is a 'pan' and how may it be produced?
5 State four ways of recognising a soil which needs draining.
6 Copy the diagram showing the effect on plants of poor drainage.

Drainage improvement

Drainage can be improved by adding organic matter to open up the soil. This is an even more effective method than adding coarse materials such as sand or shingle, though they can be useful too.

If there is a hard pan, it can usually be broken up by a deep ripping bar on a tractor, called a subsoiler.

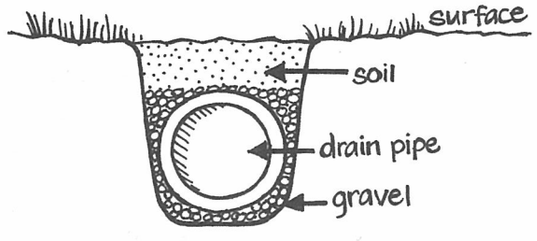


Raised beds are easy to work

Raised beds are another solution to poor drainage, especially if the water table is high. They should be made of a light, fertile soil mixture. Raised beds have the advantage of warming up quickly and being easy to work.

Where there is a severe drainage problem a system of ditches, tile drains or pipe drains may be needed.

The most efficient method is to use field or pipe drains. These are expensive but provide a permanent solution to a drainage problem. The pipes of clay or plastic must be laid with sufficient downhill fall to allow water to drain freely inside them without silting up. They are laid on gravel in sloping trenches which all lead to one main trench going to a suitable drain, ditch or soak pit (a large hole filled with stones). The pipes are covered with gravel or metal chips to within 30cm of the soil surface.



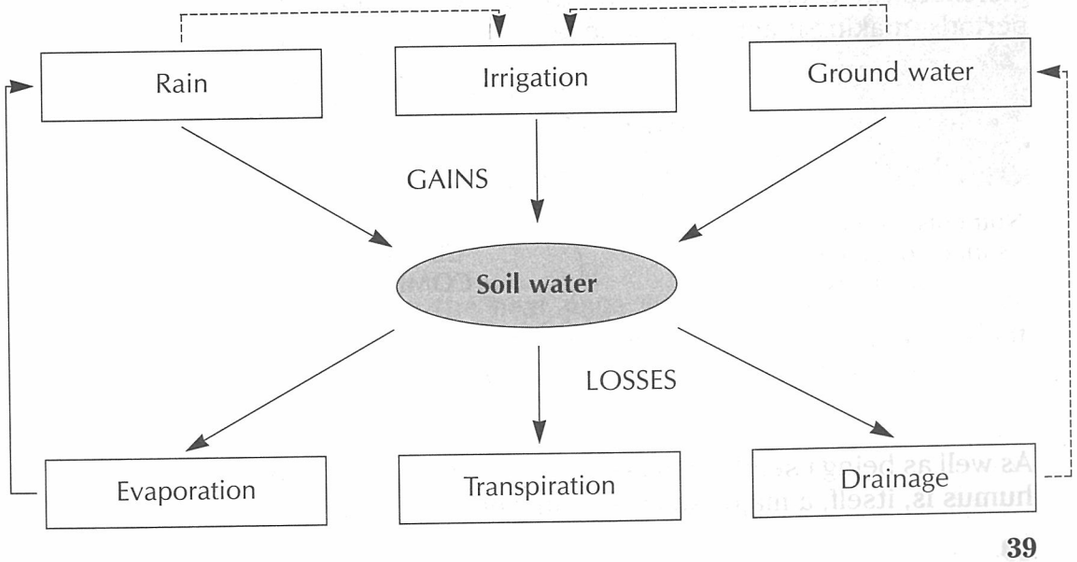
Trenches containing rubble or brushwood, covered with soil, will also provide an efficient though less permanent drainage system.

Exercise

1 Describe how overcultivation can damage soil structure and how this affects the following soil properties:
   a drainage
   b aeration
   c fertility
2 Describe TWO methods of soil cultivation and explain how each affects the soil structure.
3 How does poor soil drainage affect the root system of a plant?
4 Describe three methods of drainage improvement.
5 Why do soils with poor drainage often have a bad smell?
6 Write a paragraph explaining how poor drainage affects plant growth.
7 Give TWO examples of weeds which grow well in poorly drained soils.

Movement of water through the soil

Water is lost from the soil by evaporation from the soil surface into the air. It is also removed by the transpiration of the plants growing in the soil. Drainage removes excess water from the soil. Water is returned to the soil naturally, as rain, or through irrigation systems.



Rainfall is the climatic factor which has the greatest effect on the soil. When a lot of water falls on soil leaching can occur, and the soil will lose important nutrients. However if evaporation is too great water will move up through the soil and nutrients will be deposited at the surface, often creating salty conditions. It is not just plants that need water. Important soil organisms like worms and bacteria also need to remain moist or they will die.

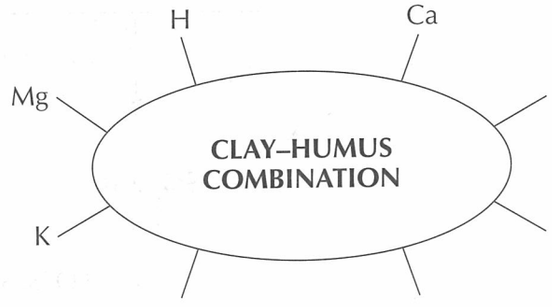
The amount of water in soil must be carefully controlled—not too much and not too little.

Adding organic materials to soil

The best way to improve soil is to add organic materials to it. They will help soil structure and soil nutrient supply, increase water and nutrient retention and increase biological activity in the soil.

Organic materials should be added to soil in a decomposed state. If they are put into the soil fresh there is a huge increase in micro-organism activity as the materials get broken down and this may result in a temporary nitrogen deficiency.

When organic materials are decomposed by bacteria and fungi they form humus. Humus and clay particles together form a powerful combination. Nutrient ions are attracted to the surface of these particles and held there. Leaching is prevented, and the nutrients are available for plant roots when needed. As well, the humus-clay combination increases the capacity of the soil to hold water during dry periods, making it act like a sponge.



Nutrients are held on the surface of clay-humus particles

As well as being useful when associated with clay particles, humus is, itself, a major source of nutrient nitrogen.

?

Questions

1 Give three ways in which water may be lost from soil.
2 Which climatic factor has the greatest effect on soil?
3 What can be the effect on soil of excess evaporation?
4 Why should organic materials always be added to soil in a decomposed state?
5 Draw a diagram showing a clay-humus combination and give two reasons why it is useful in soil.

Types of organic materials

Not all organic materials are equally useful in soil. The amount of nutrients they can supply differs greatly and so does the effect they have on the micro-organisms in the soil.

A compost heap contains countless micro-organisms

The table on the next page gives details of some of the various organic materials that may be used, with their nutrient compositions and their effects on soil.

Organic material	Effect on soil structure	Main nutrients	Comments
Farmyard manure	Good	N and K	Best added to compost
Poultry manure	—	N	Can produce harmful ammonia Add to compost
Sludge from sewage	Too liquid to be useful	N and P	May contain high levels of trace elements like zinc which may harm plants
Liquid plant manures	Liquid	K, N, S	Made by steeping leaves to e.g. lucerne or nettle in water Also helps disease resistance
Seaweed e.g. kelp	Very good	K, Na, I	Good for heavy soils Activates compost Helps soil particles to clump
Green manure crops	Excellent	N	Must be well dug or ploughed into soil Prevents leaching of nitrates from soil
Sawdust, straw, bark grass clippings	—	(N)	Compost or mulch *only* Should never be added directly to soil as they cause a huge increase in activity of micro-organisms which creates nitrogen deficiency
Wood ash (never use treated timber)	Can destroy soil structure in excess	K, Ca, P	Highly soluble nutrients Use sparingly on the compost heap ($5kgm^{-3}$)
Compost	Very good	Various, including many trace elements	Best all-round organic material, being a mixture of substances See * below
Rock dust	Good	Si, P and many trace elements e.g. Zn, Mn	Gives increased resistance to pests and diseases Helps root growth

* Compost also attracts soil micro-organisms. Composting involves providing the right conditions for accelerated decomposition of plant and animal remains. The conditions required are adequate air and water, a suitable temperature and pH, and a nitrogen supply to stimulate bacterial action.

Questions

1 Why are all organic materials not equally useful in soil?
2 What are the main nutrients in seaweed?
3 Which organic materials have a good effect on soil structure?
4 How should grass clippings and sawdust be used?
5 Which organic material can destroy soil structure?
6 Give the names of two trace elements found in rock dust.

Part of an article on composting
('The Wheel of Life' from "Growing Today", November 1990):

"... This is the most significant thing about a compost heap, it teems with the life we want to give back to the soil.

The life is intense, if unseen — countless millions of microscopic organisms will fit on a teaspoon. These same organisms are present in the soil but usually in lesser numbers; amazing microflora, bacterial exudates, enzymes and fungi. In time the electron microscope may possibly reveal this amazing living world to us in our own homes.

These micro-organisms have the same basic requirements as other living things: air, moisture, food and warmth. The art, or science, of composting is providing these basics in the right proportion. If you want to be really scientific you can look at all the chemical requirements too, carbon to nitrogen ratios, etc., but that's beyond the scope of this amateur gardener.

Anything that will decompose can go into the compost. No plastic, glass or metal though if the odd piece finds its way in, when you empty the vacuum cleaner bag for instance, it won't do any harm. All garden refuse should go in — weeds, prunings, spent plants fallen leaves, lawn clippings; wood and paper ash, but not coal, glossy paper or coloured inks, they are all toxic. Household wastes like the contents of the vacuum cleaner or the dustpan, scraps of natural fabric, small amounts of newspaper (moistened); animal waste; kitchen waste, of course, including scraps of meat and fish and small bones — but best keep it covered to deter rats, dogs and large birds.

If you are worried about seeding weeds or diseased plants, don't be because the heat generated in the heap should be enough to destroy anything harmful, especially if the suspect material is placed at the centre of the heap.

For the smallish home garden the simplest plan seems to be to have basically two or three bins and to concentrate compost building at those peak times of the year when there is plenty of plant material i.e. spring/early summer and again in autumn.

The first bin should be reasonably near the kitchen to take all the organic refuse from the kitchen and the house in general. Plastic bins are available but they will get smelly though the smell disappears once the material is composted. The occasional layer of soil may also help.

Another bin, or even pile, in the garden takes all the garden waste and it can be a good idea to have this covered too to keep in the moisture. Wire netting with stakes at the four corners is simple, or wooden sides, even blocks as long as there are gaps to allow air circulation.

This bin/heap can be the medium-term compost with layers added over the months or weeks until it is the right size. Then it is covered and left to mature which could be as soon as six weeks in spring and as long as six months or more in winter. A third bin will be necessary if you do it this way so you can be making another compost while the first is maturing."

Exercise

1 Read the article from "Growing Today" (November 1990) about compost. Then answer the following questions.
- **a** Why should coal ash not go into compost?
- **b** Give one reason for keeping the heap covered.
- **c** Why are weed seeds not a problem in a compost heap?
- **d** How long will compost take to mature in spring and how long may it take in winter?
- **e** What are four basic requirements of micro-organisms?

2 If large quantities of organic materials are added directly to the soil its micro-organisms rapidly increase in numbers. Give one advantage and one disadvantage of this.

Mulching

'Mulching' means covering the soil around plants. The most commonly used mulches are plastic sheeting (clear and black) and organic material, such as straw, sawdust, grass-clippings, bark and compost.

Mulches prevent the growth of weeds and keep moisture in the ground. They also alter the soil temperature. A plastic mulch will give a warmer soil temperature by trapping heat. Straw mulches, which are light coloured, will reflect radiation from the sun and keep the soil cool. Straw and compost both provide an insulating layer for the soil beneath because of the air they contain, so they reduce changes in temperature.

Mulching of strawberry plants

Mulching can have drawbacks as well as benefits. Mulches encourage slugs, snails and other pests which must be controlled. If a mulch is left on soil during cold, wet weather disease organisms may flourish beneath it, and if plastic mulches are left in place for too long they can cause soil structure to break down.

To get the best from a mulch it should be applied when the soil is moist, free of pests and warm.

Organic mulches are especially useful because they can later be dug into the soil to increase its organic content.

Questions

1 What is meant by 'mulching'?
2 Give examples of four commonly used mulches.
3 What are two benefits of mulching?
4 Explain how different mulches alter the soil temperature differently.
5 What are three possible drawbacks to using mulches?
6 Why are organic mulches especially useful?

Materials for mulches

The table summarises the properties of the three main types of mulches: those made of dark materials, those made of light materials, and living mulches.

Type	Form	Comments
Dark material mulches 	Compost	Warms ground early in spring. Has few pests. Good for micro-organisms and worms. Improves soil texture. Holds moisture.
	Black polythene	Warms ground in spring. Keeps moisture in but may hide pests.
Light material mulches 	Straw, hay	Keeps soil cool. Holds moisture but encourages pests. If it rots may create nitrogen deficiency. Reduces weed growth but hay may contain weed seeds.
	Grass clippings	May get hot. Suppresses weeds and adds nitrogen. Encourages worms.
	Sawdust	Poor aeration. Suppresses weeds, builds soil texture but may create nitrogen deficiency as it rots so use sawdust from slow rotting species.
Living mulches 	Vines with large leaves e.g. pumpkin	Short term only. Reduces evaporation and weed growth. Moderates soil temperature. Need to keep under control.
	Clover and other herbs	Long term. Adds nutrients, shades soil, prevents erosion. May compete for moisture.

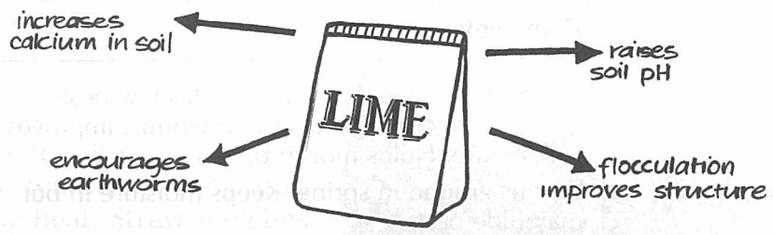
Questions

1 Which mulch will cool the soil but encourage pests?
2 What sort of sawdust should be used as a mulch? Give reasons.
3 Name three sorts of plants that can be used as 'living mulches'.
4 Compare the usefulness of compost and black plastic as a mulch.
5 Which mulch could be used to keep soil cool and retain moisture?
6 What problem may occur if a straw mulch rots?

Adding lime

If a lot of organic matter is used to improve soil it may result in the soil becoming more acid. Lime is added to soil to raise its pH and make it less acid. It also increases the supply of calcium in the soil and encourages earthworms.

Lime helps the very tiny particles in clay soils to group together and form larger particles. The clay particles group themselves around the lime particles. This process, which is called 'flocculation' results in soil with better structure.



Dolomite lime is often used because, as well as calcium, it contains magnesium which is needed by plants.

Sometimes soils contain too much lime. In this case the pH can be lowered by adding sulphur, fertilisers containing ammonia, or by digging peat into the soil.

Soil disinfection

In enclosed areas like greenhouses the number of disease-causing organisms and pests can build up in the soil. It may be necessary to disinfect soil to get rid of these organisms. There are two main methods of soil disinfection: heat treatment and chemical treatment.

Heat treatment is normally carried out with steam. As well as disinfecting soil the treatment improves soil structure which gives better drainage and aeration. It does not kill the useful micro-organisms in the soil.

Chemical treatment, using gases such as methyl bromide or chloropicrin, is another way of disinfecting soil. The gases are trapped in the soil under sheets of plastic while they work. Most chemicals are very poisonous and can kill useful micro-organisms as well as harmful ones. It is difficult to treat large areas efficiently with chemicals.

Questions

1 Copy the diagram showing the good effects of lime on soil.
2 What is 'flocculation' and why is it useful?
3 Name two nutrients that are in dolomite lime.
4 If a soil contains too much lime how can the pH be lowered?
5 Why may soil disinfection be needed in a greenhouse?
6 What are the two main methods of soil disinfection?

ACTIVITY

In this activity you will see what difference mulches make to the temperature of the soil beneath them.

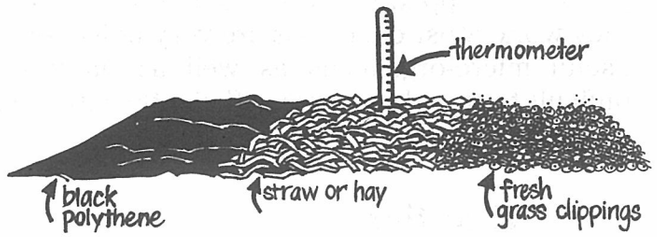
AIM:
To compare the temperature of soil beneath three different types of mulch.

WHAT TO DO:
1 Choose a sunny plot in your garden and clear away any surface growth from it so bare soil is left.

2 Divide the plot into three equal parts. On top of one part spread a sheet of black polythene, weighted at the edges, on the second part put a layer of straw or hay and on the third part spread an equal layer of fresh grass clippings. Leave for several days.

3 Put a thermometer into the soil below each mulch so the bulb of the thermometer is completely covered by soil. Read the

thermometer while it is still in the soil (the reading will quickly change when you take it out). Record the temperature under each mulch each day for several days.



REPORT:
Write a report of this experiment. Use the headings Aim, Method, Results and Conclusion.

5 Alternative growing media

SUMMARY

The materials that are used in containers are called media, growing media or mixes.

Soil is not used alone in containers because it packs down, does not drain well and may contain disease organisms.

A good medium should provide good root anchorage and adequate drainage, water, air and nutrients for the plant that is grown in it. It should be free of weed seeds, pests and diseases.

Materials used in media differ in size, cost, weight and water, and air-holding ability.

Media ingredients

You can buy a growing medium mixed and ready to use or you may get ingredients separately and make your own. It is cheaper to choose ingredients that are produced in your local area because transport costs can be expensive. The ingredients should be consistent in their composition so they do not break down easily with use.

Organic materials used in media

Organic materials include peat, sawdust, shredded bark, sphagnum moss and compost. These materials are used because they hold water and provide air spaces.

PEAT
Peat develops in bogs, from rotting plant remains. It is often named after where it comes from, for example, Hauraki peat.

Advantages of peat:
Peat is a good ingredient because it soaks up plenty of water but does not hold it too tightly, so the water is easy for plant roots to absorb. It has plenty of air spaces. Peat is light in weight.

Disadvantages of peat:
Peat is expensive. Because peat takes a long time to form it is a non-renewable resource.

SAWDUST
Sawdust can often be obtained free of cost. Sawdust from timber treated with preservative should never be used because it can damage plants. Coarse sawdust is more useful than fine sawdust.

Advantages of sawdust:
Sawdust is inexpensive. It has quite good air spaces.

Disadvantages of sawdust:
Sawdust does not have good water holding capacity. It rots away quickly if it becomes contaminated by wood-rotting micro-organisms. When it rots it uses up nitrogen that would otherwise be available to the plants growing in it.

SHREDDED BARK
Different sizes of bark pieces are available. The size of the pieces influences the amount of water and air the bark can hold. Bark is usually processed to remove the materials contained in natural bark that are harmful to plant growth. It may be composted or put through an extraction process.

Advantages of bark:
Bark is a comparatively inexpensive medium with good air spaces and good drainage. It has moderately good water holding capacity. It comes from a renewable resource.

Disadvantages of bark:
Unless properly processed, bark may contain harmful chemicals. As it decomposes it uses up nitrogen.

SPHAGNUM MOSS
Sphagnum moss secretes an antibiotic material which inhibits the growth of fungi, including those which cause 'damping off' of seedlings. It is used as a germination medium, or in a layer on top of another germination medium.

Advantages of sphagnum moss:
Fine sphagnum moss assists germination. The moss drains well and has plenty of air spaces.

Disadvantages of sphagnum moss:
Nutrients must be supplied in solution at regular intervals because they leach out easily. Sphagnum moss is very expensive.

?

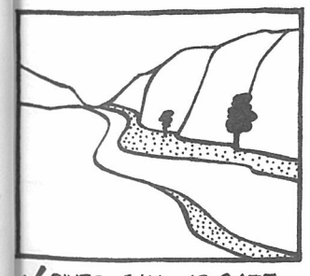
Questions

1 Why is it cheaper to choose media ingredients from your local area?
2 Name four organic materials used in media.
3 Where does peat develop?
4 What sort of sawdust must never be used in a mix?
5 How are harmful materials removed from natural bark?
6 Which media ingredient secretes an antibiotic material?

Mineral materials used in media

Mineral materials include pumice sand, gravel, sand, vermiculite and perlite. These materials are used because they provide bulk and increased air spaces.

PUMICE SAND, GRAVEL AND SAND
Pumice sand, gravel (or scoria), and sand are used to improve drainage, aeration or water holding ability and to reduce cost. The effect they have depends on particle size. Large particle size, for example gravel, results in less water being held in a medium. Small particle size, for example that of fine sand, increases the amount of water held and available to plants when it is used in combination with other ingredients like peat or bark.


✓ RIVER SAND IS SAFE TO USE


✗ DO NOT USE SEA SAND

Sea sand contains salt which is harmful to plants. River sand is safe to use. Sand is especially useful in media used for rooting cuttings because it improves aeration. Good aeration is needed for the growth of roots on cuttings.

PERLITE AND VERMICULITE
Perlite is produced by heating a volcanic material which

causes it to expand. It is both bulky and light–weight, with a foam-like structure. It can hold plenty of both air and water.

Vermiculite also comes from volcanic material. It is very expensive because it is imported. It holds more water than perlite and is used for covering germinating seeds because it prevents them from drying out.

Questions

1 Name four mineral materials used in media.
2 Why are mineral materials used?
3 What effect does particle size have on water holding ability?
4 Why should sea sand not be used in a growing medium?
5 How is perlite made?

Exercise

Construct a TABLE which clearly shows the advantages, disadvantages and uses of all the media ingredients discussed in this chapter.

Nutrient supply

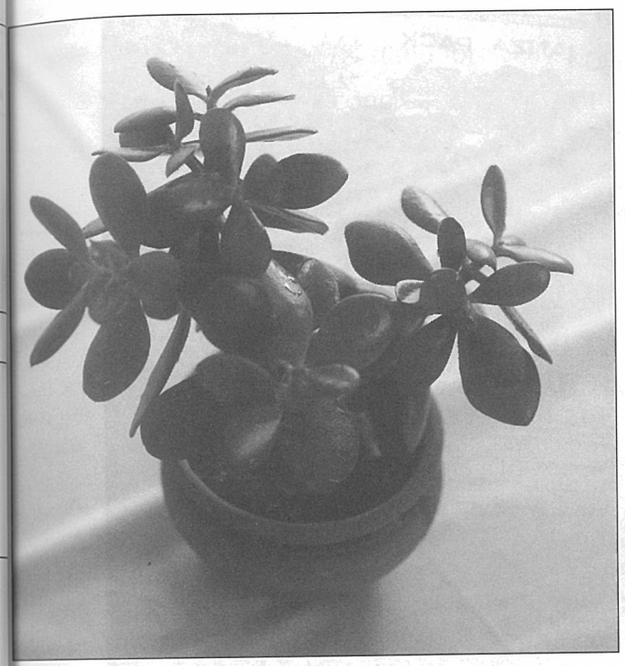
Because none of the bulky ingredients of media provide nutrients for plants it is necessary to add fertilisers to supply nutrients. Lime may be added to balance the acidity of some of the ingredients, especially peat.

Nutrients are provided by mixing fertilisers with the bulky ingredients or by liquid feeding.

Only small amounts of nutrients are added to seed raising and cutting media because plants only stay in these media for a short time. For plants grown in the same medium for longer, slow release fertilisers like Osmocote are used. They contain the three major elements: nitrogen, phosphorus and potassium. They can be bought with different release periods, for example 3–4 month Osmocote and 8–9 month Osmocote. They provide nutrients without producing too high a soluble salt content in the medium. Because container plants are watered frequently, leaching losses would be high if quick release fertilisers were used.

Trace elements are made into suitable slow release mixtures by adding them to molten glass. When the mixture hardens it is ground into a powder called 'fritted trace elements' — 'FTE'. Mixtures of salts of trace elements are also available.

All ingredients must be mixed thoroughly in a place that is free of pathogens. Mixing is usually done by machine.



Pot plants need slow-release fertilisers

Commercial media come ready mixed and sterilised. Some also contain a fungicide to kill any fungal pathogens that may enter the mix when it is in use. Mixes containing slow release fertilisers should be used within three months, before fertiliser concentration in the mix gets dangerously high.

Questions

1 Why is it necessary to add fertilisers to media?
2 What three major elements are contained in slow release fertilisers?
3 Why are quick release fertilisers not used for container plants?
4 How is 'FTE' made?
5 Why should mixes containing slow release fertilisers be used within three months?

Exercise

Look carefully at the photograph of a bag of potting mix and then answer these questions:

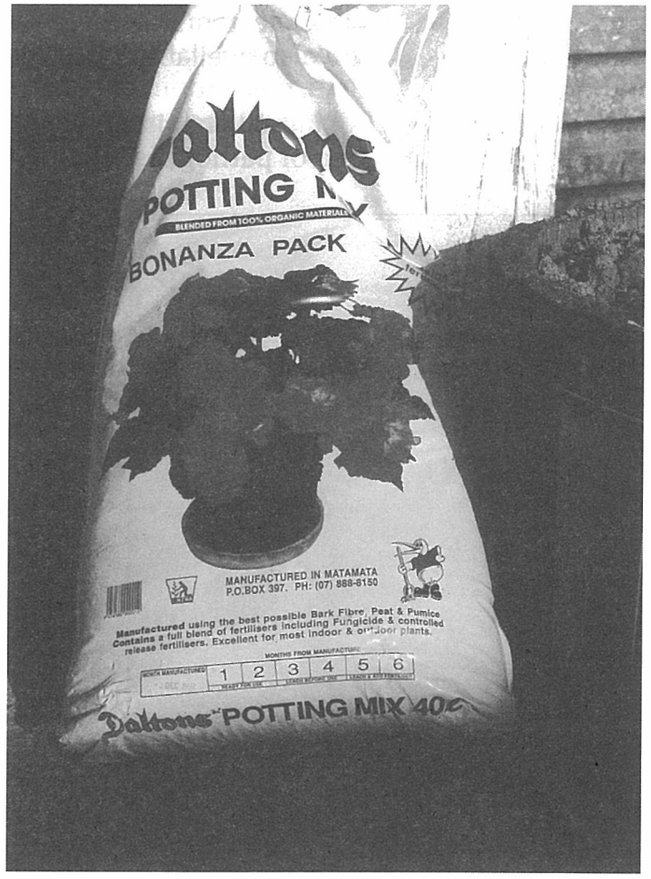
a What three bulky ingredients are in this mix?

b What sort of plants is the mix used for?

c Why does the mix contain fungicide?

d What sort of fertiliser does the mix contain?

e The chart at the bottom of the bag gives the month and year of manufacture and months from manufacture. At five and six months from manufacture the chart says "Leach and add fertiliser". Explain why it says this.



Recipes

Because plants differ in their requirements, recipes are available for many different media, for example germination mixes, seedling mixes, growing-on mixes and specialist mixes like those that are used for orchids or cacti. They differ in the amounts of the various ingredients, and in the fertilisers that are used.

A mix that is suitable for a wide range of purposes is one containing half sand and half peat or bark, together with lime and fertilisers. The sand provides air spaces while the peat retains adequate moisture for growth.

Basic Growing Mediu

- *1m³ peat*
- *1m³ sand*
- *3kg dolomite lime*
- *1.5kg lime*
- *125g FTE*

On clean concrete, mix the peat sand in layers.

Mix the fertilisers thoroughly and spread them on the heap.

Turn the heap several times to mix well.

Exercise

An example of a recipe for a basic growing medium is given on the previous page. Study it and then answer the questions that follow.

a What are the useful properties of firstly sand, and secondly peat in the mix?

b What important extra element does dolomite lime supply?

c Why is lime added to the mix?

d What does 'FTE' stand for? Why are they added?

e Why is clean concrete needed for mixing?

f The heap must be mixed well. Why is this?

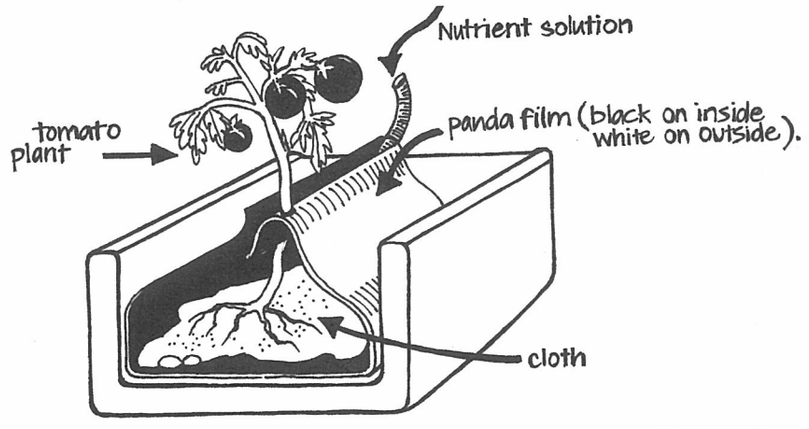
Hydroponics

Conventional media are not used in hydroponics. Plant roots grow in sand or gravel with a continually circulating liquid medium around them. Hydroponic growing requires a high capital investment and good technical knowledge.

A major advantage in growing plants by this method is that the grower has total control over the nutrients that are in the liquid medium. There is also no need for weed control, which takes time and money.

Exercise

The diagram shows apparatus used to grow tomatoes hydroponically. Study the diagram and then answer the questions.



a State one advantage to the grower in growing the plants hydroponically rather than in soil.

b Explain why this is an advantage to the grower.

c One of the possible problems in hydroponic growing is the growth of algae in the nutrient solution. Suggest how the apparatus shown above could help stop the algae growing.

ACTIVITY

In this activity you will investigate two commercially prepared potting mixes and try to decide which would be best to buy.

AIM:
To compare the properties of two different potting mixes.

WHAT TO DO:
Use two small bags of different potting mixes. For each:

1 Read the writing on the bag carefully. Note what it says about any nutrients in the mix. Is fungicide included? What did each cost?

2 Put some of the mix in a large test tube and add an equal amount of water. Shake them together and then allow the mixture to settle. Draw a diagram to show what you see. Compare the two samples. Which has most material floating on top (organic material)? Which has most at the bottom of the tube (mineral material)?

3 Put a strip of pH paper into the water in the test tube. Compare it with a pH chart to find out if the mix has acid or alkaline properties.

4 Design an experiment to see which potting mix holds most water. Carry out your experiment.

REPORT:
Write a report about your investigations, answering the questions and including the diagrams. Make a statement, if possible, about which potting mix seems to give best value for money and explain your reasons for coming to this conclusion.

Section Three

Plant Propagation

6 Plant propagation

SUMMARY

You propagate plants to increase their numbers. By propagation, new plants are obtained from old ones. Plant numbers are increased either by sexual reproduction (seeds) or by asexual reproduction (vegetative methods). It is necessary to know the best methods of propagation for the plants you are dealing with if you want to be successful in increasing their numbers.

Propagation can take place in soil when the plants are to be grown on in the open ground. For plants that are to be grown in containers various artificial growing media are used, depending on the plant and the method of propagation.

The environment around the growing plants may need to be controlled so that the plants receive optimum amounts of light and water, and so that they are in the most suitable temperature and humidity for growth. The environment is controlled by using such structures as greenhouses, shadehouses, cloches and cold frames. Hot beds and mist units are also used to increase propagation success.

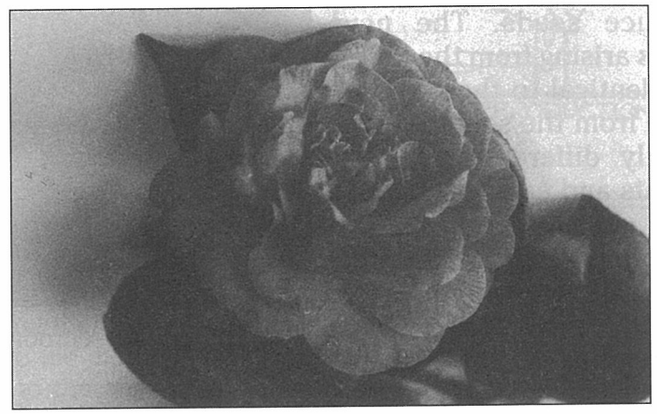
Advantages and disadvantages of sexual and asexual methods of propagation

Sexual reproduction

Sexual reproduction involves the joining of male and female genetic material to form seeds which will grow into new plants.

Using seed to propagate plants is simple and cheap. Plant breeders use seed because a variety of different young plants are produced from which they can choose the ones most suitable for their purpose. Seed is easy to transport and store and many seeds can survive over a long period of time. Seed is usually free of virus diseases.

However, using seed has limitations. Seeds do not produce identical plants. This may mean that the crop which is produced is difficult to handle. Some seeds do not remain viable for long, for example, camellia seed is only viable for a few days after it leaves the parent plant.



Camellia seed is viable for a short time only

Many plants, especially trees and shrubs, are slow to reach adult stage from seed, because they go through a juvenile stage which can last for a number of years. An example is the avocado, whose juvenile stage can last for up to ten years.

All seeds have specific germination requirements which the grower must meet. They may need soaking or chilling. Some need light. Not all seeds are easy to handle. They come in a wide range of shapes and sizes, from the huge coconut to tiny begonia seed, which is just like fine dust. Some plants, for example cultivated bananas, do not produce seed at all.

?

Questions

1 Give three advantages of growing plants from seed.
2 Why is it difficult to grow camellias from seed?
3 Give an example of a plant which has a long juvenile stage.
4 What are three disadvantages of growing plants from seed?
5 Give an example of a plant which does not produce seeds.

Asexual reproduction
Asexual reproduction takes place without the fusion of male and female genetic material. All the plants produced are identical to the parent plant from which they came.

Asexual reproduction may occur naturally in addition to sexual reproduction. For example, lilies increase their numbers from bulbs as well as having flowers which produce seeds. The new plants arising from the bulbs are identical to the parents; those from the seeds will be slightly different from the parents and each other.

Lilies reproduce by bulbs and seeds

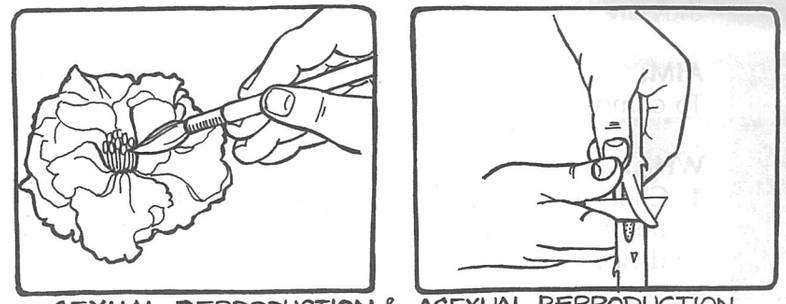
Growers use vegetative propagation techniques to produce new plants which are identical to the parents. Parts of the parent plant are removed, encouraged to form roots, and grown to form new plants. In this way the good qualities of the parents are maintained in the new plants. The disadvantage is that any disease organisms present in the parents may also be passed on unless special aseptic techniques are used to produce new plants, for example laboratory cloning.

Mature plants are produced more quickly by vegetative methods than from seed because the vegetative parts used, for example stems or roots, are quite large and provide a good start for the new plant. However their size may make them difficult to store and transport.

Some vegetative propagating techniques are complicated and time consuming and not always successful.

Methods of vegetative propagation include cuttings, grafting, budding and plant division. Natural methods which growers make use of include runners, bulbs, corms and tubers.

The same plant may be propagated in a number of different ways depending on the desired outcome. For example, a rose breeder will use sexual reproduction to develop new varieties of roses and asexual reproduction to continue production of a particular rose that has been bred.



Questions

1 Give an example of a plant that reproduces both sexually and asexually.
2 What is one advantage, to the plant, of asexual reproduction?
3 What is one advantage, to the grower, of using vegetative reproduction techniques?
4 What are two disadvantages of asexual reproduction?
5 Name four vegetative propagation techniques.
6 Name four natural methods of vegetative reproduction that are made use of by growers.

Exercise

Growers A, B, C and D have different requirements for growing plants. For each grower state whether sexual or asexual propagation methods would be best, and explain why.

Grower A: Wants to breed a completely disease-resistant variety of tomato.

Grower B: Needs all his chrysanthemum plants to be the same colour.

Grower C: Is in a hurry to make money from the avocado orchard she is setting up.

Grower D: Wants to grow plants that are free of virus infection.

ACTIVITY

This activity will make you aware of how different plants are when they are grown from seed.

AIM:
To compare the plants resulting from a packet of seed.

WHAT TO DO:

1 Choose plants that can be grown quickly and easily from seed. Some ideas are snapdragons, lettuces, radishes, sweet peas, dwarf beans.

2 Follow the instructions on the seed packet to grow your plants.

3 When the plants are old enough, compare them. Measure their heights, leaf size, flower colour or whatever else is relevant for the plants you have grown.

REPORT:
Present your results in the form of a graph, table or picture to show how the plants were different from each other. Make a statement about growing plants from seed.

7 Sexual reproduction

SUMMARY

Sexual propagation means growing plants from seeds. Seeds are produced and dispersed after pollination and fertilisation of flowers. Cross fertilisation gives the resulting seeds characteristics from the two different parent plants. Hybrid plants are formed. Self fertilisation will not result in new characteristics if the parent is pure breeding. Each seed comes from an ovule that is fertilised by a pollen grain during sexual reproduction. Seeds are often held inside a fruit. The seed consists of a protective seed coat, young root (radicle), young shoot (plumule) and one or two seed leaves, called cotyledons, which contain the food for the developing embryo.

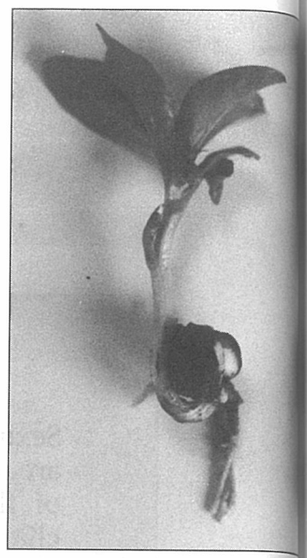
Conditions required for seed germination include viable seed, water, oxygen, and an optimum air temperature. Techniques to use when growing plants from seed include sowing, thinning, pricking out, hardening off and transplanting.

Seed dormancy

Seed dormancy is a temporary resting stage during which the young plant is alive in the seed, but not growing. It is a way of protecting the embryo from germinating at the wrong time.

Dormancy has to be broken before a seed can germinate. Then the seed will take in water, chemical activity will begin and food reserves will be used up as the young seedling begins to grow. This happens in nature when conditions are right for growth, often after a period of gradual breaking down of the seed coat in the soil.

Various methods are used to remove dormancy and ensure a high germination success rate from a batch of seeds. These include scarification, stratification, heat treatment,



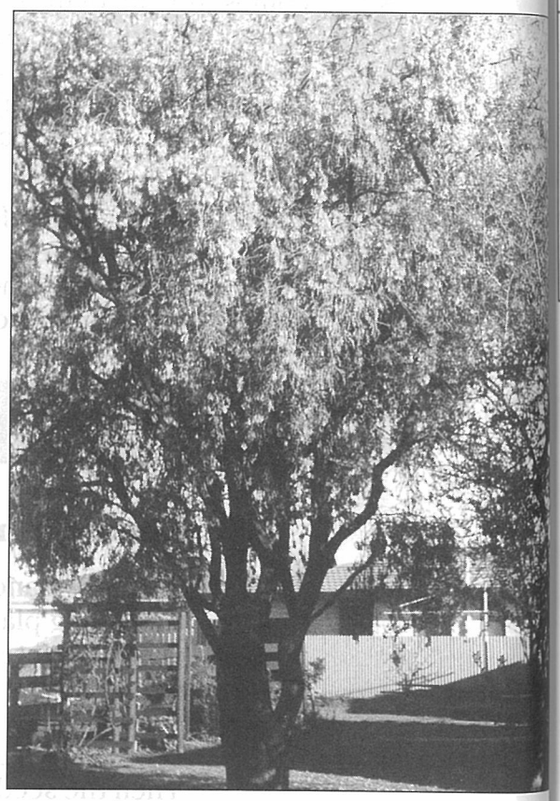
Germinating bean seed

Questions

1 What is seed dormancy?
2 What is the value, to the plant, of seed dormancy?
3 What takes place inside the seed after dormancy is broken?
4 Name four methods that are used to remove dormancy.

Scarification

Scarification involves chipping the hard seed coat to let water in so the seeds can germinate. Some plants which have seeds with very hard coats, for example kowhai, live naturally near rivers where seeds would be scratched as they roll around on the river bed. To imitate this condition you can chip, file, cut or scratch the seed coats of these seeds before you sow them.



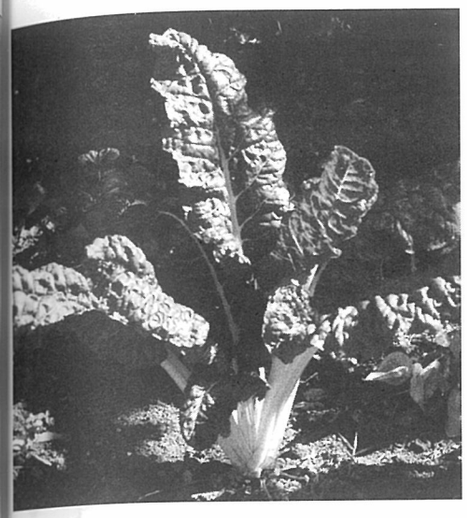
Seeds of the kowhai have a hard coat

Stratification

Stratification is chilling of seed, usually for four to twelve weeks at three to four degrees Celsius. This can be done in a domestic refrigerator. Seed should not be frozen, as freezing will kill the delicate embryo. The seed is mixed with moisture-retaining material such as peat while it is being chilled. Celery seed and the seed of *Impatiens* both need pre-chilling before sowing.

Heat treatment

Heat treatment is also used to break dormancy. Seeds are placed into nearly boiling water and left there until the water has cooled.



Silverbeet seed is soaked in water before sowing

Soaking

Soaking in cold water is used with a number of species, for example beetroot, parsley and silverbeet seeds. Seeds should not be left in water for more than twenty-four hours because they will run out of oxygen very quickly once the chemical processes inside them begin.

Questions

1 Explain the difference between scarification and stratification.
2 How would seeds get chipped in nature?
3 At what temperature is stratification carried out?
4 Why should seed not be frozen?
5 Give an example of a plant whose seeds should be soaked before they are sown.
6 Why should seeds be removed from water after twenty-four hours?

Rinsing

Rinsing in clean water may be necessary to remove chemicals which prevent germination. This is especially the case with seeds from fleshy fruits, for example tomatoes.

Light

Light is a requirement of some seeds, for example those of chrysanthemums and zinnias. Experiments have shown that even a flash of light is enough to bring about germination in some seeds which would be unable to germinate in total darkness.

Darkness is a requirement of other plants. For them, light will inhibit germination. Two examples are nasturtiums and forget-me-nots.

All seeds should be sown at their correct depth, which is usually two or three times the diameter of the seed.

Questions

1 Why may rinsing be needed for some seeds?
2 Give an example of a plant whose seeds need rinsing to help germination.
3 Give an example of a plant whose seeds require some light to germinate.
4 What is the correct depth at which to sow seeds?

Exercise

Copy and complete the following table. The first line has been done for you.

Symbol	Name of treatment	What to do	Plant example
	Scarification	Chip the hard seed coat	Kowhai
		Chill seed at 3°C to 4°C for 4 to 6 weeks	
	Soaking		
			Tomatoes
	Light	Make sure seeds have some light	

Seed storage

Correct storage keeps seed viable (capable of germination) until you are ready to use it. The seed is alive but in a 'hibernation state' in which food reserves are being used slowly. This means that seeds do not last forever. Their ability to germinate lessens with time. Seed packets have a "use by . . ." date before which the contents of the packet should be able to germinate.

For seed to remain viable it must be stored in dry cool conditions in a sealed container.

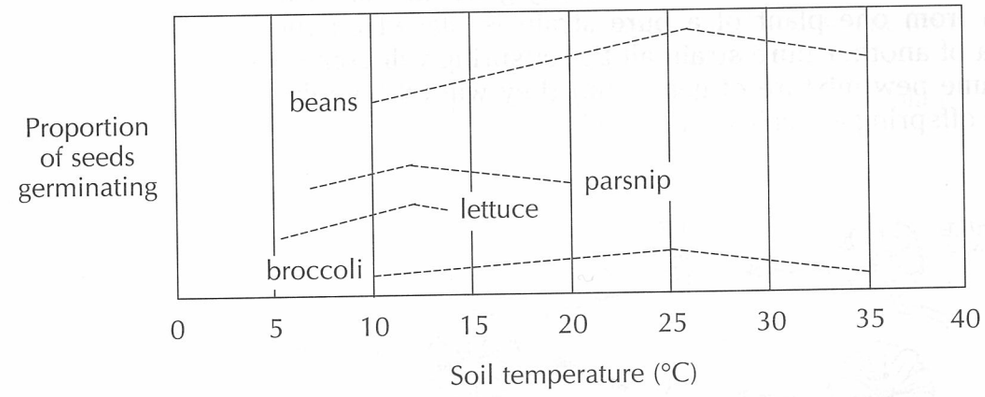
Questions

1 What is meant by 'viable' seed?
2 Why don't seeds last forever?
3 What can inform you about seed viability?
4 How should seed be stored?

Exercise

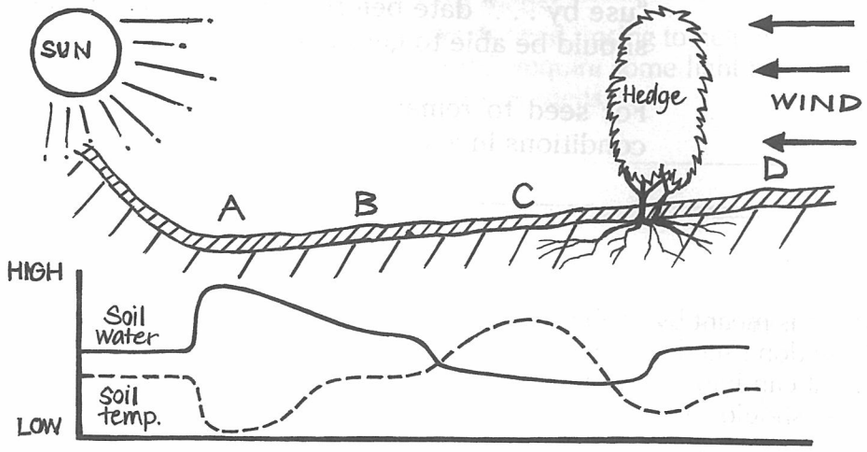
1 Use the graph to answer the questions that follow.

Graph showing optimum temperature ranges for seed germination



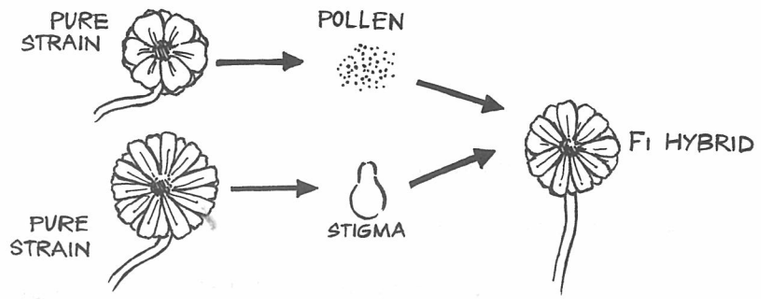
a What is the optimum soil temperature for the germination of bean seeds?
b What happens to seed embryos below zero degrees Celsius?
c Which two types of seeds might not germinate well in the soil in summer?
d Write a statement about lettuce seed germination.

2 The diagram shows the effect of shade and water on the soil temperature and moisture levels of garden soil. Copy the diagram and label the area which would be most suitable for sowing seeds. Then write a short paragraph to explain why you chose that area.



Hybrid seed

If flowers self-fertilise over a number of generations the plants will develop pure strains. Plants grown from their seeds will remain true to form for many generations. If the pollen from one plant of a pure strain is placed on the stigma of another pure strain all the offspring will contain the same new mixture of genes and they will all be alike. These offspring are called F1 hybrids.



F1 hybrids are popular with growers because they usually grow more strongly than either of their parents. This is called "hybrid vigour". They are also popular because they will all mature at the same rate and they will produce similar flowers and fruit. Because it may require hand pollination and so can be labour-intensive to produce, F1 hybrid seed is expensive to buy.

When F1 hybrids are allowed to go to seed the characteristics get mixed up again and all the offspring will be different.

Questions

1 What is meant by a 'pure strain'?
2 How are F1 hybrids produced?
3 Give two reasons why growers like F1 hybrids.
4 What is meant by 'hybrid vigour'?
5 Why is F1 hybrid seed more expensive than other seed?

Exercise

A grower cultivated some cuttings and some seedlings from a large attractive *Coleus* plant.

- The cuttings grew into plants looking the same as the parent plant.
- The seedling plants all looked different from the parent plant.

a Explain how sexual reproduction causes seedlings to be different from each other and from the parent plant. (Describe two points.)

b A grower bought some F1 hybrid cabbage seeds. What is a hybrid plant? (Describe two points.)

ACTIVITY

This activity will give you practice in breaking seed dormancy to ensure germination success.

AIM:
To carry out stratification using apple seeds.

WHAT TO DO:

1. Cut open three ripe apples and extract the seeds.
2. Put half the seeds on a damp paper towel. Sprinkle with a little fungicide to prevent them going mouldy. Roll them up and put the damp roll in the refrigerator for two weeks. Make sure it stays damp, but not wet.
3. Sow the other half of the seeds in damp potting mix.
4. After they have been in the refrigerator, sow the first set of seeds in damp potting mix.
5. Watch for germination in both sets of seeds. Note when it occurs and how many seeds germinate.

REPORT:

Write a report of this experiment into your notes. Explain how apple seeds would undergo stratification in nature.

8 Asexual reproduction

SUMMARY

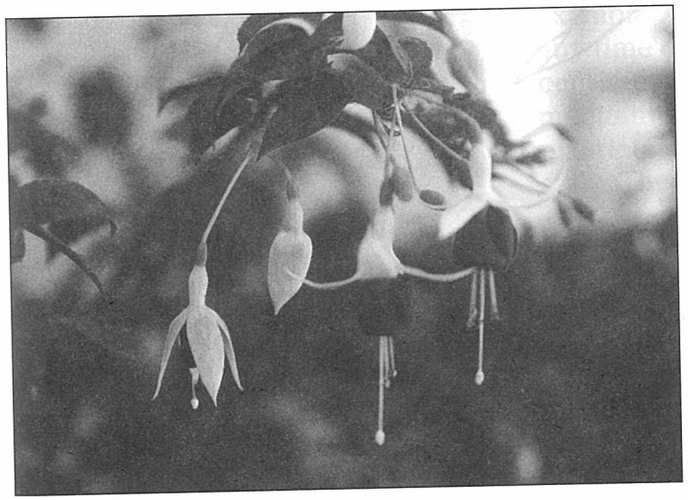
In vegetative propagation, sections of the root, stem or leaf of a plant are grown to form a separate plant. Seeds are not involved.

Some plants reproduce naturally by means of tubers, suckers, runners, bulbs and corms. Growers also make use of these natural methods to propagate plants.

Stem cuttings are an important means of vegetative propagation. Types of cuttings include herbaceous and tip cuttings, semi-hardwood and hardwood cuttings, both deciduous and evergreen.

The environment into which a cutting is placed must prevent the cutting from drying out, promote root growth and protect the cutting from diseases.

When cuttings have formed roots they are potted up and hardened off before being planted out.



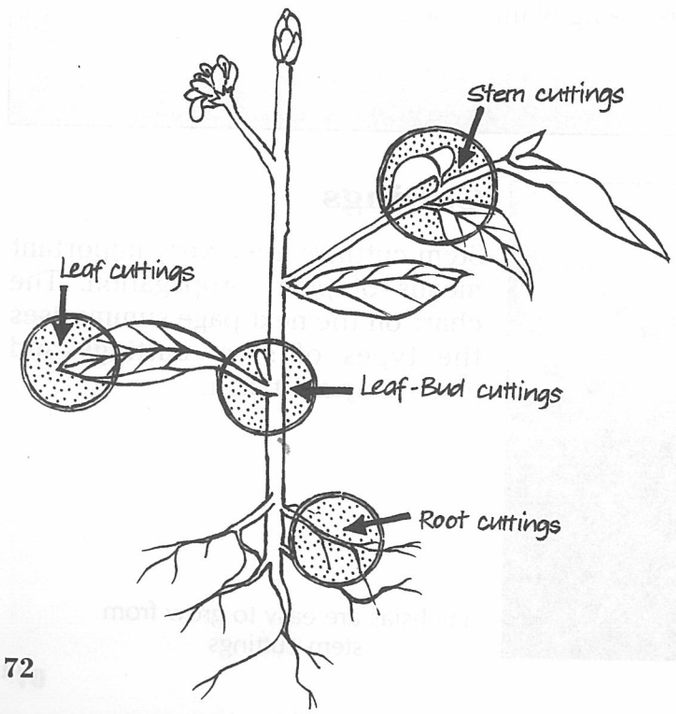
Cuttings

Stem cuttings are a very important means of plant propagation. The chart on the next page summarises the types of stem cuttings and when they are taken.

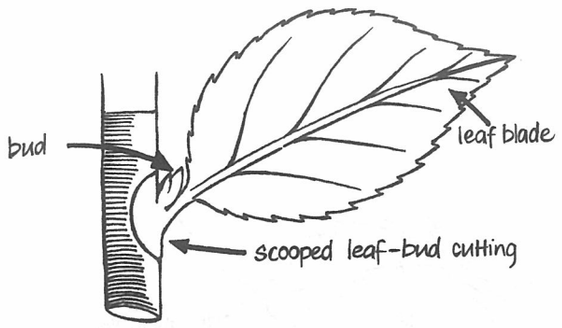
Fuchsias are easy to grow from stem cuttings

STEM CUTTINGS

Type of cutting	Parts to use	When to take cuttings	Notes	Examples
Tip cuttings	Fast-growing tips of plants	Spring	Good ability to make roots but lose water very easily	Fuchsia Lavender
Herbaceous cuttings	Stem tops after spring growth has slowed down	Early summer	More hardy than tip cuttings	Geranium Chrysanthemum Vines Berryfruit
Semi-hardwood cuttings (evergreens)	Strong shoots	Late summer to early autumn	A heel with the cutting gives a firm base and helps make roots	Hebe Cypress Honeysuckle
Deciduous hardwood cuttings	Woody stems	Autumn and winter	Easiest to grow	Blackcurrant Roses Willows



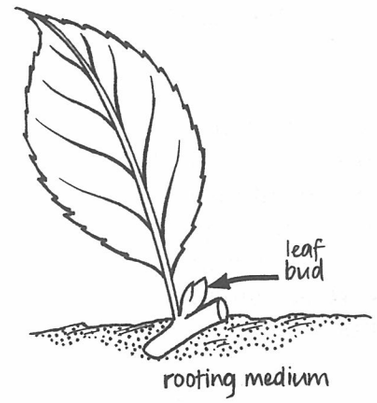
Cuttings can also be taken from other parts of the plant, as shown in the diagram.



Leaf-bud cuttings

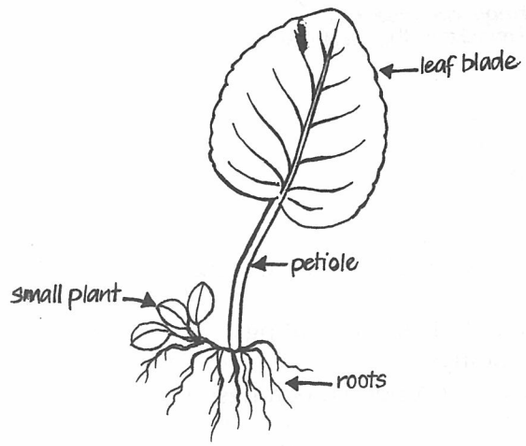
Leaf-bud cuttings consist of a leaf blade, a petiole and a short piece of stem with an axillary bud. A large number of cuttings can be made from a small amount of stock material. The method also saves propagating space. Cuttings should be taken only from material with well-developed buds and strong, almost mature leaves. This method is used for camellias, rhododendrons, citrus and hydrangeas.

Leaf-bud cuttings are put into the rooting medium so that the bud is level with, or just above, the surface. Bottom heat and mist will promote growth.



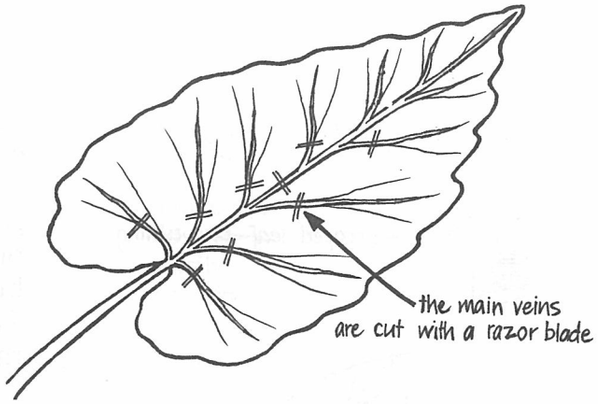
Leaf cuttings

Many herbaceous perennials, indoor pot plants and bulbs are propagated from leaf cuttings. They are used for plants whose stems are too short to take stem cuttings. Leaf cuttings should be made only from mature, healthy, fully-developed leaves.

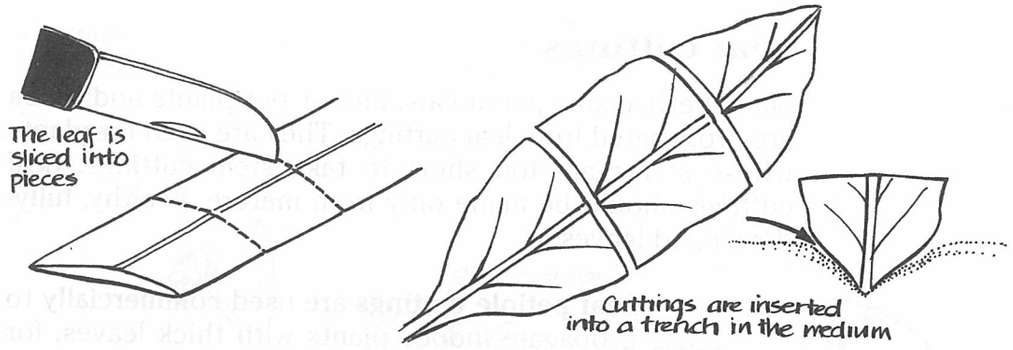


Leaf petiole cuttings are used commercially to propagate indoor plants with thick leaves, for example African violets. They can be taken at any time of year. A leaf is cut off with about two centimetres of petiole, put into a rooting medium and kept in warm conditions. New plantlets develop on the cut surface of the leaf stalk. They can be separated and potted up.

Non-petiole cuttings are made from entire leaves with the veins cut. A leaf is removed from the plant and the main veins are cut with a razor blade. Then the cut leaf is pegged down onto the rooting medium. After two or three weeks new plants start to grow from the cut leaves. Rex begonias are often propagated like this. High humidity and bottom heat are needed.

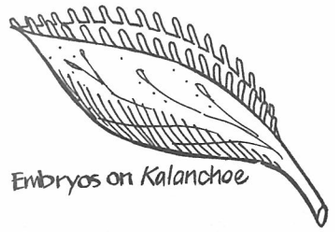


Leaf portions. This method is especially useful for plants with big leaves, and for monocotyledons such as snowdrops and *Sansevieria* species. The leaves are cut into portions of two to three centimetres with a piece of large vein on each portion. The cuttings are put in trenches in the rooting medium and firmed in. After a few weeks, small plants grow at the base of the cut leaf segments.



Questions

1 Give two advantages in using leaf-bud cuttings.
2 Draw a diagram to show how a leaf-bud cutting should be put into the rooting medium.
3 Name three species able to be propagated by leaf-bud cuttings.
4 What sort of leaves are needed for leaf cuttings?
5 What sort of conditions are needed to grow non-petiole cuttings successfully?
6 Explain how some plants can be propagated from leaf portions.

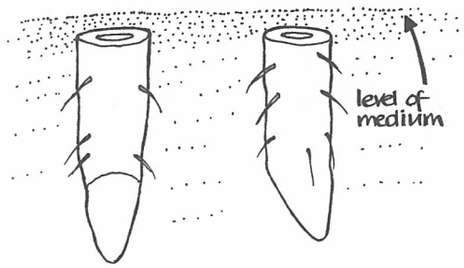


Plantlets

A few plants, for example *Bryophyllum* fern species and *Kalanchoe* species, are capable of producing small embryo plants around the edges of the leaves. To propagate these plants, mature leaves are detached and put on the surface of rooting medium. When the embryos form roots they are detached and potted up.

Root cuttings

Many plants are able to be propagated by root cuttings, for example, berryfruit, apples, pears, plums, cherries, kiwifruit and poplars. However this method is not widely used commercially because the same plants can usually also be propagated by stem cuttings, which are easier and more convenient.



Root cuttings are made from late summer to early spring. Roots from young plants are cut into five centimetre sections and placed either horizontally or vertically in the medium. They must not be allowed to dry out. Bottom heat will stimulate growth.

The rooting medium

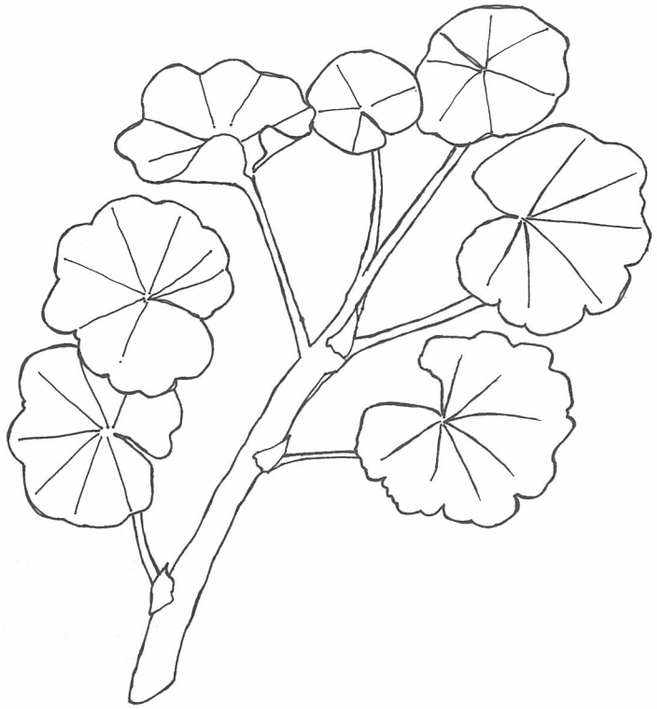
The rooting medium for cuttings must hold the cuttings in place while they form roots, provide moisture, and be free-draining. It must provide air at the base of the cuttings and be free from pests and diseases. A commonly used mix contains sawdust, peat and sand in a ratio of three parts sawdust to two parts peat and one part sand by volume.

Questions

1 Give an example of a plant which produces small embryo plants on its leaves.
2 Why are root cuttings not widely used commercially?
3 When are root cuttings made?
4 List five requirements of a good rooting medium.

Exercise

This diagram shows a piece of plant from which a softwood cutting is to be taken.



a Copy the diagram and then mark clearly on it where the cut should be made.

b Some of the leaves were then removed. Show on your diagram which leaves should be removed.

c How does removing leaves help the cutting to form roots?

d Name two conditions that are necessary to ensure successful root formation on softwood cuttings.

e Explain why each of the conditions is needed.

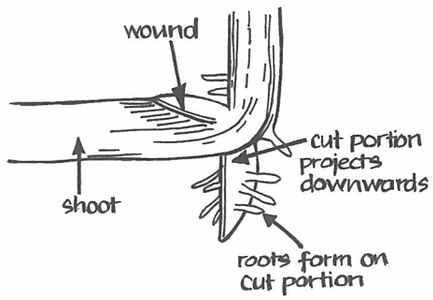
Layering

In some plants the stems can be encouraged to form roots while still joined to the parent plant. In this process, called layering, the stem is wounded to expose the growing region, called the cambium. Organic compounds accumulate at the wound, stimulating roots to form. One advantage of layering is that the layer gets water and nutrients from the parent plant until it has rooted and can support itself. However it is a time consuming technique. Layering is normally used to propagate plants which are difficult to strike from cuttings, for example magnolias.

Magnolias can be propagated by layering

Ground layering

The disadvantages of this method of propagation are that it is slow, needs a large number of stock plants and takes up a lot of space. A flexible stem is bent and partly covered with soil. A peg is usually needed to hold the stem down, and a stake holds the tip upright. The stem may be wounded to stimulate root formation and a rooting hormone applied.



After a good root system is established the new plant is separated from its parent. This can take up to twelve months. Ground layering is usually done in spring, using one year old stems. It can be used for berryfruit, climbers and many shrubs, for example daphne. It often occurs naturally in plants like blackberries and boysenberries.

Air layering

Air layering is rarely used commercially because it is very slow and only a few plants can be obtained from a parent plant. It is mainly used to propagate tropical or sub-tropical plants like the rubber plant.

Sphagnum moss is used because it prevents infection and retains moisture. Once a strong root system has formed the stem is cut off below the roots and the new plant can be potted up.

Questions

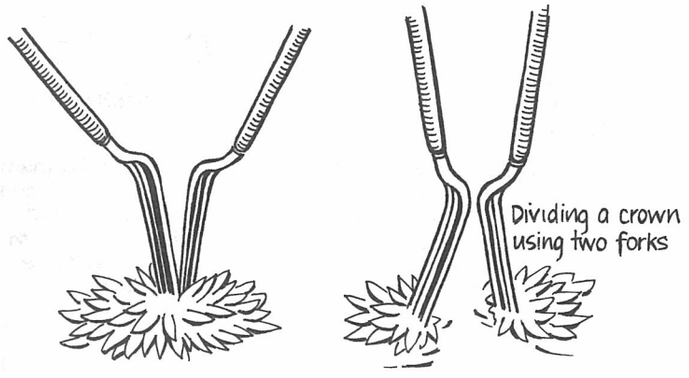
1 What is one advantage of using layering as a method of propagation?
2 What are two disadvantages of the layering technique?
3 What tissue is exposed when the stem is wounded during layering?
4 What is the purpose of wounding the stem during layering?
5 Give an example of a plant that can be propagated by ground layering.
6 Why is sphagnum moss used in air layering?

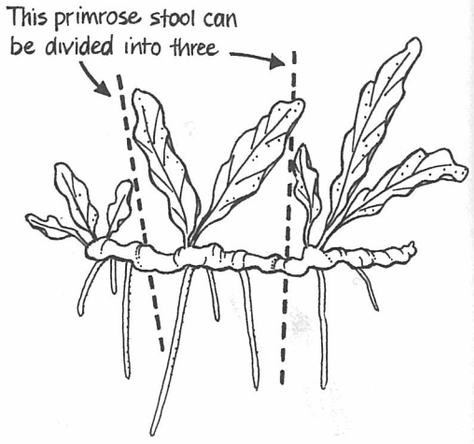
Division

Division is the breaking apart of the modified structures of some plants. The structures that are divided may be crowns, tubers, rhizomes, runners, stolons, offsets, bulbs or corms. Each part forms roots and is grown on as a separate plant.

Crowns

The crowns (or 'stools') of many herbaceous plants, for example Michaelmas daisies and chrysanthemums, can be divided into smaller pieces and replanted. Two forks can be used, or a spade.

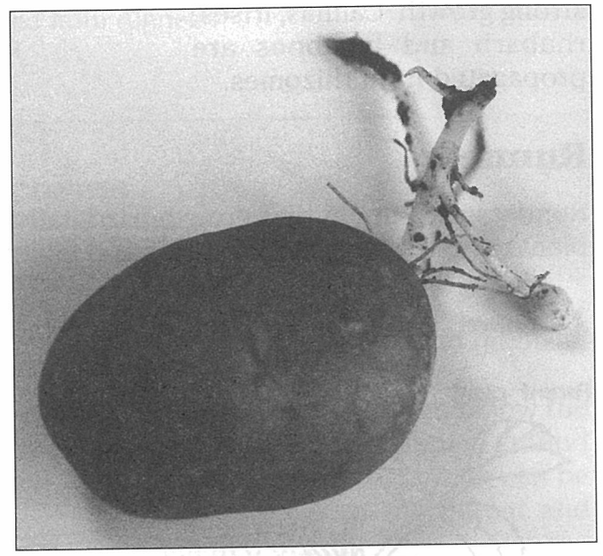




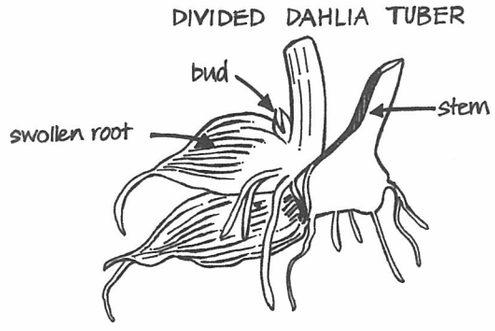
Flax cultivars are propagated commercially by crown division. It is important to get root and growth buds on each piece when dividing plants.

Tubers and tuberous roots

A tuber is a swollen underground stem. Potatoes are stem tubers. They can be divided by being cut into pieces. Each piece should have at least one bud from which the new plant will grow. The 'eyes' on potatoes are the buds.



Potatoes are swollen underground stems



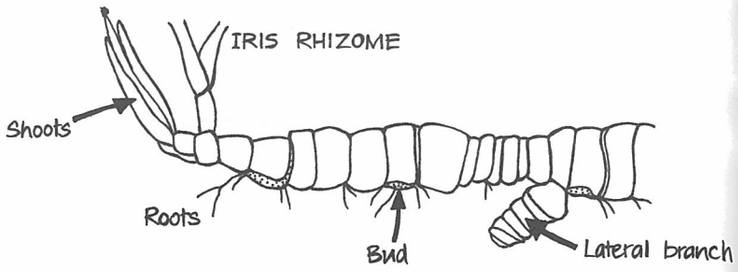
Tuberous roots are swollen roots. Buds are present only where last year's stem joined the root. Dahlias and kumara are examples of tuberous roots. As growth begins in spring dahlias are divided by being cut with a sharp knife. A small bit of stem is left with each piece.

Questions

1 How is division of plants carried out?
2 Name a plant that is propagated commercially by crown division.
3 What is a tuber?
4 How should tubers be divided?
5 Where are buds found on tuberous roots?
6 Give an example of a plant that has tuberous roots.

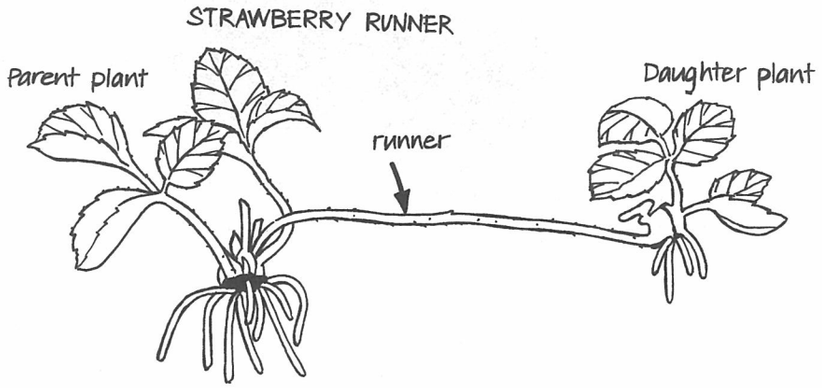
Rhizomes

Rhizomes are storage stems that grow just under the soil surface. They are divided by being cut into small sections, each of which has some strong growth. Cannas, irises, rhubarb and bamboos are propagated from rhizomes.



Runners

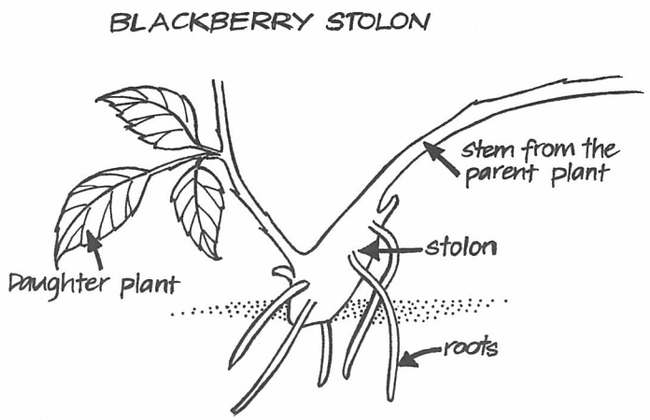
Runners are shoots that grow horizontally, producing new plants at the nodes. Strawberries and violets are examples.



Stolons

Stolons are swollen stem tips that form when a shoot touches the ground. The stolon swells and develops roots. Blackberries form stolons.

In propagation from runners and stolons the daughter plants are detached and replanted.



Offsets

Offsets are side shoots or branches that develop from the main stem of many plants. They are cut off at the base and transplanted. Many succulents reproduce by offsets.

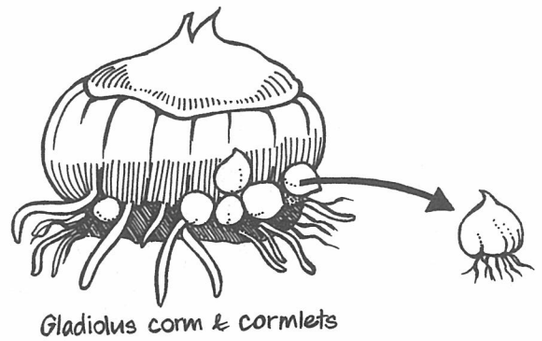
Questions

1 What name is given to storage stems that grow just below the soil surface?
2 How are irises propagated?
3 What is the difference between a runner and a stolon?
4 Give an example of a plant that forms stolons.
5 How are strawberry plants propagated from runners?
6 What are offsets?

Bulbs and corms

Bulbs are shortened stems with thick, fleshy leaf scales around them. Examples of plants propagated from bulbs are members of the daffodil and onion families. Bulbs increase naturally by splitting, offsets, bulbils and bulblets.

Bulblets are produced by some lilies on the stem below the soil surface. Bulbils are produced on the above ground parts of some lilies. Both can be separated from the parent and planted out.


Gladiolus corm & cormlets

Corms are solid stems, swollen to store food. Some corms, for example those of *Gladiolus*, produce cormlets at their bases. The cormlets may be grown on for one or two years to flowering size.

Questions

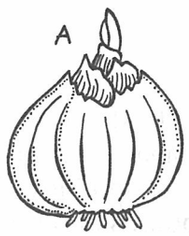
1 What is the difference between a bulb and a corm?
2 Give two examples of plants that produce bulbs.
3 How do lily bulbils differ from bulblets?
4 How are cormlets used to produce new plants?
5 Give two examples of plants that produce corms.

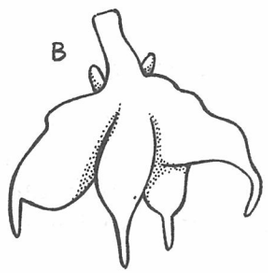
Exercise

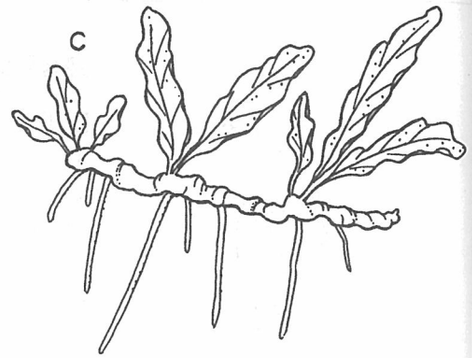
1 Match the names of the organs with their diagrams AND give examples of two plants which reproduce naturally by each method.

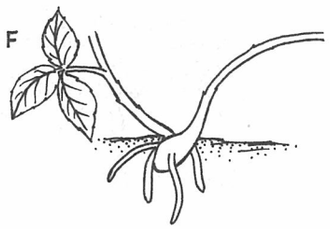
Names:

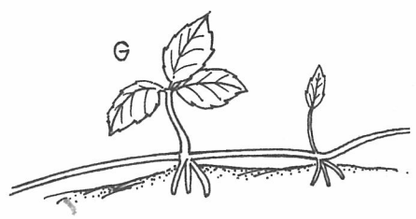
1	Stolon	2	Root tuber
3	Rhizome	4	Corm
5	Stem tuber	6	Stool
7	Runner	8	Bulb

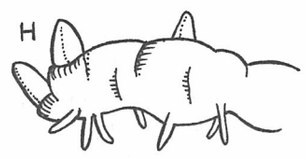












2 Bulbs, corms and tubers all store food for the plant to use during the dormant season. How is this an advantage to the GROWER?

Grafting

Grafting is the joining of parts of two plants so they unite and continue their growth as one plant. The parts joined are:

- the scion: forms the shoot system
- the rootstock (stock): forms the root system

Top cleft grafting on an apple tree

The two plants used must be closely related to each other because their cambium cells must be able to grow together and join the scion to the rootstock. To be compatible, stock and scion are usually of the same species. So a stonefruit rootstock, for example plum, would be used with another stonefruit, for example cherry, but not with pipfruit like apples and pears.

Grafting is carried out to give the benefits of the rootstock, for example disease resistance, to the scion variety. It is used to propagate varieties which are difficult to propagate by other methods. Sometimes it is used to make use of an established rootstock or it may be used to bring pollinators together.

There are various methods of grafting. All involve exposing the cambium, which is the actively growing layer of cells just below the bark. Cambiums from both scion and stock are brought together and held so they will grow together.

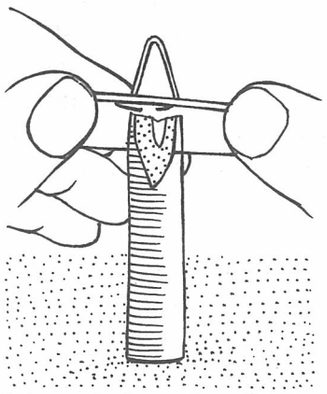
Woody plants are grafted in early spring, just as growth begins.

Questions

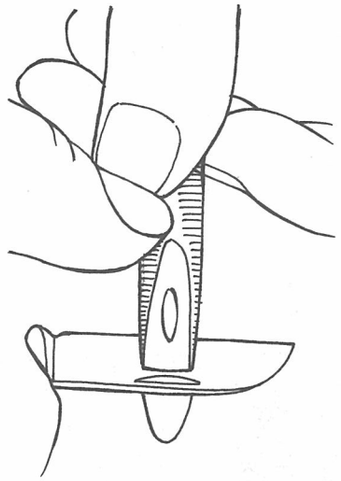
1 What is grafting?
2 Explain the difference between 'stock' and 'scion'.
3 Why must the two plants used be closely related to each other?
4 Give four reasons why grafting may be carried out.
5 What is the name given to the actively growing layer of cells just below the bark?
6 At what season of the year are woody plants grafted?

Whip and tongue graft

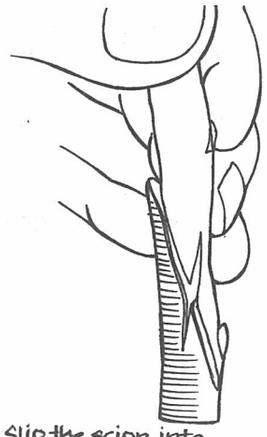
A zig-zag cut is made on both scion and woodstock. The two pieces are fitted together. They are tied and sealed until buds appear on the scion. This sort of graft is used for many plants, including citrus trees, cherries and kiwifruit. Stock and scion are the same size which helps the cambium layers to match up.



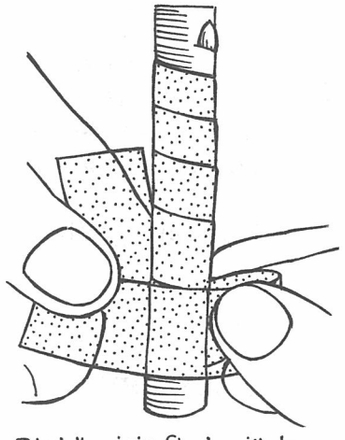
Make a sloping cut on the rootstock & slice into it.



Make a sloping cut on the scion & slice into it



Slip the scion into the rootstock.



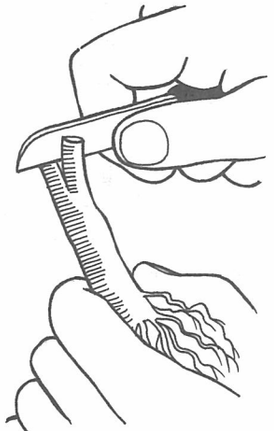
Bind the join firmly with tape. Leave the top bud outside the tape.

Cleft grafting

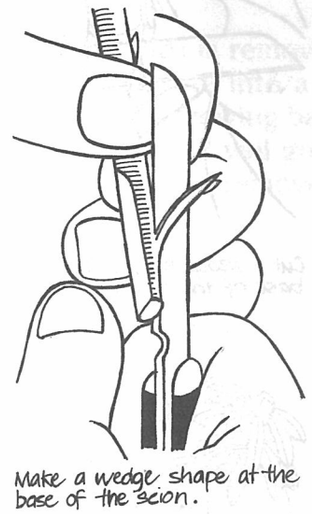
Cleft grafts can be used when the stock is much bigger than the scion.

Top cleft graft

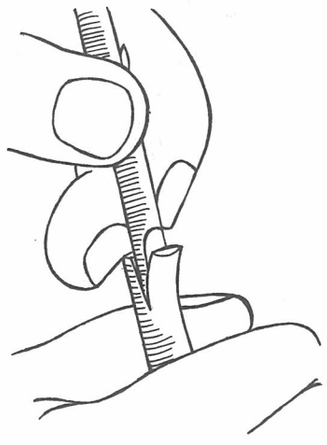
This type of graft is used on old fruit trees. It is also used for grapes, kiwifruit, citrus, camellias and some conifers. The top of the stock is cut off and cuts are made in the bark and wood. The scion is cut to form a sharp wedge and is forced into the stock so the cambium layers line up. More than one scion may be used on each stock if the stock is big enough. The grafts are sealed until they 'take'.



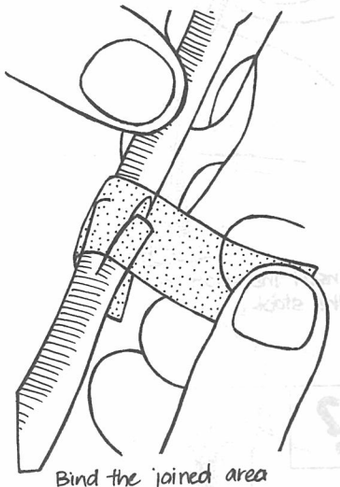
Make a cut in the root stock.



Make a wedge shape at the base of the scion.



Push the scion into the stock.

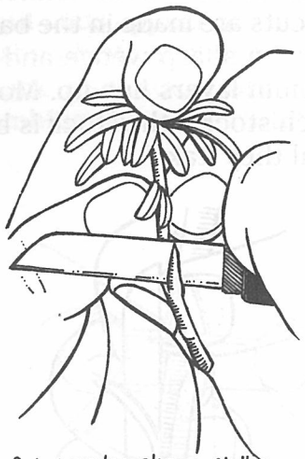


Bind the joined area with tape.

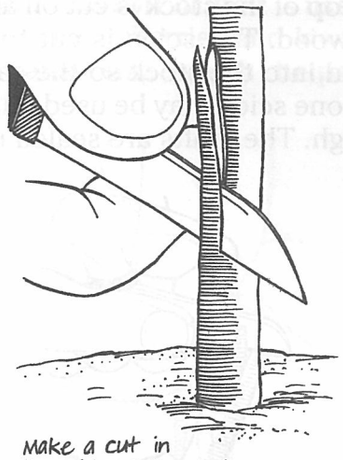
Side cleft graft

This method is used for conifers and other evergreen ornamental plants. The base of the scion is cut in a wedge

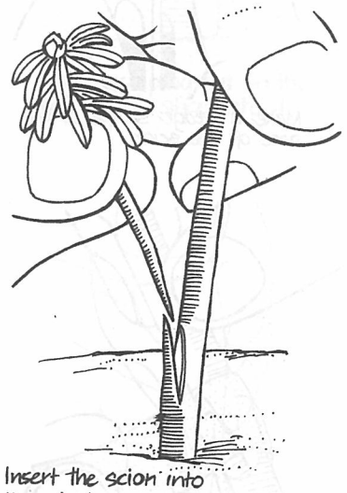
shape which is forced into a cut made in the side of the stock. The top of the stock remains in place until the graft has taken.



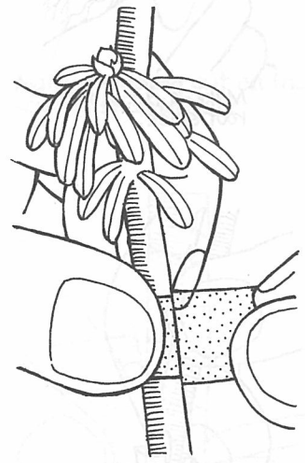
Cut a wedge shape at the base of the scion.



Make a cut in the side of the stock.



Insert the scion into the stock.



Leave the top of the stock in place until the graft 'takes.'

Questions

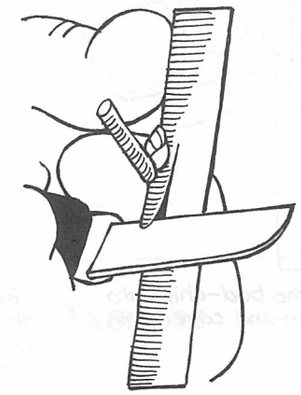
1. What sort of cut is made for a whip and tongue graft?
2. What helps the cambium layers to match up in a whip and tongue graft?
3. What sort of graft can be used if the stock is much bigger than the scion?
4. Explain how a side cleft graft is made.
5. Give an example of plants that may be grafted using the side cleft method.

Budding

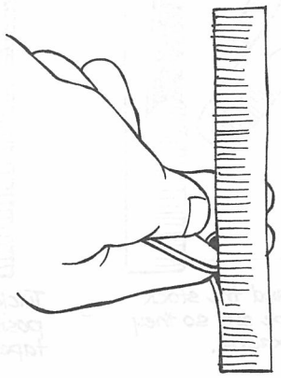
Budding is a simple, fast and economical method of grafting which uses very small pieces of scion material consisting of only a bud. It is used for roses, apples, pears, apricots, plums and other fruit trees as well as beeches, birches and maples. It is usually carried out in spring or summer.

T-budding (Shield budding)

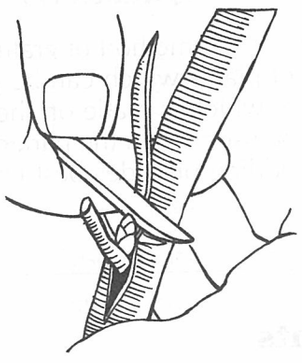
A mature bud with a piece of bark (the shield) is removed from the current season's growth. It is inserted into a T-shaped cut which has been made on actively growing bark of the stock and it is tied in. Eventually the bud will grow into a shoot and the top of the stock plant can be removed.



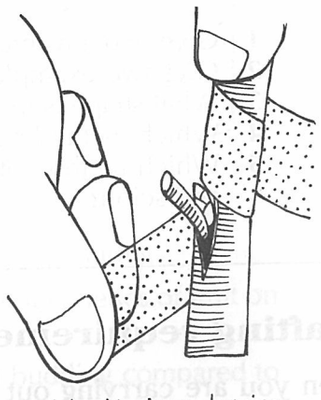
Remove a healthy bud with a piece of bark.



Make a T-shaped cut in the stock and loosen the flaps.



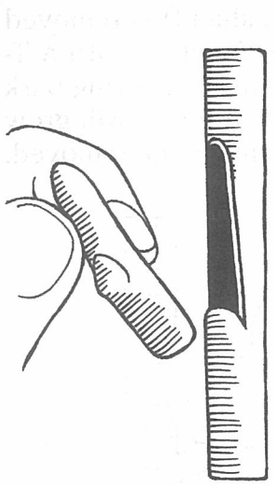
Slip the bud into the cut.



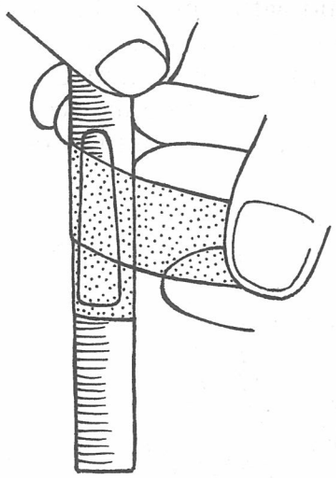
Bind with tape, leaving the bud exposed.

Chip budding

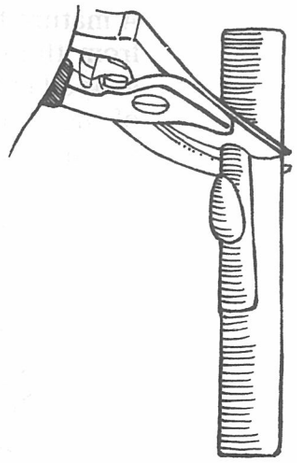
Chip budding provides greater contact between the cambiums of the stock and the scion than T-budding does. This method is useful when the bark of the stock will not lift easily. Stock and scion should both be cut so their shapes match exactly. The bud is inserted in the stock and both are wrapped with clear grafting tape to prevent drying out until the bud begins to develop.



A bud and the stock should be cut so they match exactly.



Tuck the bud-chip into position and cover with tape.



Remove the tape once the bud has united. Cut the stock back close above the bud.

Questions

1 Give two advantages of the method of grafting known as 'budding'.
2 Give two examples of plants which can be propagated by budding.
3 What shape is the cut which is made on the stock for shield budding?
4 Which method can be used when the bark of the stock will not lift easily?
5 Which method of budding provides best cambial contact between stock and scion?

Grafting requirements

When you are carrying out any sort of grafting you must make sure that the two plants are compatible. Both stock and scion should be free of disease. The stock may be

produced from seeds, cuttings or layering. It should provide vigorous growth and a desirable growth habit, be disease-resistant and easy to propagate.

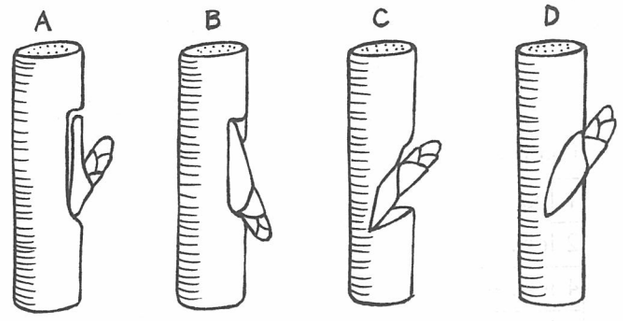
Both stock and scion must be at an appropriate stage of development for grafting to be successful. Clean cuts must be made with a very sharp knife so that the wound will heal quickly, and the cut surfaces must be placed together as quickly as possible so they will not dry out. Sealing compounds and grafting tape help prevent drying out, hold the surfaces together and provide warmth while the graft takes.

Questions

1 By what methods can you produce stock for grafting?
2 Give four characteristics of good rootstock material.
3 Why should a very sharp knife be used for grafting?
4 Why should grafting be carried out quickly?
5 Why are sealing compounds and grafting tape used?

Exercise

1 The diagram shows four chip buds.
   a Which ONE of the buds is likely to "take"?
   b For each of the other buds, give one reason why it will not grow onto the stock.



2 Give THREE factors which could cause a graft to fail. Explain how each can be overcome.
3 What is the cambium layer? Describe its importance in grafting.
4 Why would a commercial orchardist not graft different varieties of fruit on to one tree?
5 Describe two advantages and two disadvantages of budding compared to other forms of grafting.

ACTIVITY

Water is lost by transpiration from the leaves of cuttings, but some leaf surface is necessary so the cutting can carry out photosynthesis to make food and grow. In this activity you will investigate the relationship between the number of leaves left on cuttings and how well they grow. An indication of the growth of a cutting is how well it develops roots.

AIM:
To find the relationship between the number of leaves and the amount of root growth on *Impatiens* ("Busy Lizzies") cuttings.

WHAT TO DO:

1 Take 20 cuttings from a strongly growing *Impatiens* plant in five groups of four cuttings:
   - **a** leafless (0 leaves)
   - **b** with 1 leaf on each cutting
   - **c** with 2 leaves on each cutting
   - **d** with 4 leaves on each cutting
   - **e** with 6 leaves on each cutting

2 Trim any large leaves so that all leaves are approximately the same size.

3 Put the cuttings in containers of pumice. Keep them on a hot-bed and make sure they are watered regularly.

4 After one week remove all the cuttings from their containers and count how many small roots have grown on each cutting.

RESULTS:
Record your results on a table like this:

	Cutting number:				
	1	2	3	4	Average number of roots
Leafless					
1 leaf					
2 leaves					
4 leaves					
6 leaves					

REPORT:
Write a full report of this experiment, including your results and, if possible, a graph to show the relationship between number of leaves and root formation. Mention any problems that arose in the experiment. Make a statement about how the number of leaves affects root formation for *Impatiens* cuttings.

Section Four

Plant Husbandry

9 The growing environment

SUMMARY

Plants grow well when they have the correct amounts of all the things they need. The main things that affect plant growth are water, light, nutrients, temperature, wind, humidity, pests and diseases.

The best conditions for growth are similar to those where the plant would grow in nature. Specialist plants like orchids, ferns and cacti need special treatment to provide conditions similar to their natural environment.

The environment for plants can be modified by cultivation, which improves drainage, soil structure and aeration, and gets rid of weeds. Methods include digging, weeding, raking, hoeing and mulching; and using tools such as spades, forks, hoes, rakes and trowels. The tools should be used and cared for correctly.

Plants need protection from extremes of temperature, wind, light and water. This can be provided outside by shelterbelts which may be natural or artificial. Indoor shelter is given by shadehouses, greenhouses, tunnel houses, cloches and cold frames. The environment inside these structures may be further modified by heating and irrigation systems.

Training controls the shape, size and direction of plant growth. Methods include staking, stopping, disbudding, thinning and pruning.

Life cycle conditions

Different conditions may be necessary for different stages of a plant's life cycle. For example, most deciduous fruit trees, like apples, pears and peaches will not grow or fruit well without cold winter temperatures. This need for low

temperatures is called the chilling requirement. It is measured as the total number of hours below 10°C that the tree needs. Many stone and pip fruits have a high chilling requirement (about one thousand hours) and will not produce fruit of high quality where winters are mild. However, once the trees begin flowering in spring they must be protected from severe frost that can damage young flowers and fruit.

Peach blossom needs frost protection

High summer temperatures help fruit to ripen well.

In spring, young kiwifruit must be well sheltered from winds which can break off tender young growing shoots at their bases. Shelter is again required in autumn when leaves may get blown off before the flower buds have formed for next season's growth.

?

Questions

1 Give an example of a tree which needs different conditions at different stages of its life cycle.
2 What is meant by the "chilling requirement"?
3 How is chilling requirement measured?
4 Why must peach trees be protected from severe frost in spring?
5 During which seasons do kiwifruit most require shelter, and why?

Exercise

Read the following information about orchid growing and then answer the questions that follow.

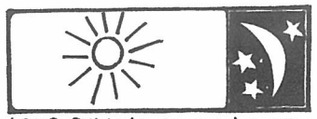
"Cymbidiums (a type of orchid) need the protection of a greenhouse or similar structure. The flowers are initiated during summer. Initiation is best when temperatures are kept down. A good cooling system (ventilation and perhaps a misting system) is needed, or the plants should be shifted into a shade house. If the summer day temperature is kept to a maximum of 25°C the number of flower spikes per plant can be doubled. In winter the night temperature for flowering plants should not be allowed to drop below 14°C. Non-flowering young plants are best kept consistently warm to encourage them to grow quickly. A temperature of between 15 and 20°C, day and night, is best for young plants."

a When do cymbidiums have to be kept cool, and why?
b What is the lowest night temperature advised for the flowering plants?
c How do young plants differ in their temperature requirements?
d Cymbidiums grow naturally in tropical jungles. Do the facts in the extract suggest this? Explain your answer.

Light intensity

While all green plants must have some light, plants are to be found in conditions which range from bright sunlight to deep shade. Each plant type is adapted to live in a range of light conditions. This range may be narrow or quite broad. The table shows the light preferences of some common flowering plants.

Name	Preferred growing position		
	Sunny	Partly shaded	Shade
Alyssum	✓	✓	
Anemone	✓		
Cineraria	✓	✓	✓
Forget-me-not		✓	✓
Fox glove	✓	✓	
Gladioli	✓	✓	
Lupins	✓		
Pansies		✓	
Polyanthus		✓	✓
Zinnia	✓		



Length of day and night

Many plants, for example tomatoes and peas, simply flower when they reach a certain size. However others, for example tobacco, chrysanthemums and primroses, are said to be 'short-day' plants because they will not flower until the days are shorter than a particular critical length, which varies with each species. Others, like spinach and oats, need long days and short nights and are called 'long-day' plants. If growers want to produce year-round flowers in greenhouses they must provide artificial conditions of light and dark to meet these needs.

Questions

1 Name two flowering plants that grow best in shaded conditions.
2 Name one flowering plant that will only grow well in a sunny position.
3 What is required for tomatoes and peas to flower?
4 Explain what is meant by a 'short-day' plant and give an example.
5 How can growers meet the requirements of short and long-day plants in greenhouses?

Exercise

Read the following information about chrysanthemum growing and then answer the questions.

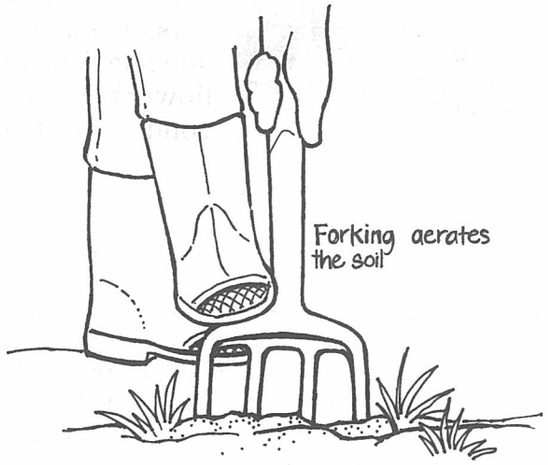
"When chrysanthemum plants are growing strongly they need a period of 10.5 hours of darkness every night to bring them into flower. In New Zealand this occurs naturally between 7 March and 7 October. To make chrysanthemums flower in summer the plants must be darkened artificially during the evening and early morning. Black polythene can be used to cover the greenhouse but care must be taken to prevent overheating under the cover. Covers should be drawn back at night to prevent build up of humidity. Blacking out can be automated, using a time switch. Chrysanthemums need good light to produce quality flowers so you should not make the hours of darkness longer than is necessary."

a Are chrysanthemums long-day or short-day plants?
b What period of continuous darkness is needed by chrysanthemums to bring on flowering?
c How can dark conditions be provided in summer?
d How can a build-up of humidity be prevented?
e If the hours of darkness are too long, what may happen to the flowers?

Cultivation times

Only very sandy soils can be cultivated soon after wet weather. Medium textured soils make clods if they are cultivated too soon and clay soils turn slimy and their structure is spoiled.

Autumn is the best time for cultivation if you are using a spade or a rotary cultivator. The soil is usually dry in autumn and winter frosts can then complete the job of breaking up the particles to a fine tilth. In spring and summer, forking is a useful method of cultivation. Forking aerates the soil and annual weeds can be cleared at the same time. Forking can be carried out among established plants if it is done carefully.



To prevent annual weeds growing around shrubs and trees the ground can be covered with a mulch of bark, lawn clippings or a similar material. Weed control mats of polypropylene may also be used as a mulch. They are an improvement over black plastic because while they are sufficiently closely woven to prevent weed growth, they still allow water, nutrients and air through to the soil.

?

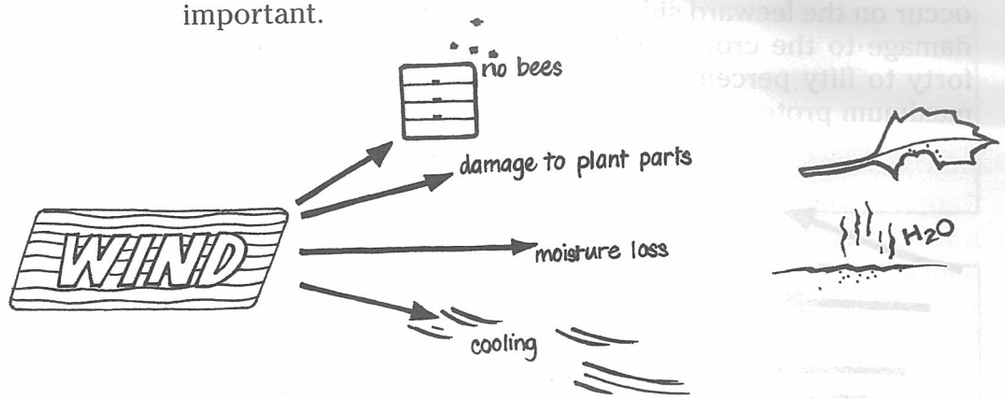
Questions

1 What is the only type of soil that can be cultivated soon after wet weather? Explain your answer.
2 Why is autumn the best time for using a spade or rotary cultivator?
3 Which method of cultivation is best in spring and summer?
4 How can you prevent annual weeds growing around shrubs and trees?

Shelter from wind

Wind can damage plants directly or indirectly. Direct damage includes mechanical damage to stems, leaves, flowers or fruit. Indirect damage includes the cooling effect of wind, which slows down growth. As well, wind reduces the activity of pollinators like bees, and increases moisture loss from the soil and from the plants themselves. Shelter

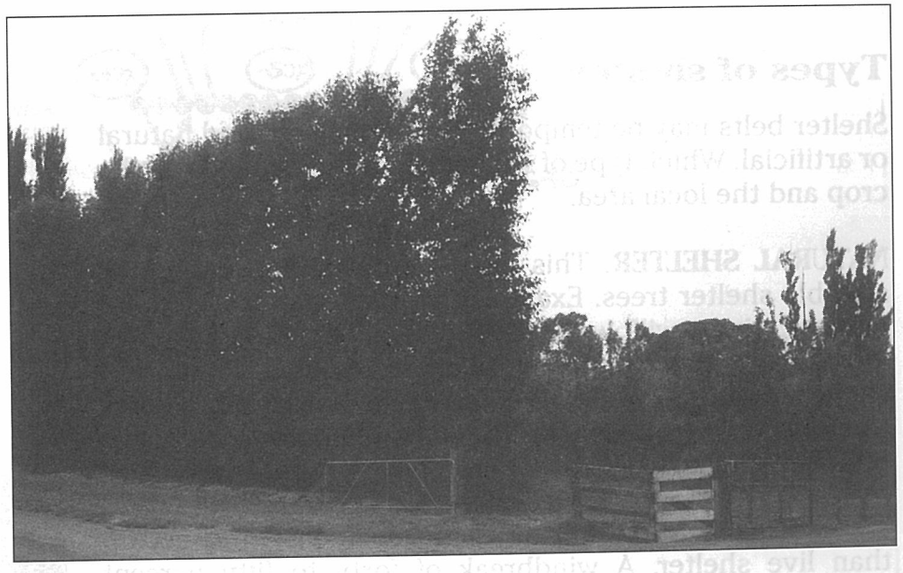
has some disadvantages, for example, it may harbour some pests and diseases. However, its benefits are far more important.



Shelter belts

A good shelter belt requires adequate height, length and permeability.

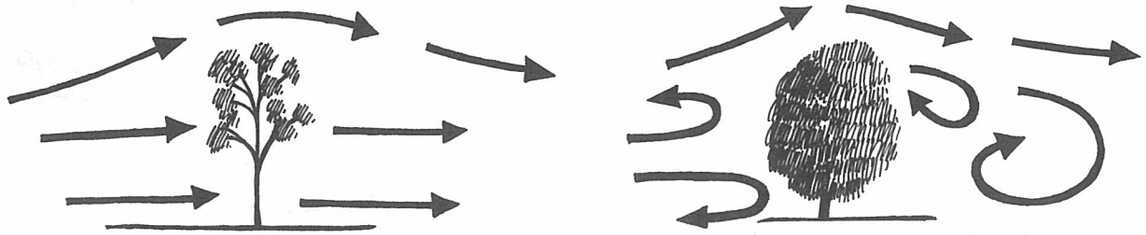
HEIGHT. The protected area is directly proportional to the height of the shelter. Good protection is provided for ten to fifteen times the height of the shelter. So a shelter ten metres high will give wind protection for 100 to 150 metres. The amount of protection decreases as distance from the shelter increases



Natural shelter protecting an orchard

LENGTH. Windbreaks should be as long as possible and have no gaps, because an increase in wind speed occurs at the ends of a shelter belt. Gaps allow wind to funnel through.

PERMEABILITY. The shelter belt should act as a wind filter rather than a solid barrier, because wind turbulence may occur on the leeward side of a dense shelter belt and cause damage to the crop. Shelter that reduces wind speed by forty to fifty percent provides the smoothest airflow and maximum protection.



Questions

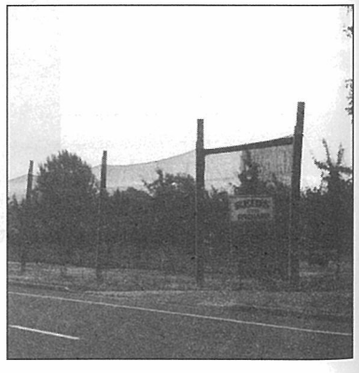
1 What are the three requirements of a good shelter belt?
2 How is the height of the shelter related to the amount of protection it gives?
3 Why should windbreaks have no gaps?
4 What bad effect is caused by a solid barrier?
5 What is meant by 'permeability' and why is it important?

Types of shelter

Shelter belts may be temporary or permanent, and natural or artificial. Which type of shelter is chosen depends on the crop and the local area.

NATURAL SHELTER. This means growing and caring for suitable shelter trees. Examples of trees that are used are poplars, pines, willows and cypresses. Sometimes a quick growing species of shelter plant is used as temporary shelter for a crop while permanent, slower growing shelter trees become established. Then the temporary shelter is removed and another row of crop plants is put in its place.

ARTIFICIAL SHELTER. This is more expensive to set up than live shelter. A windbreak of forty to fifty percent permeable plastic mesh is usually used. Its advantages are that it does not take up much space, it does not compete with the crop for nutrients or light and it does not provide a place in which pests and diseases can live.



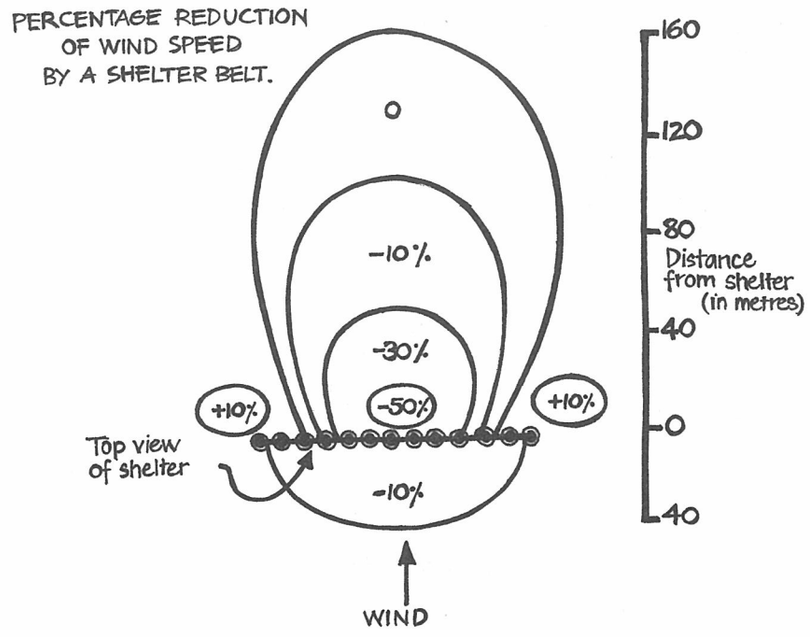
Artificial shelter

Questions

1 Give two examples of trees that are used for natural shelter.
2 From what material is artificial shelter usually made?
3 Give one disadvantage of artificial shelter.
4 Give three advantages of artificial shelter.

Exercise

Study the diagram showing percentage reduction of wind speed by a shelter belt and then answer the questions.



a Where, in relation to the shelter belt, is wind reduction greatest?
b For what distance from the shelter is wind protection given?
c What effect does the shelter have on the windward side?
d What happens at each end of the shelter belt?
e Approximately how high would the shelter be? Explain your answer.

Pruning

Pruning changes the natural form of a plant as you cut away parts of the plant. It may be carried out to control the shape of the plant, improve flowering, remove dead or diseased parts, improve light penetration, aid harvesting, or for a mixture of these reasons.

Different species require different pruning treatment. For example, some plants are best pruned in winter, others in spring, and still others need no pruning at all. Some plants fruit on new wood — others on old wood. Pruning must take account of this. It is important to know what you want to achieve for the particular plant you are pruning.

The chart shows the growth that must be encouraged for each type of fruiting plant because the fruit is carried on this growth. Other shoots may be pruned away.

Fruit is carried on:

New season's growth	Wood which grew the previous season	Wood that is two years and older
Kiwifruit	Feijoa	Apple
Grapes	Lemon	Pear
Passionfruit	Nectarine	Blackcurrant
Tamarillo	Orange	Cherry
Walnut	Peach	English plum
Quince	Raspberries	
Persimmon		

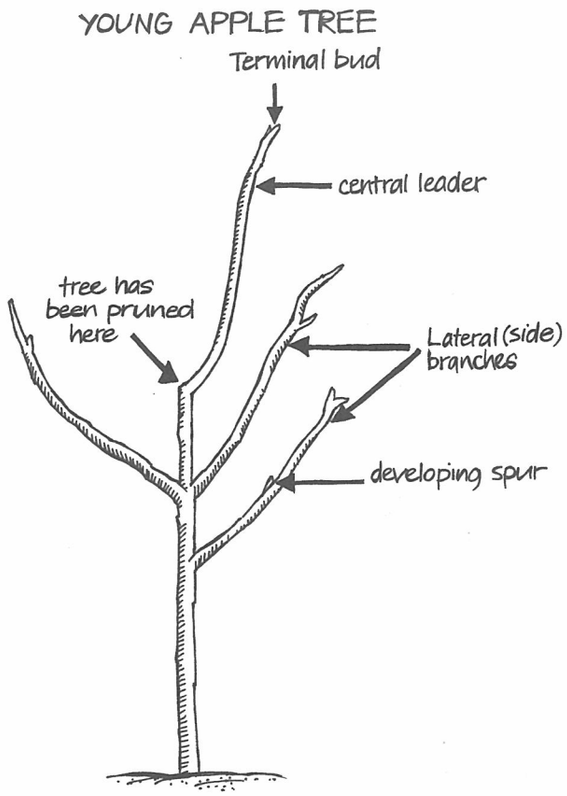
?

Questions

1 What is meant by "pruning" a plant?
2 Give five reasons why pruning may be carried out.
3 Name three plants which carry their fruit on the growth which is produced the same season as the wood.
4 Why do pear trees need to have plenty of two-year old wood remaining on them?

A pruning example — apple trees

Correct pruning of apple trees results in trees which are easy to manage and produce good quality fruit. Following, is one method of pruning them.



The young trees are pruned so that only one main shoot, the 'leader' is allowed to grow. From this main central leader side branches or 'laterals' are allowed to grow, spaced evenly in sets of four about one metre apart. The laterals are kept pruned so they do not outgrow the leader.

As the tree grows older the leader and laterals grow short shoots or 'spurs'. Some spurs must be cut away to prevent overcrowding, but some must be left because apple wood must be at least two years old before flowers and fruit develop on it.

Pruning of fully mature trees in winter consists of removing any weak and dead branches and twigs, or any that are crossing or crowded, as well as cutting back worn out laterals to provide replacement shoots which will bear fruit two years later.

?

Questions

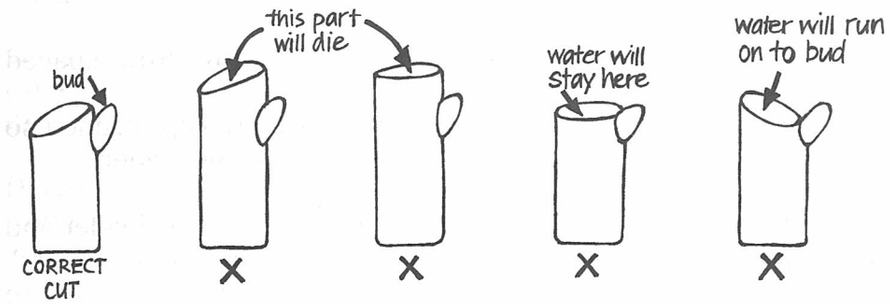
1 Why is it desirable that apple trees should be pruned?
2 Describe the appearance of a young apple tree which has been pruned using the method described here.
3 What is a 'spur'?
4 What age must apple wood be before flowers will grow on it?
5 What is the aim when fully mature trees are being pruned in winter?

Pruning principles

All pruning cuts should be made above a healthy bud which will continue growing, leaving no stump to dry and die. Dead stumps are entry sites for disease organisms. Any dead or diseased wood must be cut away.

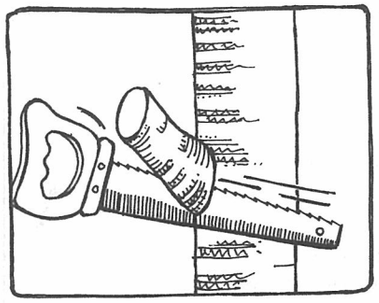
The cuts should be made cleanly using sharp tools to prevent damage to the plant. Pruning cuts are made at an angle of forty-five degrees to the shoot that is being cut.

The sloping cut allows water to run off, which helps to prevent rotting.

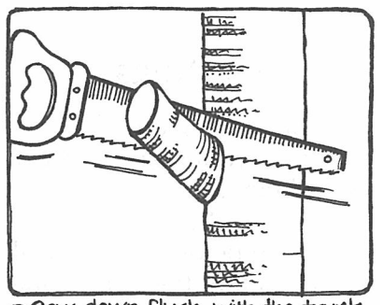


If a very large cut has to be made it should be made flush with the trunk and the cut should be smoothed with a pruning knife to reduce the total surface area over which disease organisms can enter. The cut can be coated with a pruning compound to keep out disease organisms while the cut heals.

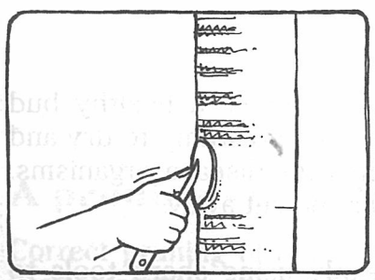
If a large limb has to be removed from a tree the branch should first be cut back to a stump of about 600mm so that the falling branch does not tear the trunk and leave a large wound. Then the stump is dealt with as shown in the diagrams.



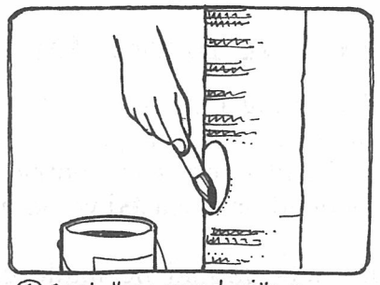
①Undercut to prevent tearing.



②Saw down flush with the trunk, to meet the undercut.



③Clean up with a pruning knife to make the exposed surface as small as possible.



④Seal the wound with a wound dressing paint to keep out bacteria & fungi.

Tools used for pruning include secateurs, loppers, knives and pruning saws. For efficiency and safety they should be kept sharp, clean and well-oiled. Mechanical pruners are used for some crops, for example, kiwifruit.

Questions

1 Why should pruning cuts be made above a healthy bud?
2 Why are cuts made at an angle to the shoot?
3 Copy the diagram showing correct and incorrect pruning cuts.
4 How can disease organisms be prevented from entering a large cut?
5 Name four tools used for pruning.
6 How should you care for pruning tools?

Exercise

Read the extract about pruning kiwifruit and answer the questions that follow.

"Kiwifruit pruning is a demanding but vital part of vine management. Good open pruning of kiwifruit allows sprays to penetrate and makes sure that there is good access for bees during the flowering period. Air is able to move freely through the vines and this helps to minimise conditions favourable to fungal diseases. Open pruning also lets in adequate light to ripen fruit and helps new shoots to grow.

While kiwifruit crop on growth of the current season, the fruit only forms on growth that comes from one-year-old wood. So the aim of winter pruning is to leave the optimum amount of one-year-old wood on the vine, evenly spread out, ready for the fruiting shoots to grow from it.

Several summer prunings are necessary during the growing season to maintain spacing and light access. Shoots to be kept for next season are selected to remain unpruned on the vine, while fruiting laterals are shortened and tangles removed. It is important not to overprune in summer because there must be sufficient leaves on the vine to enable the fruit to reach a good size and prevent it being scorched by the sun."

a Give four reasons why kiwifruit vines are pruned.

b Explain why the aim of winter pruning is to leave one-year-old wood on the vines.

c Why are summer prunings also necessary?

d Overpruning in summer is undesirable. Why?

ACTIVITY

Plant husbandry is so important that many people are involved in providing the tools and structures used by growers to care for their plants. In this activity you will investigate the wide range of equipment that is available for growers.

AIM:
To get some idea of the tools and equipment currently available to help growers care for their plants.

WHAT TO DO:

1 Use gardening magazines and advertising material from hardware shops and horticultural suppliers. Cut out twenty advertisements for items that will help improve the growing environment for plants.

2 Arrange the items in groups according to whether they assist with water, nutrients, cultivation, protection or training of plants. (Some items will fit in more than one group.)

3 Stick the pictures, in their groups, on to a large sheet of paper. Add a brief note about each item.

4 Display your work in a suitable place.

10 Plant nutrition

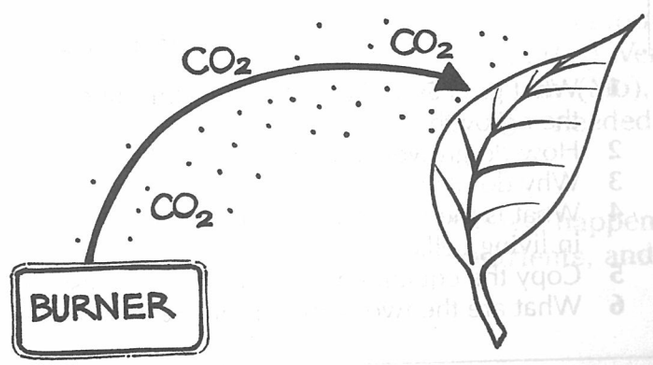
SUMMARY

The process of photosynthesis produces food for the green plant. It requires light, chlorophyll, carbon dioxide and water. Sugar is made and turned into starch for storage. Oxygen is released. Water enters the plant through the roots and is lost from the stomata on the leaves in the form of water vapour during the process of transpiration. Water and the nutrients dissolved in it are transported in the xylem. Food is carried in the phloem.

Nutrients like nitrogen, potassium and phosphorus are needed for good growth. The NPK rating tells how much of each of these nutrients is in a fertiliser.

Carbon dioxide enrichment

Carbon dioxide is an important raw material for photosynthesis. By adding more of this gas to the air around plants their rate of photosynthesis can be increased and growth speeded up. Many greenhouse growers provide extra carbon dioxide from fuel which is burnt in small burners inside the greenhouse. They try to keep the carbon dioxide concentration in the greenhouse at about 0.1% all day. The burners are not needed at night when plants are respiring.



Respiration

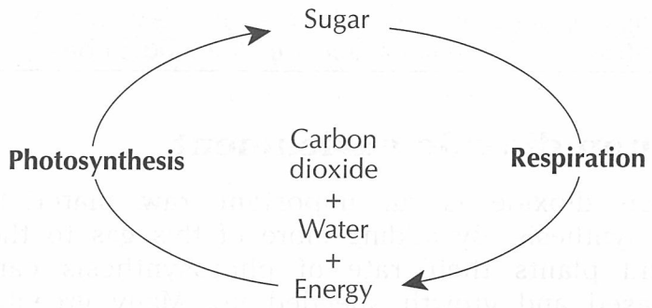
The food that is made during photosynthesis provides a store of energy for the plant. Plants need energy for growth, reproduction and all life processes. They get energy from their food by the process of respiration.

Respiration is a complex chemical process that goes on inside all living cells. It is a breaking down process. Carbohydrates like sugar are broken down, usually with the help of oxygen, and energy is produced. Carbon dioxide and water are the waste products of respiration.

This equation gives a summary of the process of respiration:

Sugar + Oxygen ⟶ Water + Carbon dioxide + Energy

The process is the reverse of photosynthesis, which is a building up process.



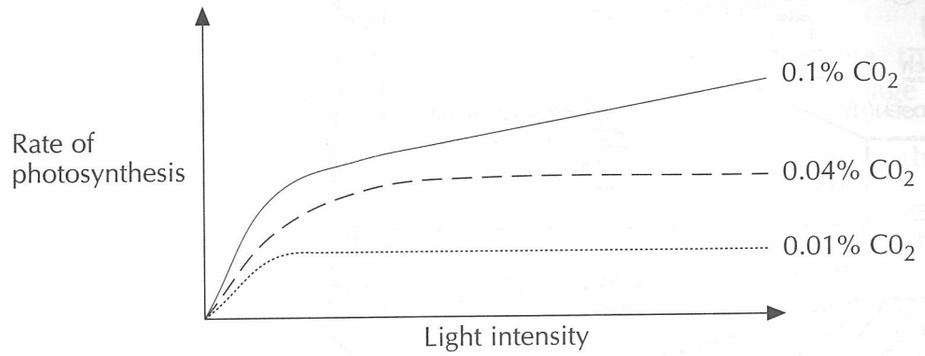
Growth involves building new plant materials using carbohydrates, the energy from respiration and nutrients taken up from the soil.

Questions

1 What gas can be added to the atmosphere around plants to speed up their growth?
2 How do growers provide carbon dioxide in greenhouses?
3 Why do plants need energy?
4 What is the name of the process which produces energy from food in living cells?
5 Copy the equation which summarises respiration.
6 What are the two waste products of respiration?

Exercise

Study the graph, which shows how carbon dioxide concentration is related to the rate of photosynthesis in a green plant, and then answer the questions.



1 Does increasing the light intensity also speed up photosynthesis? Explain your answer.
2 Which would be the best carbon dioxide concentration for plant growth?

Nutrients

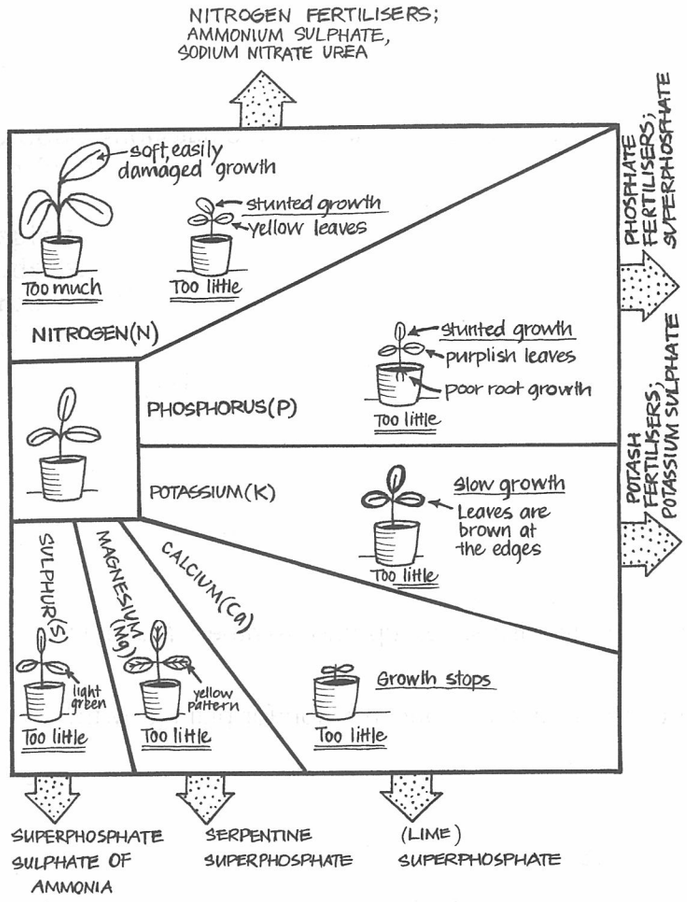
Plants take up chemical elements from the soil with the water they take in to their roots.

The three major elements that they must have are:

- Nitrogen (N)
- Phosphorus (P)
- Potassium (K)

Elements which are needed in smaller amounts are magnesium (Mg), sulphur (S) and calcium (Ca). Very small amounts of manganese (Mn), molybdenum (Mo), copper (Cu), zinc (Zn) and boron (B) are also needed. These elements are the 'trace elements'.

The table on the next page shows what will happen if there is a deficiency in each of the major nutrients, and how to supply the nutrients.



Questions

1 Name the three major nutrients that all plants need.
2 What are 'trace elements'? Give an example.
3 What effect does too much nitrogen have on plants?
4 What three elements does superphosphate supply?
5 What deficiency might you suspect if leaves turn brown at the edges?
6 Give an example of a nitrogen fertiliser.

Fertilisers

In nature, plants grow without any added fertiliser. However, horticultural crops need fertiliser for three main reasons:

1 Many crops are cultivars which have been specially developed to produce high yields. They need high nutrient levels to do this.

2 In nature, plants return to the soil when they die. Horticultural crops are removed from the soil and sent to market, so their nutrients are lost to the soil.

3 Irrigation of crops may cause nutrients to be lost through leaching (washing out in the drainage water).

So growers need to add nutrients to their soil in the form of green manure crops or fertilisers.

ORGANIC FERTILISERS are often byproducts of the meat industry. They are also obtained from fish, seaweed and poultry litter. Examples are bonedust and dried blood. Most of these fertilisers are insoluble in water so they are added to the soil, where they are broken down by soil organisms and release their nutrients. They are comparatively cheap, but slow acting. Their nutrient content is not very high.

INORGANIC FERTILISERS come from natural mineral deposits or are manufactured from inorganic substances. Examples are urea and superphosphate. Their nutrient content is high. Some inorganic fertilisers will alter the pH of the soil, for example urea, which makes soil more acid. Inorganic fertilisers are usually quick-release (that is, they dissolve soon after they are added to soil), although some are slow-release and suitable for use in containers.

SIMPLE FERTILISERS contain only one plant nutrient.

COMPOUND FERTILISERS contain at least two of the major nutrients (N, P and K). They are often expensive. An example of a compound fertiliser is nitrate of potash (potassium nitrate) which has an NPK rating of 13-0-35. It is commonly used in foliar feed sprays which are sprayed on the leaves of plants.

A BALANCED FERTILISER contains approximately equal amounts of N, P and K.

Questions

1 Give three reasons why horticultural crops need fertiliser.
2 What helps nutrients to be released from organic fertilisers?
3 From where do inorganic fertilisers come?
4 What effect does urea have on soil pH?
5 Give an example of a compound fertiliser.
6 What is meant by a 'balanced fertiliser'?

Exercise

The table shows some common fertilisers and the nutrients they contain.

Fertiliser	NPK rating	Other elements
ORGANIC		
Bone-dust	4 – 8 – 0	
Blood and bone	7 – 6 – 0	
Dried blood	14 – 0 – 0	
Fish manure	8 – 5 – 0	
INORGANIC		
Urea	46 – 0 – 0	
Sulphate of ammonia	21 – 0 – 0	Sulphur
Superphosphate	0 – 9 – 0	Sulphur and calcium
Serpentine superphosphate	0 – 7 – 0	Sulphur, calcium and magnesium
Sulphate of potash	0 – 0 – 40	
COMPOUND		
'Ammophos' (trade name)	16 – 21 – 0	
Nitrate of potash	13 – 0 – 35	

Use the table above to answer these questions:

1 Which fertiliser contains the most nitrogen?
2 Why is serpentine superphoshate particularly useful?
3 Which major element is NOT contained in nitrate of potash?
4 Which major element is NOT contained in fish manure?

Use of fertilisers

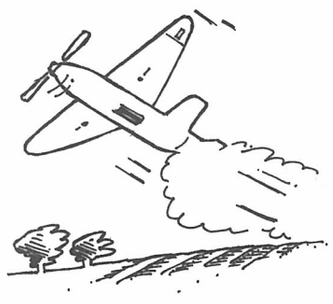
The usual way of deciding which fertilisers to apply is by scientific soil testing. By the time plants show symptoms of lacking certain nutrients these elements will be in very short supply in the soil.

Care must be taken if you are mixing fertilisers, because chemical reactions may occur that will change the nutrients into forms the plants cannot use. Fertiliser companies sell suitably mixed fertilisers. Those with all the major nutrients and trace elements in a balanced ratio are called **complete** fertilisers.

If solid fertiliser or concentrated liquid fertiliser comes into contact with the leaves or stems of plants it can damage or kill them. Fertilisers are usualy added to the soil before the crop is planted. The main application of nutrients is called a **base dressing**. Later applications are called **side dressings**. When and how fertilisers are applied depends on the soil conditions, age of the plants, stage of growth and time of year. For example, with a perennial crop you would apply the base dressing in early spring to make sure nutrients are available for spring growth.

Questions

1 How do you decide which fertilisers to apply?
2 Why do you need to take care if you are mixing fertilisers?
3 Explain what is meant by a 'complete' fertiliser.
4 Why must solid fertiliser not come into contact with the leaves or stems of plants?
5 Explain the difference between a base dressing and a side dressing.
6 What four conditions influence when and how fertiliser is applied?

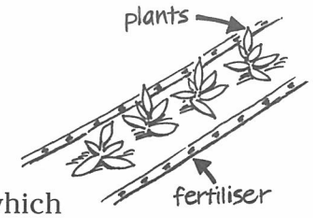


Fertiliser application

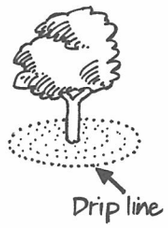
Solid fertiliser may be applied:

- as topdressing (scattered uniformly over the surface of the ground)
- by band placement (machinery is used to place fertiliser under the surface in bands beside plant rows)

- around trees to the drip line
- mixed into container media.



Liquid fertiliser can be applied directly to the soil, which should be watered first. It can also be added to irrigation water or sprayed in a diluted form on to plant leaves (foliar feeding). Foliar feeding is useful for rapid correction of trace element deficiencies.



Manures

Manure is faeces and urine of animals, plus whatever other material is used where the animals are kept, for example straw or sawdust. Manures have low nutrient content, for example horse manure has an NPK rating of 0.7 – 0.1 – 0.5. However, manures are useful to increase the organic content of the soil.

?

Questions

1 Give four ways in which solid fertiliser may be applied.
2 What sort of fertiliser can be used in irrigation water?
3 Explain what is meant by 'foliar feeding'.
4 What is 'manure'?
5 What is the NPK rating of horse manure?
6 Why are manures useful?

Exercise

Study the label from a bottle of Orchid Food fertiliser on the next page and then answer the questions.

1 What is the NPK rating of this fertiliser?
2 Could you put Orchid Food directly on to orchid plants? Explain your answer.
3 Name the trace elements that are present in Orchid Food.
4 Explain how to use this fertiliser for young plants.
5 Is this a 'complete' fertiliser? Explain your answer.
6 Why is less fertiliser needed for young plants in winter?

LUSH
ORCHID FOOD
FAST ACTING MAKES UP TO 200 LITRES OF PLANT FOOD

YATES LUSH ORCHID FOOD promotes healthy vigorous vegetative growth and flower development of Orchid plants. It supplies optimum amounts of all nutrients including trace elements. They can be absorbed through both the leaves and roots, giving a quick response.

Use on young plants all year round. Use on mature Orchids particularly during flower initiation and production, then again after flowering to replenish and strengthen the plant. Lush can be mixed with most commonly used pesticides for foliar application.

Application	Rate	Frequency
Young plants (under 1 year old).	Use 5mls per 4 litres water.	Apply at 3-5 day intervals during summer and 5-10 day intervals during winter.
Back bulb divisions & plants over 1 year old.	Use 5mls per 2 litres water.	Apply at 3-5 day intervals during summer and 5-10 day intervals during winter.
Mature plants.	Use 5mls per 2 litres water.	Apply at 5-10 day intervals.
	Use 10mls per 2 litres water.	For occasional feeding.

ANALYSIS

Contains:

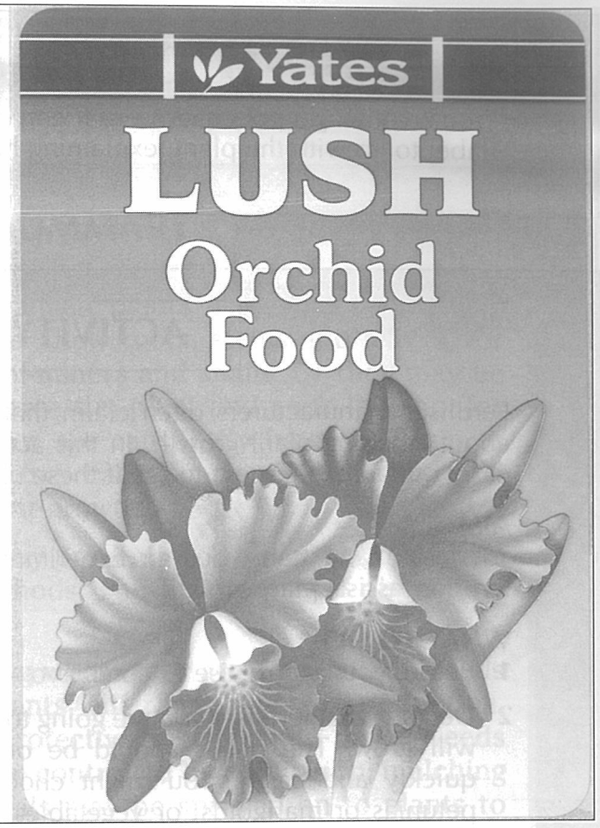
Nitrogen	8%
Phosphorous	3%
Potassium	10%

plus trace elements magnesium, iron, copper, zinc, manganese, boron and molybdenum in a chelated form.

NET CONTENTS 500mls

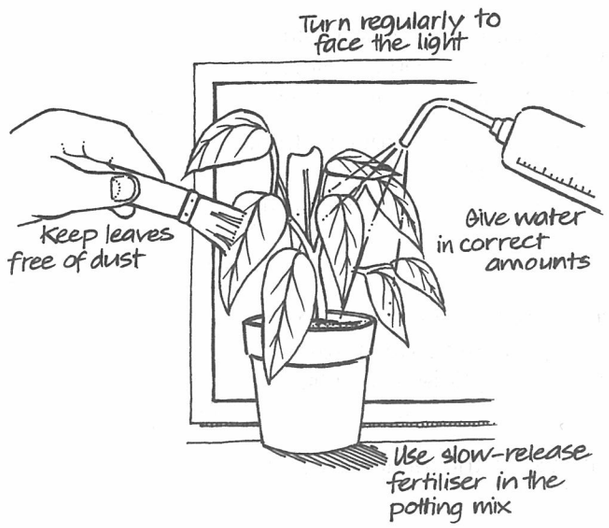
Yates New Zealand Limited
4 Henderson Place, Onehunga, Auckland

9 400099 443923



House plants

When plants are grown indoors, special attention needs to be given to plant nutrition.



Carbon dioxide enters through leaf stomata, so keep leaves free of dust.

The amount of **light** needed depends on the type of plant. Plants that grow naturally in shade are the ones to choose for low light areas. When light comes from only one direction, turn plants regularly to give even growth.

Water is needed in correct amounts. Pots should never be allowed to dry out completely and should not be left standing in water.

Fertiliser should be the slow-release sort and should be renewed at the end of the release period.

Exercise

You are giving a potted fern to a friend as a gift. Design and write an attractive label to go with the plant, explaining how it should be cared for.

ACTIVITY

Fertiliser manufacturers often claim that their product will bring about amazing plant growth. In this activity you will design and carry out an experiment to see if these claims are true.

AIM:
To design and carry out an experiment to see if a particular fertiliser assists plant growth.

WHAT TO DO:

1 Before you start, revise Chapter Two – Experiments With Plants.

2 Decide what fertiliser you are going to use, and what plants you will grow. The plants should be ones that will grow fairly quickly and easily. You might choose flowering plants like petunias or marigolds; or vegetables, for example radishes or lettuces. Make sure the fertiliser you use is suitable for the type of plants you are growing.

3 Write your own "Aim" for your experiment.

4 Decide when, how and in what quantity, you will apply fertiliser to one set of plants. Remember to keep another set of plants without fertiliser, as a control. Decide how many plants to use so that you get reliable results. What will you measure at the end of the experiment to compare the two sets of plants?

5 Now go ahead and set up the experiment. Remember to treat both sets of plants exactly the same, except for the fertiliser. They should be grown in the same area and given the same amount of water.

RESULTS:
When both sets of plants have grown to a suitable size take the measurements you had planned and record them on a suitable table. Draw a comparison graph if you have sufficient results.

REPORT:
Write a full report of your experiment using the headings Aim, Method, Results, Conclusion.

11 Plant health

SUMMARY

Pests are animals that damage plants. They may be chewing pests which tear, bite or chew roots, stems and leaves, for example caterpillars, leaf-miners and snails. Or they may be sucking pests which pierce the plant and suck the sap, for example aphids. Diseases are caused by fungi, bacteria or viruses. Disease organisms cause various symptoms and have a bad affect on plant growth.

Pests can be controlled by prevention, or by using biological or chemical control methods. The best control of diseases is by prevention.

Weeds are plants growing where they are not wanted. Weeds compete with wanted plants. Their high rate of reproduction, vigorous growth and protective mechanisms make weeds successful. Weeds can be controlled by cultivation, mulching and herbicides. Chemicals may be sprayed on to plants to control weeds, pests and diseases. Care must be taken when sprays are used.

Healthy and unhealthy plants

You should be able to tell the difference between a plant which is healthy and one which is not. A healthy plant is strong and vigorous. Its leaves are turgid and not wilting, it has a good root system and its flowers and fruit are the correct size and well-formed.

Pests, diseases, spray damage and nutrient deficiencies all cause symptoms which make the plant look unhealthy. Leaves may wilt, curl or change colour. Stems and roots may be stunted or die. Flowers and fruit may be a strange shape or not grow well.

A grower needs to be able to prevent pests and diseases from damaging a crop. If they do occur the grower needs to be able to identify and control them.

A healthy rose bush

Strong plants are less likely to be attacked by pests and diseases than weak ones.

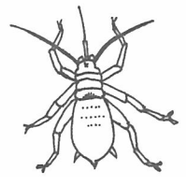
Common pests

The table on the next page describes some common garden pests. Reference books can give information about many more.

Aphids have caused these leaves to curl

Control of pests

The use of chemical pesticides to control pests is still common, but as people realise the harmful effects that chemicals can have on the environment other methods are becoming popular. Caterpillars and aphids may be destroyed by hand if only a few plants are involved. Overhead watering during dry weather will discourage such pests as red spider and thrips. Natural predators like the praying mantis, ladybirds and birds such as blackbirds and sparrows will also keep pest populations down. The predators can be harmed by chemical sprays. Sometimes companion plants will keep pests away from a crop. An example is mint, which will repel insects when its essential oils are released from its leaves. These organic control methods are especially useful for the home gardener.

Pest	Examples of plants attacked	Damage caused	Control
Aphids 	Soft new growth of roses Broad beans	Wilting Poor growth	Maldison Pyrethrum
Carrot rust fly larva 	Roots of carrots Parsnips	Tunnels Holes	Weeding Crop rotation Diazinon
Caterpillars 	Cabbages Tomatoes Fruit trees	Holes in leaves and fruit	Sprays and dusts e.g. Derris dust
Green vegetable bug 	Vegetables Ornamental plants	Poor growth	Carbaryl spray
Red spider mite 	Roses Strawberries	Leaves turn yellow and fall off	Sprinkle leaves with water Maldison
Thrips 	Camellias Gladioli	Leaves turn silver	Spray with Orthene

Questions

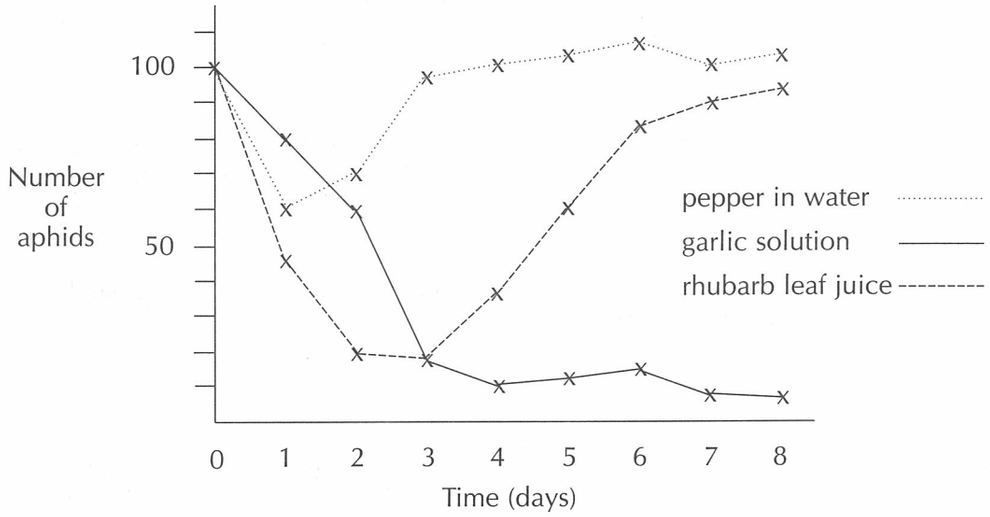
1. Give two examples of plants that may be attacked by aphids.
2. Which chemical spray is useful against red spider mite?
3. If your carrots have holes and tunnels in them, which pest would you suspect of causing the damage?
4. What sort of damage is caused by caterpillars?
5. Give two examples of natural predators.
6. Why are natural, or organic, control methods gaining in popularity?

Exercise

Some students decided to investigate natural substances as pesticides. They used three different sprays: garlic solution, pepper in water, and rhubarb leaf juice on three separate rose bushes heavily infested with aphids.

To see which of the sprays was most effective they counted the number of aphids on five stems of each of the bushes every day for eight days. Their results are shown in the graph below.

Effect of natural substances on aphid numbers



a Using the information from the graph, explain what the RESULTS of the experiment were.
b What CONCLUSION can be drawn from this experiment?

Common diseases

FUNGAL DISEASES. Symptoms of fungal diseases vary. Furry or powdery spots or patches on leaves, stems or fruit are usually signs of a fungus. Some examples are:

Black spot: black or brown spots on leaves of roses, apples, pears.

Botrytis: grey-coloured fluffy mould common on strawberries.

Brown rot: grey colour on fruit of peaches, nectarines.

Black spot is a fungus

Mildew: streaks or blotches on leaves of many vegetables.

Silverleaf: leaves of plums and apricots go silver.

Verrucosis: fruit and leaves of lemons are covered with brown scabs.

Copper oxychloride is a good preventative spray against fungal diseases.

BACTERIAL DISEASES. If plant tissue collapses and dies, or is rotten, wet or greasy, a bacterial infection is possibly the cause. Bacteria can cause swellings or 'galls' on some plants, for example, crown gall on tomato plants.

An example of a bacterial disease is fireblight, which affects pip fruit in spring. Blossoms wilt and new shoots look scorched. Leaves turn black and branches die. All diseased wood must be cut out and burned.

VIRAL DISEASES. Lack of vigour and abnormal growth is caused in many plants by viral diseases. Mottled leaves with light and dark green patches, dwarfed and wrinkled or rolled leaves and leaves or petals with stripes of colour may all be symptoms of virus infection. Among plants liable to infection are tomatoes, lilies, orchids, tulips and dahlias. There is no cure for virus infection. Plants must be destroyed.

Control of diseases

By starting with plants which are disease resistant and paying attention to aspects of hygiene such as cleanliness and the removal and destruction of dead material, and then by keeping plants healthy through giving them optimal growing conditions, it is possible to eliminate many problems before they arise.

If disease problems do arise, an integrated control programme, using cultural, biological and chemical controls, will be more effective than just using one of these methods.

Questions

1 What sort of disease organism causes furry or powdery spots on plants?
2 Describe the symptoms of Brown rot.
3 What is a good preventative spray against fungal diseases?
4 What sort of symptoms would make you suspect a bacterial infection?
5 Give an example of a bacterial disease and describe its symptoms.
6 Name three plants which are liable to viral infection.
7 How should virus infection be treated?

Exercise

"For plant diseases, prevention is better than cure." Write a paragraph (or more) explaining this idea.

Weeds

Growers should be able to recognise the weeds which are common in their local area so they can control them. Perennial weeds like dock should be removed by digging out all the roots. Annual weeds like milkweed can be removed by hoeing on a warm dry day so that the weeds wilt and die quickly. Chemicals (herbicides) are also used against weeds. Great care must be taken that the spray does not drift on to wanted plants.

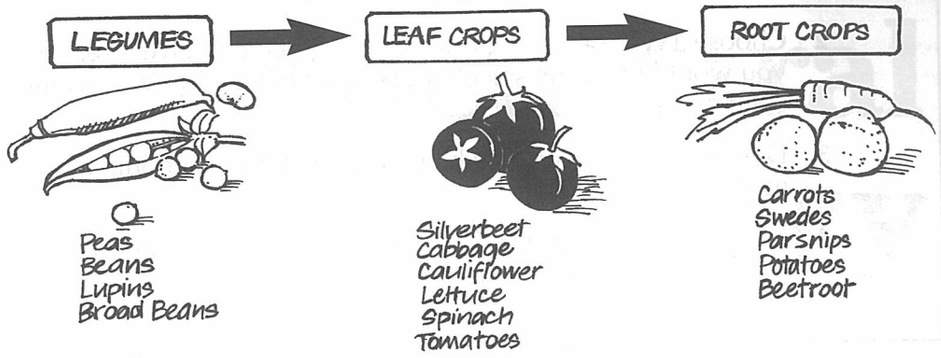
Oxalis is a common perennial weed

Crop succession and rotation

Successive sowing aims to maintain a continual supply of mature crops. Seeds are sown at regular time intervals, for example two weeks apart, during the growing season so there are always some plants ready to harvest.

Successional cropping means growing two or more crops on the same piece of land in one growing season.

Crop rotation involves growing crops that are different from each other on the same piece of land. This is done so that the pests and diseases from one crop do not affect the next crop. Crop rotation also makes the best use of soil nutrients, as different types of plants either use nutrients or return them to the soil. Each crop that is grown should be as different as possible from the previous crop. Leaf crops do well after legumes, which fix nitrogen into the soil. Root crops should follow leaf crops.



The plants that are in each group have generally similar requirements. For example the root crops need a firm level soil with a fine tilth, while the leaf crops respond well to plenty of organic manure and fertiliser. Sometimes the brassica crops (cabbage, cauliflower, Brussels sprouts, broccoli) are put in a group of their own because they need plenty of lime and grow best in a soil between pH 6.5 and 7.5.

Questions

1 Why should growers be able to recognise common local weeds?
2 What is a 'herbicide'?
3 Explain the difference between successive sowing and successional cropping.
4 Give two reasons why crop rotation is a good practice to follow.
5 What are the general requirements of root crops?
6 Why are the brassica crops put into a separate group?

Exercise

A horticulture student was planning her garden. Below is a list of the crops she intended to grow.

1 Using your knowledge of crop rotation, divide the crops into FOUR groups and arrange them on the garden grid.

cabbage, carrot, cauliflower
green manure (lupin), peas, lettuce
sweetcorn, radish, tomato

A	B
C	D

2 Choose TWO of these groups (A,B,C or D) and give a reason why you would grow the selected plants together. Give a different reason for each group.

3 Describe TWO ways in which crop rotation is important in the vegetable garden.

4 If the plot is too small for crop rotation, how can the soil be treated and how can this treatment help?

ACTIVITY

This activity involves the use of reference books. You may need to visit your school or local library to get the information required.

AIM:
To make a thorough study of a pest, a disease and a weed.

WHAT TO DO:

1 For your study choose one common local plant pest, one disease and one weed.

2 For each, try to answer the following questions:
- why is the organism successful?
- why is it a nuisance?
- how can it be controlled?

3 Either collect and preserve an example, or draw a picture of each organism.

REPORT:
Present your research study in a neat and attractive manner. You may be able to share your findings with other class members.

Section Five

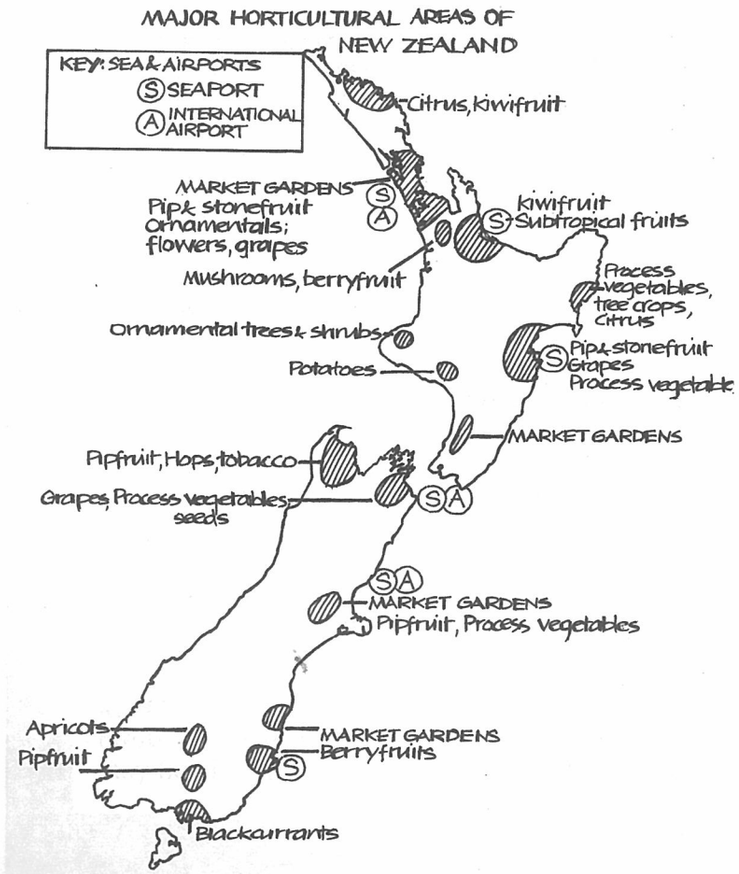
The Horticultural Industry

12 The horticultural industry

Choice of crop

The horticultural industry in New Zealand consists of a wide range of crops grown in different areas. Each of these areas has been found to be well suited for the crops that are grown there. Some of the main factors which affect a grower's choice of a suitable crop are:

- climate
- nearness to markets
- history of crops in the area
- soil
- popularity of the crop



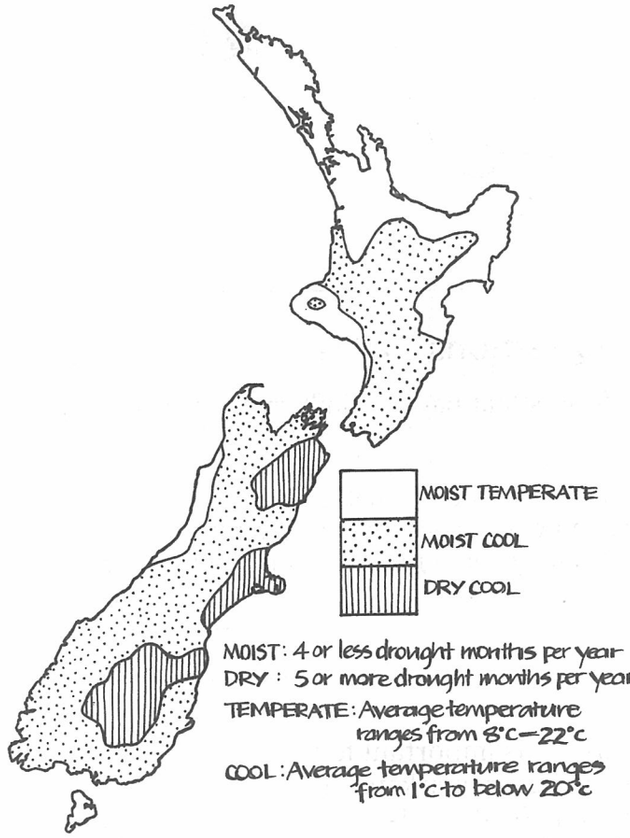
Today, the industry is looking for new crops to grow, and growers living in areas once believed unsuitable for horticulture are finding ways to grow crops successfully.

?

Questions

1. State five major factors that will influence a grower's choice of a suitable crop to grow.
2. Copy or trace the map showing the major horticultural areas of New Zealand.
3. Which three major cities have an international airport?
4. Name three areas where pipfruit are grown.

Climate

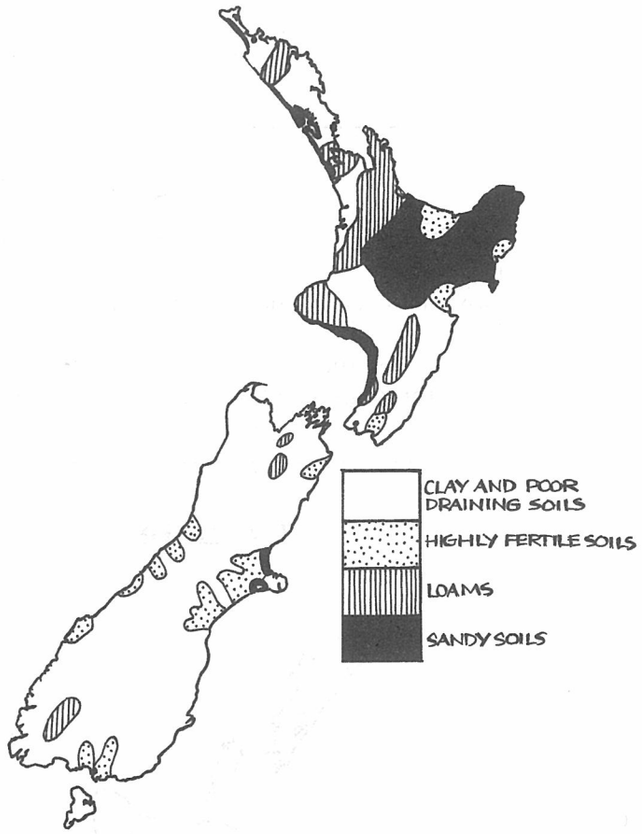


Climatic conditions have a very strong influence on what crops can be grown successfully in an area. Three major factors are temperature, rainfall and wind. The map shows the major climate zones of New Zealand. Within the major climate zones there are varying local conditions which make areas more or less suitable for particular crops.

Soil

There are many types of soil, just as there are many types of climate. Because of its very complicated geology, New Zealand has a wide range of soils. Any one area, like Canterbury or Manawatu, will have many different types of soil in it; even one orchard may contain more than one soil type.

Certain crops prefer one sort of soil to another - for example many grape varieties do best on stony soils, avocados will not survive on poorly drained soils, and the soil in which strawberries are grown must not lose its structure under the weight of pickers moving over it daily.

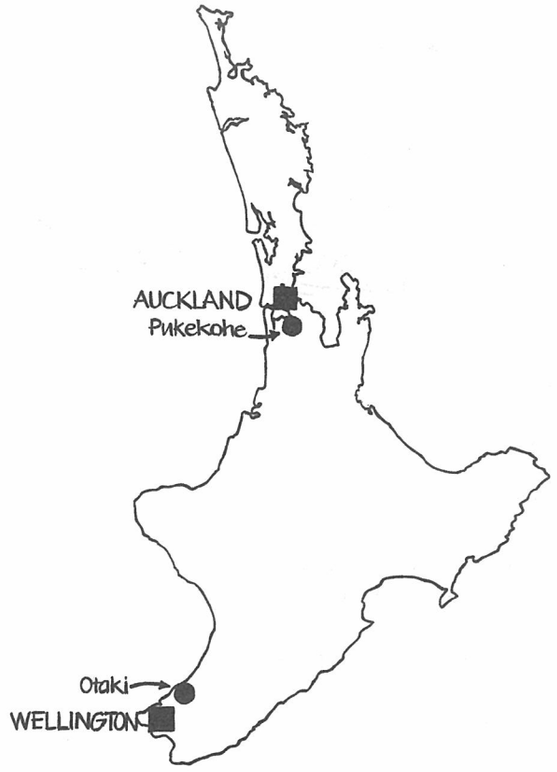


Questions

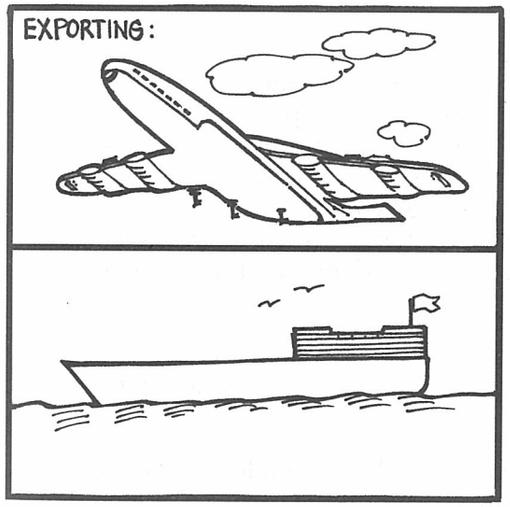
1 Give three major climatic factors that have an influence on what crops can be grown in an area.
2 What sort of climate does the Auckland region have?
3 What is the temperature range for a 'cool' climate?
4 Name a region of New Zealand where soils are highly fertile.
5 What sort of soils are found in the central regions of the North Island?

Nearness to markets

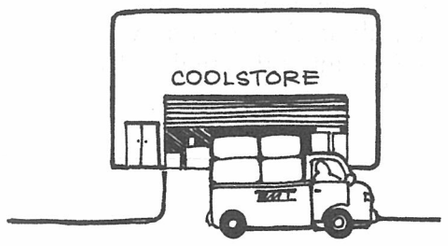
Horticultural crops are for people to use. It is important for the grower that the crops can get to their markets as quickly as possible, while they are still fresh. It is also important that transport costs should not be out of proportion to the value of the crop and that there should be a source of workers not too far away from the enterprise.



Many crops intended for daily use — vegetables like cabbages, beans, tomatoes, lettuces — are grown in market gardens close to population centres. Some well known market garden areas are Pukekohe, south of Auckland, and Otaki, north of Wellington. Many hundreds of hectares are cultivated to provide food for the two big cities.

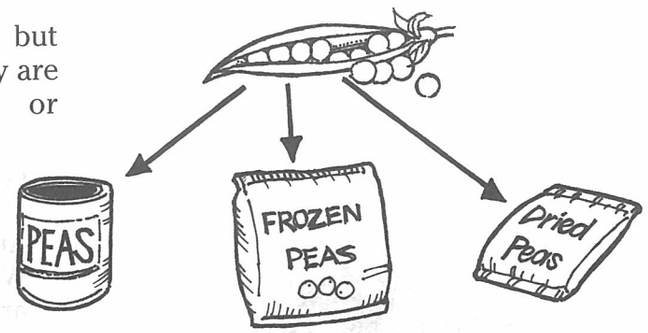


The New Zealand economy as a whole depends heavily on exports and many horticultural concerns have their markets overseas. This means the grower must be close enough to a port or airport to get the produce to market while it is still in good condition. Some exporters — berry growers, for example — hire space in cargo planes to fly crops to markets in Asia and North America. Others — apple growers, for instance — fill container ships with cartons of produce for the European and other markets.



There is a network of transport firms, coolstores and other special support structures in place for each of the major crops.

Some crops are not exported fresh, but are processed in factories before they are exported as frozen or tinned or dehydrated fruit or vegetables.



Questions

1 Give two reasons why it is desirable for crops to be grown close to markets.
2 Name an important market garden area close to Wellington.
3 What are two methods used to transport fresh produce to overseas markets?
4 In what other ways, apart from fresh, may crops be exported?

Exercise

Imagine that New Zealand's horticultural scientists have produced a world first — crossing an apple with an orange to produce an "orapple" that is crisp and sweet with an orange flavour. The fruit is green when unripe and ripens quickly, turning orange and becoming soft. It does not store very well and turns brown when kept in a coolstore. The "orapple" will be very popular in countries like Japan and Hong Kong. They grow best in areas with lots of sun, sandy soils, high rainfall (at least 1000mm per year) and temperatures higher than four degrees Celsius all year.

1 Draw a sketch map of the North Island. Shade in the areas where the "orapple" could be grown successfully outdoors without irrigation or protection.

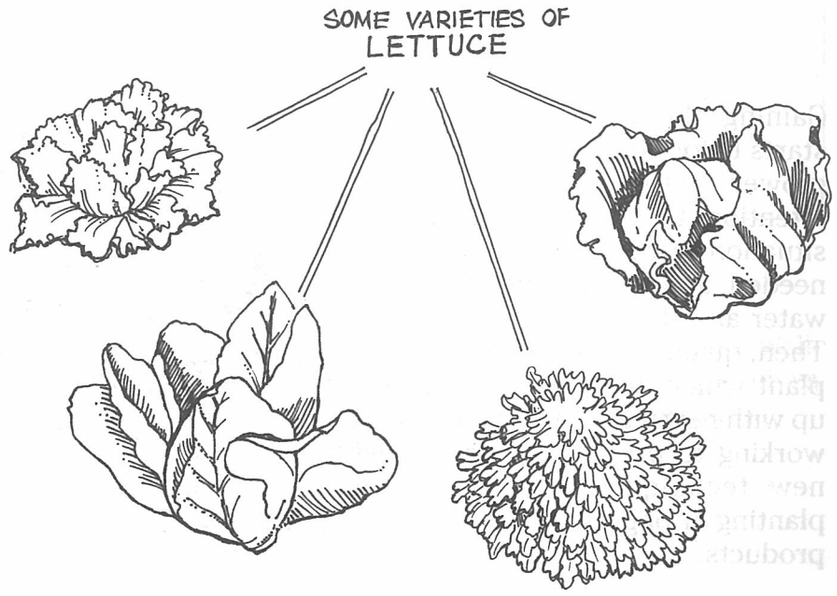
2 Mark on the map the BEST area for growing the "orapple". Write a sentence to explain why you chose this area.

3 Suppose you are looking in the area you have chosen for a suitable property to grow the "orapple". State ONE factor about the property you are looking at that you would have to take into account and explain why it is important.

Popularity of the crop

There are fashions in plants, especially those that are grown for food. When a plant becomes popular more growers will want to start growing it. A famous example of this is the "kiwifruit boom" but some other plants have enjoyed "mini-booms" of their own, for example the nashi.

Plant scientists work to develop new and better cultivars. Sometimes the cultivar has a very desirable advantage like resistance to a common disease, or a colouring that creates a market advantage. Where this happens growers may choose to move into the new variety.



History

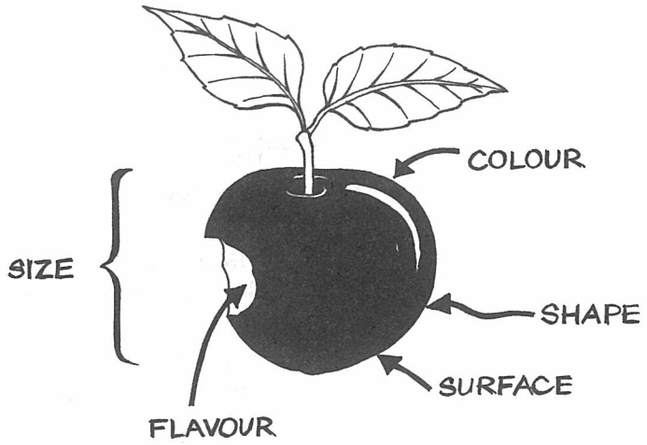
The reasons for some crops becoming established in a particular area may be historical. For example, the first grape vines established in Hawke's Bay were brought by Catholic missionaries in the mid-1800s to provide wine for the Mass. Olives are becoming established in Marlborough as a horticultural crop because of the interest displayed originally by a single grower.

Marketing

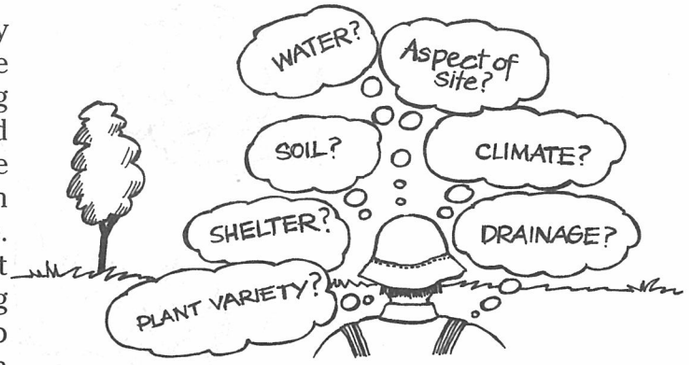
The three rules of marketing are quality, quality, QUALITY.

What is quality? For fruit, customers look for optimum size, bright colour, flawless surface, even shape, sweetness and full flavour.

Crispness and freshness are very important in vegetables.



Gaining the best possible quality starts before the crop is planted. The grower must begin by paying attention to the climate, soil, and situation of the site. Shelter may be needed and there must be enough water and the right sort of drainage. Then, quality means finding the right plant which, in turn, means keeping up with new varieties. Scientists keep working to provide the grower with new techniques — new ways of planting or of growing or of harvesting the crop — and new products.



Intensive cultivation brings the danger of pests and diseases which must be controlled. Biological controls are increasingly sought after as consumers become more aware of the harmful effects of pesticides on themselves and their environment. There are strict controls on the use of chemicals, especially in products intended for the North American market.

A move towards doing without chemicals entirely has led to a steadily increasing number of 'organic' producers who use only biological control methods. Produce from certified organic growers receives high prices in parts of the United States.

Once the crop has been harvested it is graded according to quality. Only the highest quality fresh produce is exported; second grade is sold on the domestic market and lower quality produce is processed in various ways to be sold in such forms as juice, fruit purees and dried fruit.

After grading, care must be taken with the handling, packaging and transporting of the crop to prevent damage and disease.

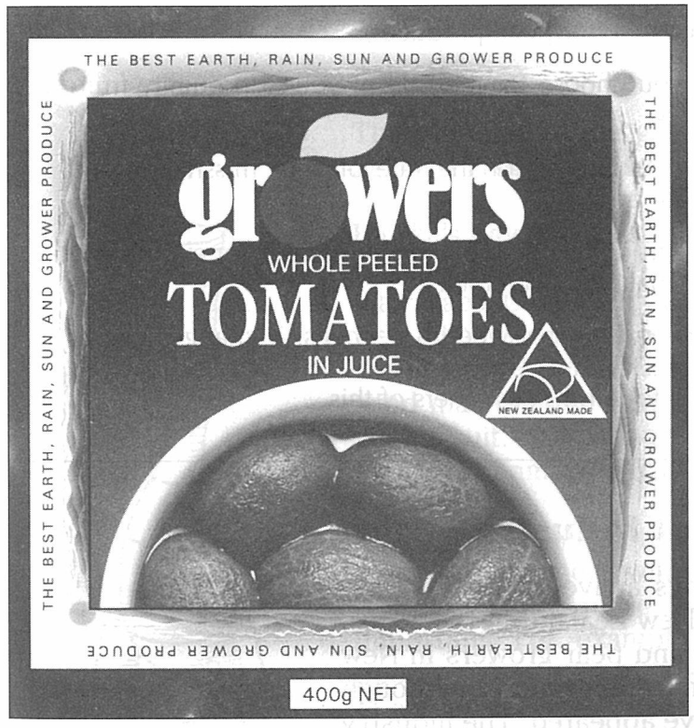
?

Questions

1. What are the "three rules of marketing"?
2. Give three features that customers look for in high quality fruit.
3. Why is produce from growers who use organic methods becoming increasingly popular?
4. What may be done with produce that is not suitable to sell fresh on the export or domestic market?
5. Why is care in the handling, packaging and transport of a crop important?

Packaging

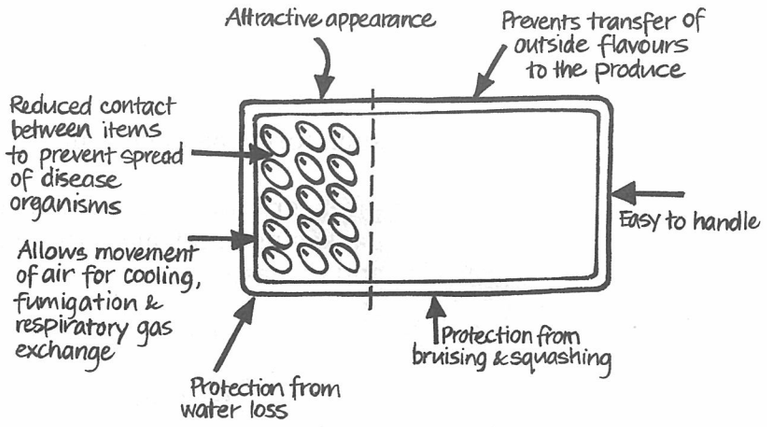
Once produce is in a well-designed package it receives much-needed protection.



An attractive label from a can of tomatoes

A good package presents the produce attractively to the wholesaler, retailer and customer. It maintains quality and extends storage life.

Expensive packaging can account for 20% of the cost of the final product, but if it reduces losses by 25% or increases the market price by 25% it will have been well worth the expense.



Exercise

Imagine that you own a property which is successfully producing large numbers of the "orapples" mentioned in the previous exercise. There are several ways of selling your crop:

- by direct export to overseas markets
- supply to local markets
- direct supply to a retailer on contract
- supply to a Producer Board
- gate sales
- supply to a processor (cannery or juice producer).

1 Which of these would you choose for the sale of your top quality fruit? Explain your answer.

2 Which method would you choose for the sale of your misshapen and marked fruit? Explain your answer.

3 State one thing about the fruit that could make it unsuitable for export, and explain how this would make it unsuitable.

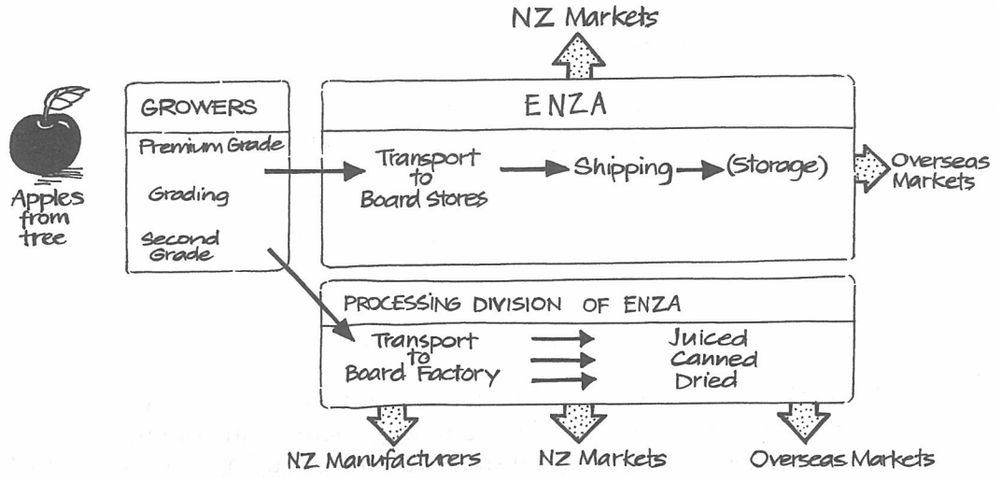
4 The fruit changes from very sour to sweet as it ripens. It changes colour from green to orange when it is ripe. Design a card that could be displayed with the fruit in the shop to inform customers of this.

Case study: The pipfruit industry

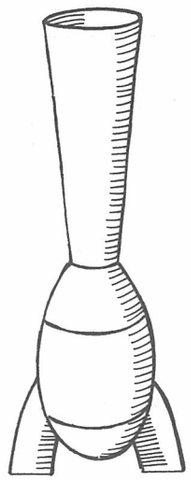
The first apple and pear seedlings arrived with the early European settlers who came to New Zealand in the 1840s. There are now over 1,500 apple and pear growers in New Zealand. Most orchards are family operations, although recently some big companies have appeared. The industry

is highly organised. Once the fruit are picked, graded and packed they become the property of the New Zealand Apple and Pear Marketing Board (ENZA).

The Board buys the fruit for a range of prices depending on variety and quality. The fruit is transferred to Board coolstores around the country where it is held before distribution to the local market or being exported. Modified containers, which provide controlled atmosphere storage, are used to transport the fruit to overseas markets.



The interests of the growers are looked after by the New Zealand Fruitgrowers Federation.


HAIL CANNON

Hawke's Bay and Nelson together account for 79 percent of pipfruit production. Other growing regions are Waikato, Wairarapa, Canterbury and Otago. Orchardists need a frost-free climate outside of winter and if this is not available they have developed various equipment like sprinklers and wind machines to minimise frost damage to blossom and young fruit. Hail cannon are used to turn hail into rain and prevent it damaging fruit.

The apple varieties that are grown vary within regions. Some require more winter chill, others, such as most red apples, require more sunlight. Soil conditions are also important. For example the premium variety Fuji likes poorer soil conditions — the fruit can turn brown instead of a deep red if the trees are grown in soils which are too rich in nitrogen.

Growers are encouraged to invest in new varieties while keeping a balance between the most popular varieties. Many plant up to ten percent of their orchard in new varieties each year.

Exercise

Study the table of selected apple varieties and answer the following questions.

Selected Apple Varieties by Volume

(Thousands of cartons)

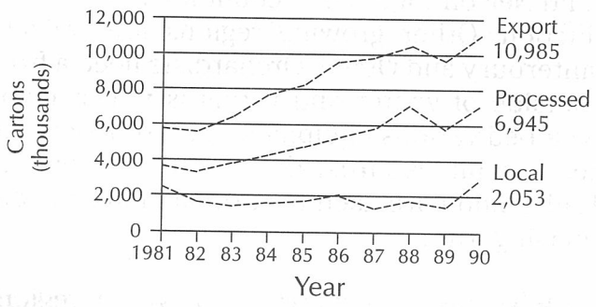
Variety	1989	1990	1991
Braeburn	1,084	1,777	2,404
Cox's Orange	811	893	972
Fuji	51	141	335
Gala	497	559	487
Granny Smith	3,582	3,550	2,592
Red Delicious	2,690	2,659	2,144
Royal Gala	1,072	1,605	2,047

(Source: New Zealand Apple and Pear Marketing Board)

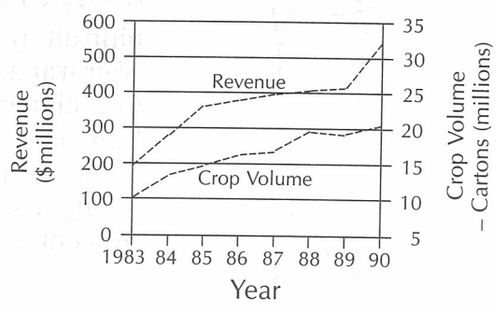
1 **a** Which variety is showing the greatest increase in volume?
b Which two varieties show a steady decrease in volume?
c Suggest a reason for the small volume of Fuji apples packed in 1989.
d Construct a graph to show these figures more clearly.

Study the graphs of apple production and answer the following questions.

Graph 1: Ten Year Crop Summary



Graph 2: Eight Year Revenue and Crop Volume Summary

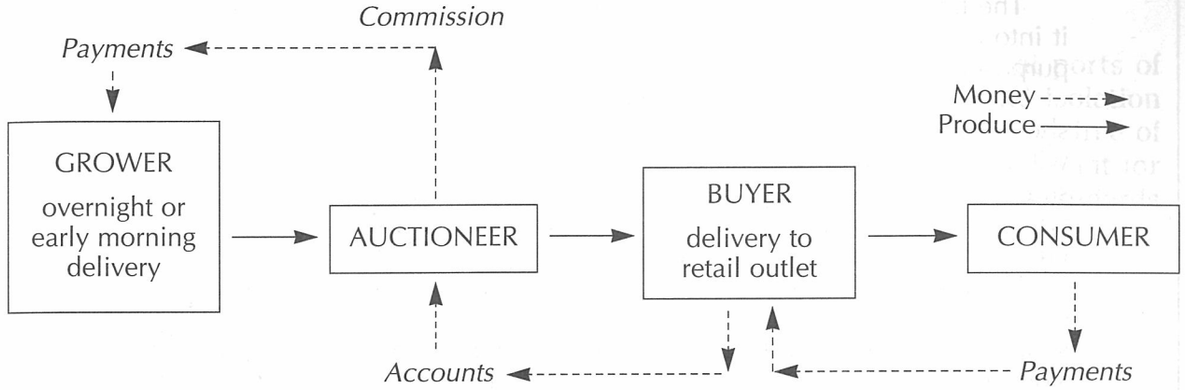


(Source: School Certificate Horticulture Examination, 1991)

2 **a** Describe what happened to the apple crop production between 1988–1990.
b What happened to the prices between 1988–1990?
c From the two graphs, give TWO reasons for these trends.

The New Zealand market

Although there are alternatives, most New Zealanders buy their fruit and vegetables from one of two sources: a supermarket, or directly from the market garden or orchard where they have been grown. Sellers and growers both recognise the need for quality produce. The supermarket (or fruit and vegetable shop) usually buys its produce at auction. The system works like this:



The GROWER needs to present the freshest, highest quality produce possible to command the best price at auction;

The BUYER wants produce that will tempt the consumer and that will keep for a reasonable time (depending on what the crop is);

The CONSUMER wants to buy food that looks fresh, tastes good and represents value for money.

Questions

1 Where do most New Zealanders buy their fruit and vegetables?
2 Where does the supermarket usually buy its produce?
3 When must the grower deliver produce to the auction?
4 Who pays the grower when he sells produce at auction?

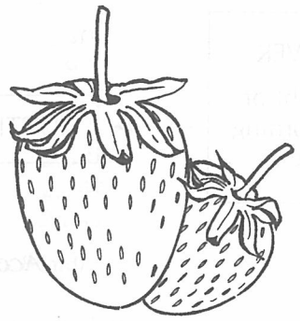
Exercise

Read about Margaret's berryfruit farm and then create a FLOW DIAGRAM showing Margaret's operation.

Margaret P. used her redundancy pay to buy three hectares of a good loam soil on a flat site in a temperate moist zone. The property had a bore from which good supplies of water could be drawn for irrigation purposes. It was twenty kilometres from a service town (population 20,000) and sixty-five kilometres from a city (population 120,000) with a port and airport.

The land had been used for grazing horses, but Margaret decided to turn it into a berry farm. Her research showed that her land was suitable for the purpose.

Margaret then investigated what sort of fruit she wanted to grow: some berryfruit grow without the need for support — for example strawberries; others need to be supported on wires, like loganberries. Margaret decided to grow strawberries as her main crop.



She hired three gangs of workers to plant her crop, which she bought from three different sources. This was partly because she wanted stock from different suppliers (she was worried about plant health) and partly because two local suppliers could not fill such a large order.

The plants grew very successfully, and in summer the planting gangs came back to do the picking. Margaret set up a stall at her gate and sold several hundred punnets to passing motorists. Her daughter drove into the local town each day and delivered orders to the two supermarkets and several dairies. These sold her strawberries to their customers. Most of Margaret's strawberries went on the rural delivery truck to the city, where they were auctioned at market. They proved very popular with the supermarkets there. Margaret also answered an advertisement and sold her very best strawberries direct to an export company, who flew them from the airport to the United States as part of a consignment from several growers in the region.

After the picking season ended there was more work for Margaret's busy gangs as they lifted the plants, divided them, and kept the new strong runners to grow on for the next season. Margaret even hoped to be able to sell strawberry plants to garden centres in the city after a year or two.

The export market

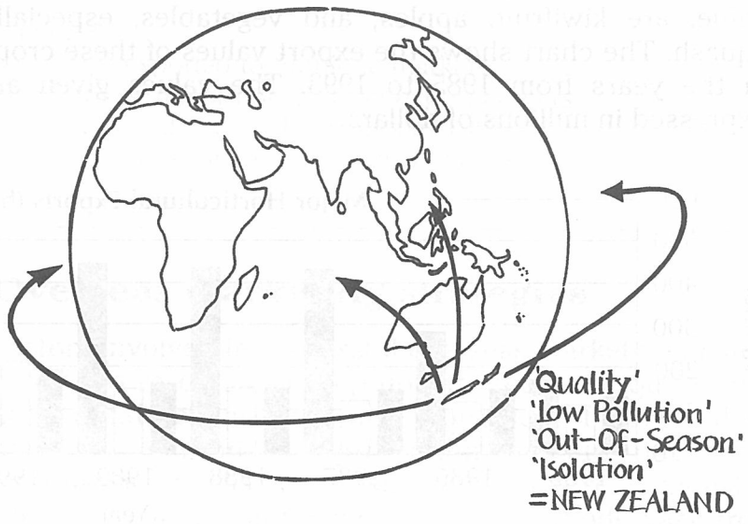
The New Zealand economy depends on exports of all sorts. Horticulture is emerging as a major force in our overseas trade.

Although New Zealand is a small country it is able to

NEW ZEALAND MADE

produce first class produce. We have a climate that allows us to grow a wide range of plants and our location in the southern hemisphere gives us major opportunities for marketing out-of-season produce in the northern hemisphere. Some crops are stored before being exported in order to extend this marketing season. Added to this is the 'clean, green' image which New Zealand enjoys and which makes our produce highly sought after in countries which are more populated and polluted. This situation is maintained by careful grading and export control of products.

New Zealand has strict quarantine regulations at ports of entry, and this, together with our geographical isolation from other countries, means that we are relatively free of many horticultural pests and diseases. It is important for our export economy that we keep up these high standards of plant health.



Questions

1 On what does the New Zealand economy largely depend?
2 What is one factor that makes it difficult to export produce from New Zealand?
3 Why is New Zealand's location in the southern hemisphere an advantage?
4 What is meant by a "'clean, green' image"?
5 Give two reasons why New Zealand remains relatively free of many horticultural pests and diseases.

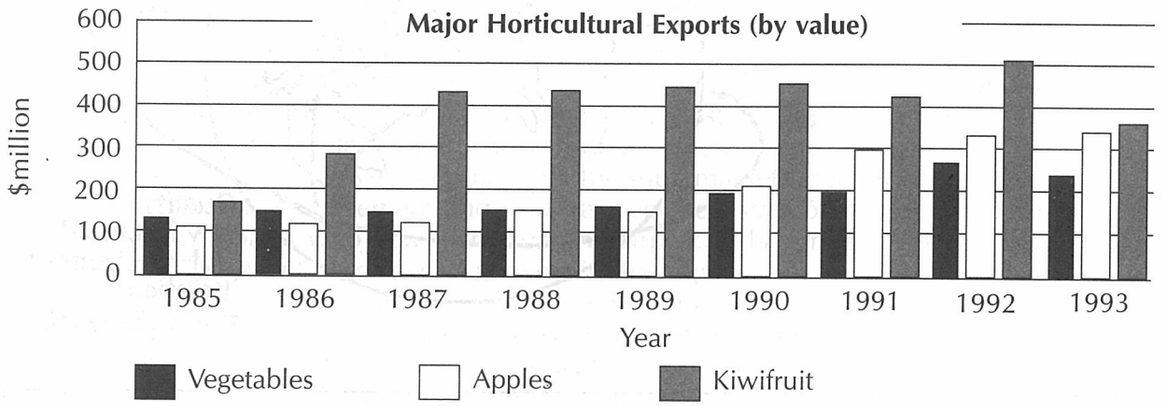
Niche marketing

The process of selling to select groups within a much larger population is called 'niche marketing'. With the enormous increase in the standard of living in developed countries, customers are demanding 'special', 'luxury' and 'natural' products. New Zealand is well placed to take advantage of this demand.

Some examples of crops that are, at present, exported in quite small quantities for niche markets are tamarillos, feijoa, persimmons, garlic and fresh flowers. A crop may begin by filling a small niche market and go on to become a major horticultural export. An example is kiwifruit, which, in spite of recent downturns, still brings in a large proportion of our horticultural export earnings.

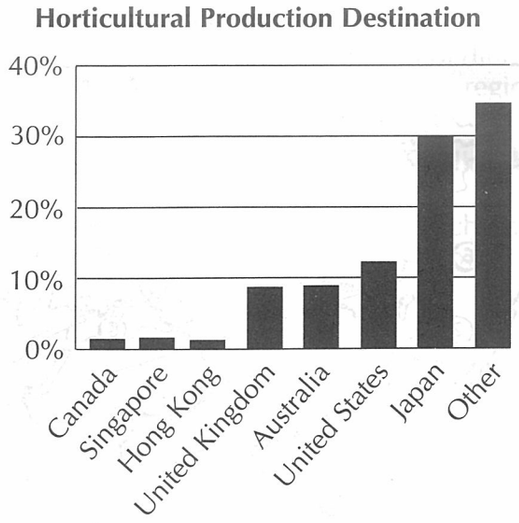
Major horticulture exports

New Zealand's major horticultural exports, in terms of value, are kiwifruit, apples, and vegetables, especially squash. The chart shows the export values of these crops in the years from 1985 to 1993. The values given are expressed in millions of dollars.



Destinations

The chart on the next page shows the proportion (by value) of total horticultural products going to New Zealand's overseas markets. Japan is the leader, and Great Britain, which was once our major market, is now only fourth. A third of our production, labelled 'other' on the chart, goes to unidentified customers belonging to the EEC or to markets taking less than 1% of the total.



?

Questions

1 What is 'niche marketing'?
2 Give two examples of crops exported to fill niche markets.
3 What are New Zealand's three major horticultural export earners?
4 Use the chart to find the value of vegetable exports in 1990.
5 Which single country buys almost one third of our produce?

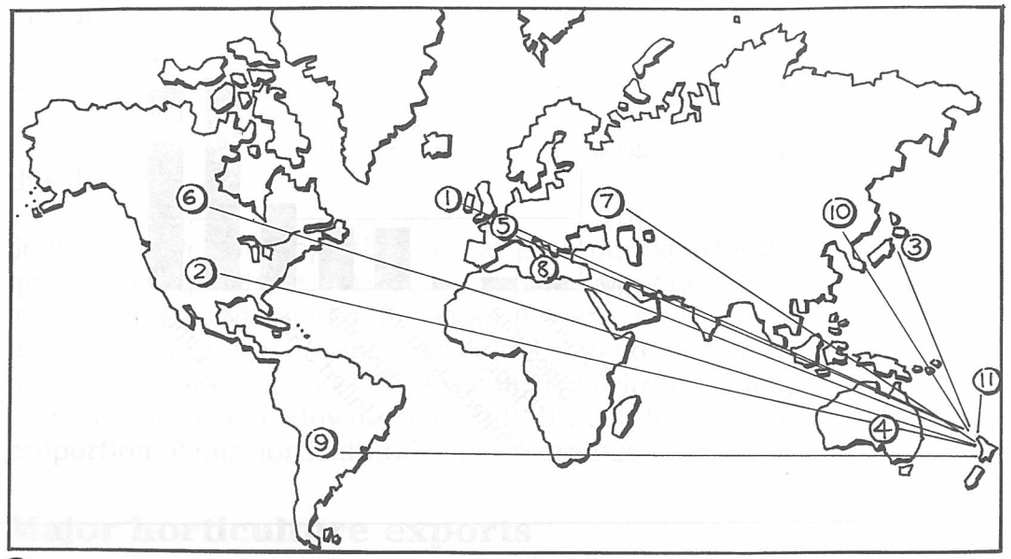
Overseas marketing strategies

Factors involved in successful overseas marketing include continued research to keep up with market requirements and to find new markets, and promotion of New Zealand produce. Methods of promotion include publishing information, media advertising and in-store demonstrations as well as trade expos. Selling methods vary from country to country.

Packaging is very important, especially in Japan where customers are said to 'eat with their eyes' and appearance is vital.

Most of our horticultural export products are highly priced fresh luxury items for the overseas consumer. Continued production of quality crops will ensure that our export market continues to grow.

New Zealand Horticultural Exports to the World



1 UNITED KINGDOM 2 UNITED STATES 3 JAPAN 4 AUSTRALIA
5 GERMANY, NETHERLANDS, FRANCE 6 CANADA 7 U·S·S·R 8 GREECE, ITALY
9 CHILE 10 CHINA, HONG KONG 11 FIJI

Exercise

Study the table showing the numbers of trays of red and gold tamarillos exported to various destinations in 1993 and then answer the questions.

New Zealand Tamarillo Export Volume by Variety, 1993

	USA	Australia	Japan	Singapore	Other	Volume
Red	23,074	2,354	1,176	30	360	26,994
Gold	6,162	166	129			6,457
Total	29,236	2,520	1,305	30	360	33,451

Note: "Other" = Canada (300), Europe (60)
Tray Volume = 3.5kg
(Source: New Zealand Tamarillo Export Council Ltd)

1 Suggest two reasons why more of the red variety was exported than the gold variety.

2 What is our major market for this fruit?

3 A major problem limiting export volumes is the presence of virus on New Zealand tamarillos. What can be done to overcome this problem?

4 Tamarillos are sensitive to frost, water-logging and drought conditions. Suggest two areas in New Zealand which could be main growing regions for the fruit.

5 Red tamarillos have a stronger flavour than yellow ones but the yellow are less acidic. Both have a high vitamin content. They can be eaten fresh, or used stewed. They are easy to preserve and make an excellent chutney. Use some or all of this information to design a colourful advertisement for an Australian magazine promoting New Zealand tamarillos.

ACTIVITY

Different parts of New Zealand produce different horticultural crops. You will need to adjust this activity to suit your local area.

AIM:
To make a thorough study of a local horticultural crop.

WHAT TO DO:

1 Arrange to visit a local horticulturist, if possible one who grows produce for export.

2 Decide on the questions you will ask when you make your visit. These should include questions about:

- Soil: type and modification
- Shelter: type, species, maintenance
- Size of the operation, number of workers
- Crop plants: propagation methods, support, training, spacing, pruning
- Growth requirements: irrigation, nutrients, protection from pests and diseases, weed control methods
- Management: spraying, harvesting, packing
- Marketing: destination, processing, distribution, trends for this crop.

3 Write out your questions, leaving space for answers.

4 During your visit make a sketch plan of the production area showing shelter, irrigation system and crop plants. Try to find answers to your questions. If you are able to take photos or a video, do so.

REPORT:
After your visit write a report. Include the plan of the area and give full details of the operation with photos if possible. Write a concluding paragraph in which you give your opinion about the good things and bad things involved in working with this crop.

Finally, write a letter of thanks to the people who made your visit possible.

Section Six

Amenity Horticulture

13 Amenity horticulture

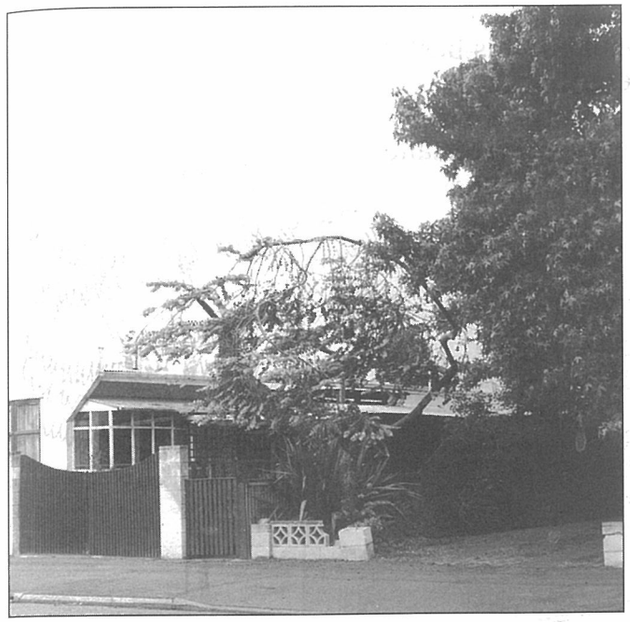
Amenity horticulture is the use of plants to make our surroundings more pleasant. In amenity horticulture, making money from plants is not important. The plants are used to provide a pleasant environment for people. This may be on a small scale, as in a home garden, or on a large scale, as in parks, playgrounds and shopping areas.

Ornamental plants

The plants that are grown for use in amenity horticulture are ones which are enjoyable to look at. Selecting plants may be the last stage in planning a garden, but it is a very important stage. Height, shape and texture all need to be considered, and colour is also very important.

HEIGHT. Plants come in all sizes, from giant redwoods to tiny ground-hugging daisies. The general form of a planted area comes from the tall trees and shrubs that are used

Upright trees make a strong statement



A heavily pruned gum tree

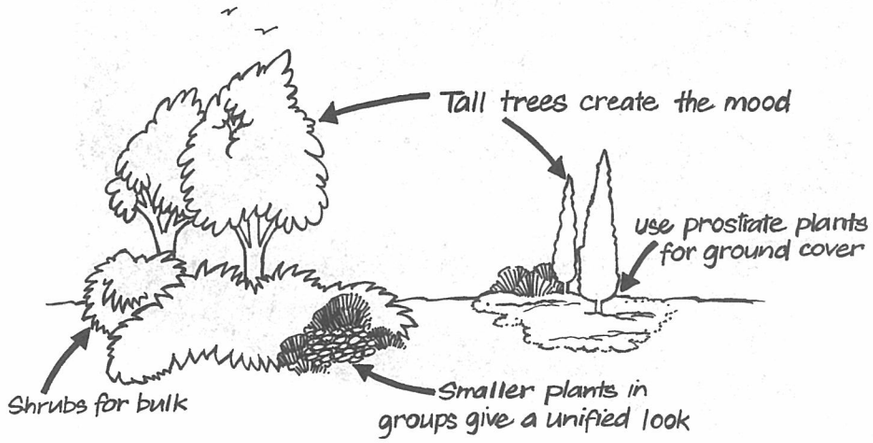
there. They should be planned and planted first, to create the mood that is required. A cedar tree, a weeping willow or a flowering cherry, for example, all have a distinctive height and shape when mature that will dominate the area in which they grow. Upright trees make a strong visual statement and tend to make a small area look larger. You need to remember that trees which grow naturally to a considerable size, for example gum trees, poplars and birches, can look sad and cramped if they have to be heavily pruned to fit in a small garden.

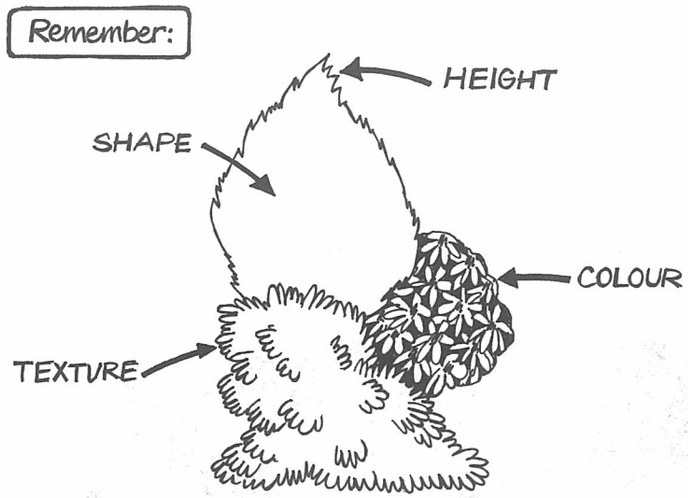
When choosing trees you must decide whether you want them to be deciduous or evergreen. Not everyone wants to rake up lots of autumn leaves.

Below trees and tall shrubs come shrubs to create bulk in the planted areas as well as providing wind shelter and screening where necessary. These shrubs may need to be evergreen to do their job well.

Smaller plants are usually planted in groups to give a unified look to the planting. These plants are the decorative ones and are usually more important for their colour and texture than their height.

Prostrate plants can be used as ground cover which will discourage weed growth.





Some suggestions

For a cool summer display: use the blues and pinks of delphiniums, asters and dianthus with some purple and white, for example sage and white daisies.

For a bright welcoming effect: use bright orange red-hot pokers set off by cool lavenders against an evergreen background.

For a quiet serene corner: use greys and pinks of stocks and carnations with soft-leaved grey plants and white emphasis.

Questions

1 What is the purpose of amenity horticulture?
2 What effect do upright trees have on a small area?
3 Why are smaller plants usually planted in groups?
4 Apart from flowers, where does colour in a garden come from?
5 Explain the idea of 'contrast' in a garden.

Exercise

Say whether each of the following plants should be used
a as part of a garden framework OR
b to create background bulk OR
c as a decorative feature
AND give a reason for each answer.

1 **Honey Locust**. A hardy, deciduous tree growing to 10m high. Its feathery leaves can set the mood in an area of planting.

2 **Petunias**. Brightly coloured annuals which tolerate dry conditions and flower continually throughout the summer.

3 **Himalayan Ceda**r. An erect evergreen tree which has grey fine foliage on horizontal branches which droop at the tips. Grows very tall and is very wide at its base.

4 **Mexican Orange Blossom**. An adaptable, compact shrub with dark green foliage. The small white flowers cover the bush in spring.

5 **Gypsophila**. Rounded hummocks of grey green leaves covered with a mass of small white flowers in summer. Height to 1m.

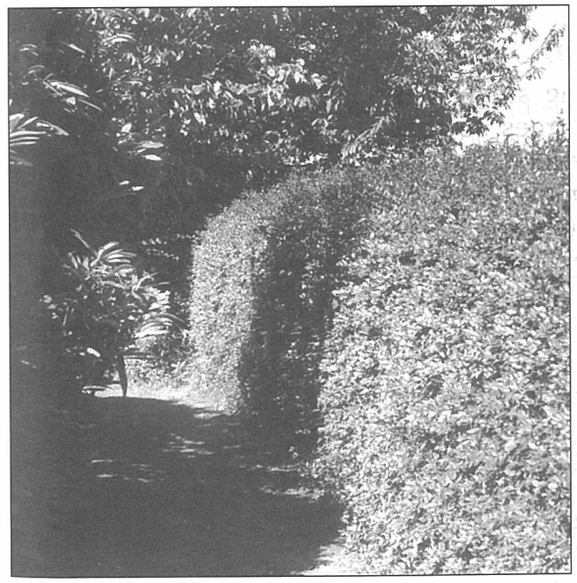
6 **Alyssum**. A popular ground covering annual with masses of tiny flowers. Looks best planted in drifts.

7 **Camellia**. A beautiful evergreen shrub, flowering in late winter and spring. Many different varieties from quite low growing to tall.

8 **Zinnias**. Annuals; bright flowers of orange, yellow and red in mid summer make a vivid display.

Using plants

Plants can be used in many ways. For every garden problem there are plants to help overcome it.



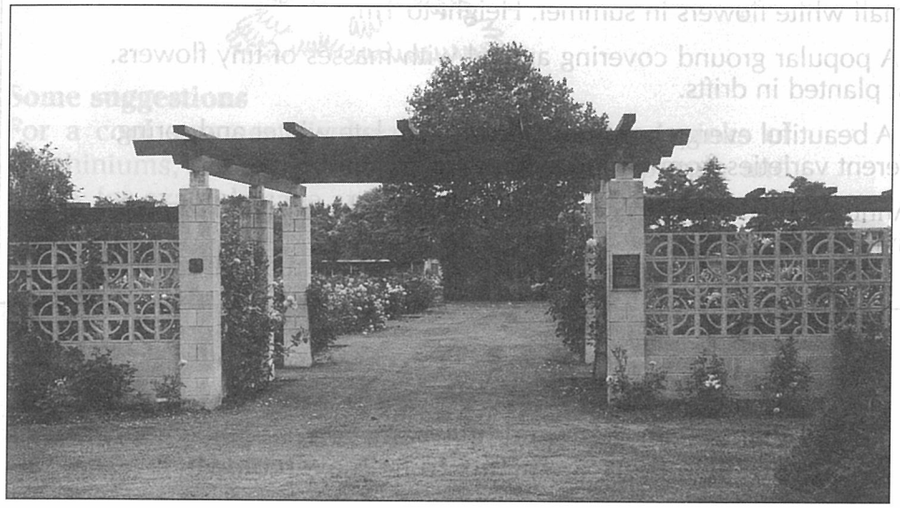
Hedges give shelter and privacy

SHELTER. People, animals and plants themselves all need protection from wind. This can be provided by hedges and fences. Hedges can be used to define boundaries and give privacy as well as shelter. In a large area they can be used to subdivide the space and provide a background for other plants. To do a good job, hedge plants should be evergreen. Two examples of suitable plants for hedges are Taupata (*Coprosma baueriana*) and *Photinia*.

Fences of materials such as wood, stone or brick take up less space than hedges, while still providing shelter. To soften their appearance there are many fruiting and flowering plants that can be grown on and over fences. Honeysuckle, clematis and jasmine are some popular climbing plants.

SCREENING. Well placed plants can be useful to screen off things that are better concealed from sight. In a home garden the rubbish bin, compost heap or clothes line may need a screen of some sort. Climbing and trailing plants like ivy can be useful, as can clumping plants like bamboo.

For a private outdoor area a trellis covered with a suitable climbing plant can provide a good screen. This effect can be enhanced with overhead planting supported by a pergola. Suitable plants would include rambling roses, wisteria, or even hops or grapes. The closer a screen is to the eye, the wider the area it hides.

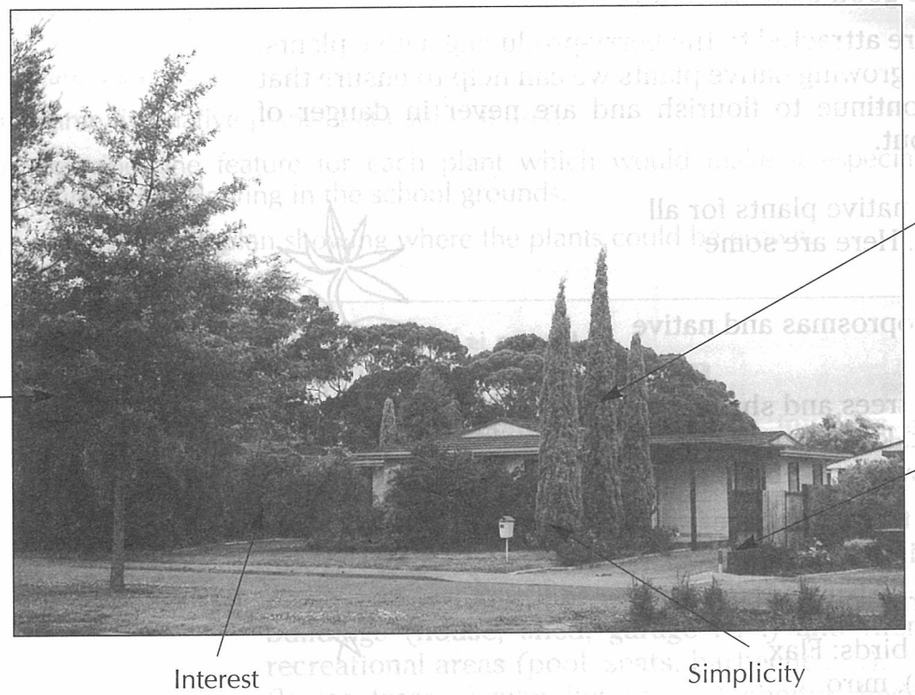


A pergola for climbing roses

SHADING. When a garden is in the planning stage it is important to consider the placing of shade trees so that they will give shade where and when it is needed. Just one well placed tree can transform a small garden and provide a cool leafy summer haven. Fruit trees can be suitable shade trees — their blossom is attractive in spring, you can eat the summer fruit and they lose their leaves before winter when shade is not needed.

CHOICE OF PLANTS. With so many plants to choose from it is easy to get confused. However, there are some design principles which are useful. The plants you choose should:

- be the right **size** to fit with each other and their surroundings
- **tone in** naturally with the whole area
- give a feeling of **unity** in their arrangement
- tend towards **simplicity** rather than fussiness
- give an **interesting** effect through their shape, foliage or colour.



A well-designed suburban garden

?

Questions

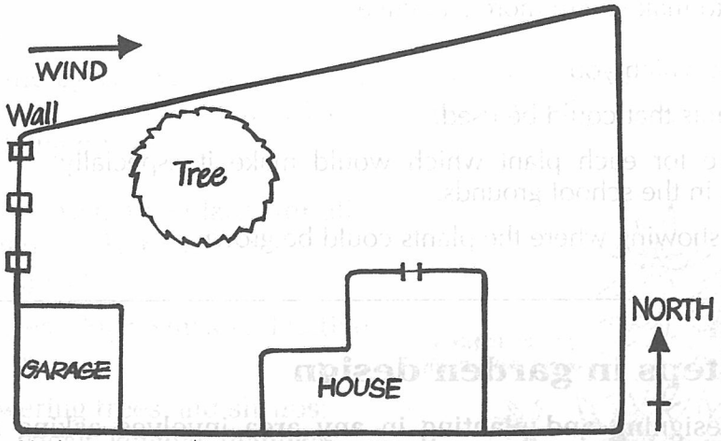
1 Give two uses of fences and hedges, apart from shelter.
2 What is one advantage of fences, compared with hedges.
3 Name two climbing plants.
4 What areas in a home garden may need screening?
5 List and explain five design principles you should remember when choosing plants.

Native plants

There are at least four good reasons for including native plants in your garden:

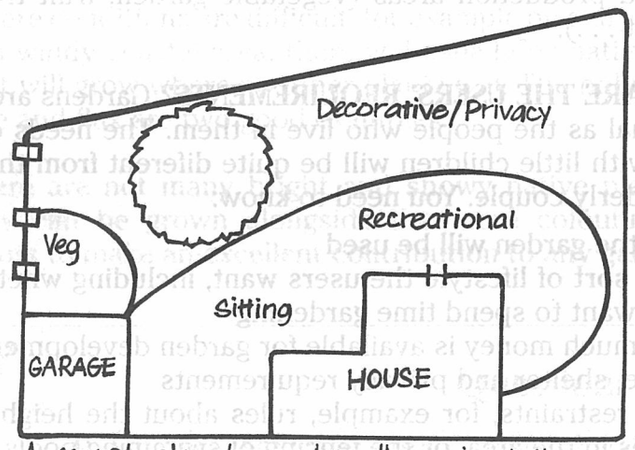
1 Plants which grow naturally in an area are usually well suited to that area — otherwise they would not be growing there. So native plants are especially well suited to New Zealand conditions.

protection, and underground services like drainage and electricity. Note neighbouring features like views (good or bad). Show the access areas from the house to the garden.



Mark on your plan the main existing areas.

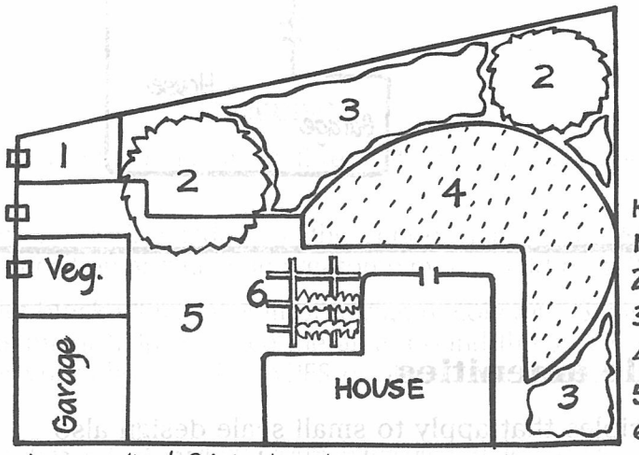
HOW CAN THE AREA BE IMPROVED? This is where your imagination goes to work. Taking into account the users' requirements, you draw up a concept plan of the area. On this plan you show the activity zones that the user wants: recreation area, utility space, production area and so on.



A concept plan shows where the main activity areas are to be.

DRAWING THE FINAL PLAN. From the concept plan you can draw a final plan showing permanent structures like fences and paths that are to be built. The final plan also gives a detailed planting diagram showing the areas

occupied by plants when fully grown. For the beginner this final stage is difficult. Reference books, nurseries and garden centres can help you in the selection of plants that are suitable to grow in your area. The job is made easier if you know the type of planting you want in each part of the garden, as in the generalised final plan shown here.



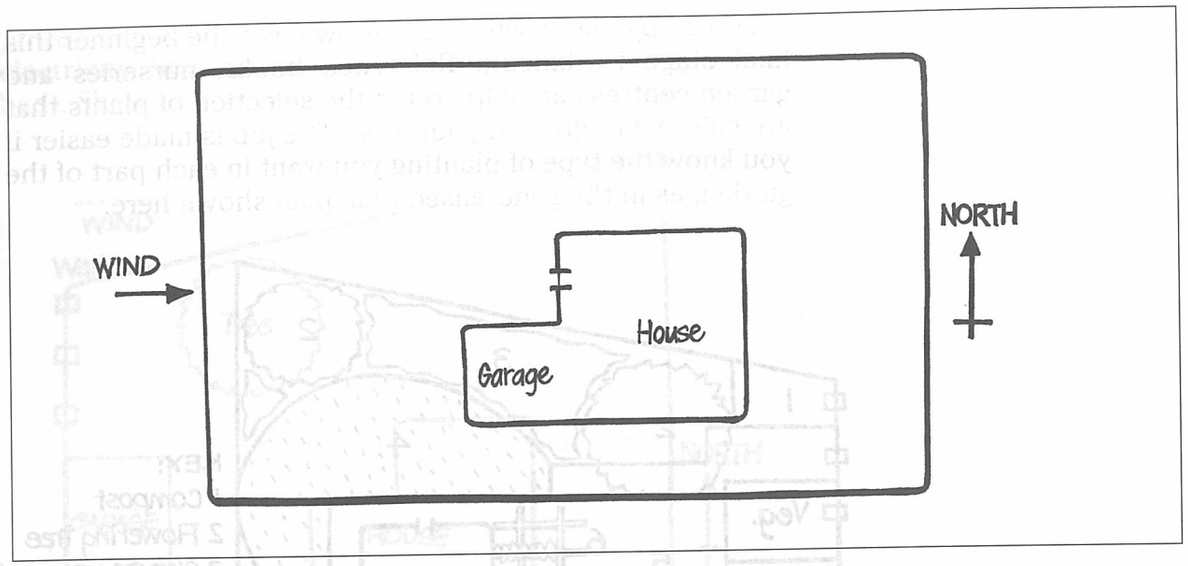
A generalised final plan shows permanent structures and types of plants.

Questions

1 What is the first thing to do when starting to design a garden?
2 Explain how the needs of a young family would differ from those of an elderly couple.
3 Give an example of a 'legal restraint'.
4 Why is it important to know where north is when planning a garden?
5 Where can you get help when selecting suitable plants to grow?

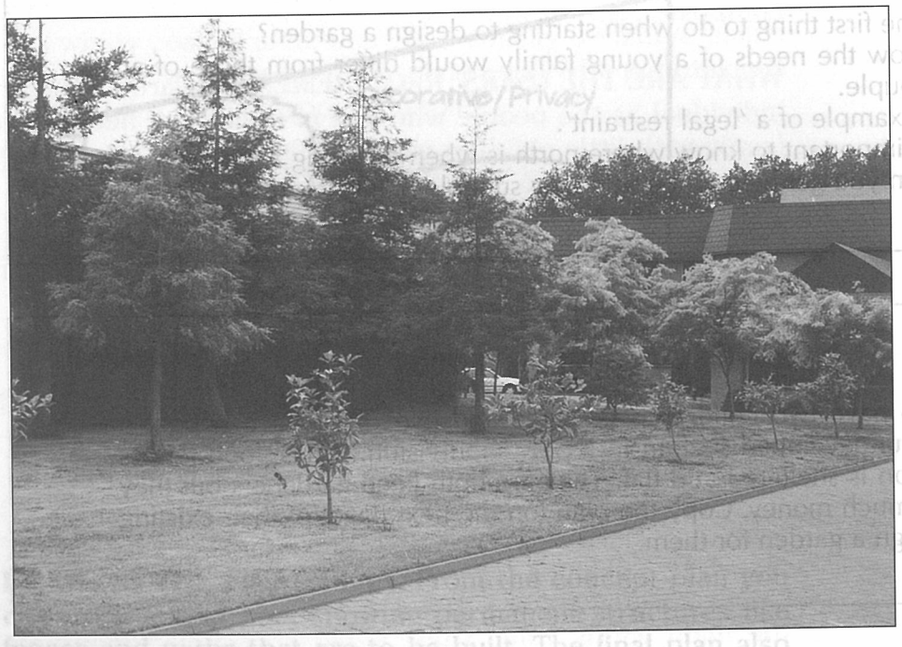
Exercise

Jan and Koro have two children aged three and five. They have bought a house on an undeveloped section in a new subdivision. It has good fences and the section is sheltered and flat. They are both keen gardeners but they do not have much money. Copy the plan (on the next page) of their existing area and design a garden for them.



Larger scale amenities

The same principles that apply to small scale design also apply to large areas such as school grounds, golf courses, factories, reserves and shopping centres. Planning is necessary before planting. However these areas are on a larger scale, so the use of plants has to be on a larger scale too, with suitable groupings of plants being very important.



Large scale use of plants in a public area

The needs of many users has to be considered. For example delicate or potentially dangerous plants would be unsuitable in a play area for children; deciduous plants may be a nuisance in a public area and so on.

The amenities should make a positive contribution to the community which pays for them.

Exercise

You have been asked to help plan a small recreation park in the middle of a busy urban area.

a A landscaping feature is needed for the centre of the park. Suggest a feature for this position and give one reason why it would be suitable.

b There is a toilet block which is built of unsightly concrete. Suggest what types of plants might help enhance the area around the toilets and give one reason for your choice. (List TYPES of plants, not specific names or varieties).

c Some planting has already been done without much thought to local climatic factors. Name one such climatic factor that should be considered and explain why it is important.

ACTIVITY

In this activity you will analyse a planted area and determine its good and bad features.

AIM:
To investigate an area in terms of its plan, plants and other features and to decide how well it is suited to the people who use it.

WHAT TO DO:

1 Choose a suitable area to analyse. It may be part of your school grounds or a park or reserve in your town.

2 Draw a plan of the area. Show paved areas, flower beds, seats, landscape features, trees and plants. Give the names of as many plants as possible. You may need to use a key.

3 Spend some time in the area, noting how people use it.

4 Decide on a score (1–10) for the area for each of the following:

- practicality
- suitability for outdoor activities
- ease of maintenance
- shelter
- shade and sun
- use of plants
- value for the money that has been spent on the area

5 How do you think the area could be improved?

REPORT:
Write a report on this activity. Include the plan and a paragraph about how people use the area. State your opinions about the area and suggest any improvements that could be made to it.

Word list

The *italicized* words are elsewhere in the list.

ACID Soil which has a *pH* below 7 is acid soil. Adding *lime* to soil makes it less acid.

AIR LAYERING A method of *vegetative propagation* in which roots are stimulated to form on a wounded stem covered with damp *sphagnum* moss.

ALKALINE The opposite of acid. Soil which has a pH above 7 is alkaline. Adding *peat* to soil makes it less alkaline.

AMENITY HORTICULTURE The branch of horticulture which is concerned with growing plants to provide a pleasant environment.

ANNUAL A plant which completes its life cycle in a year or less.

ANTHER Male, *pollen*-containing part of a flower.

APHID A small insect pest which sucks sap from plants.

ASEPTIC TECHNIQUE Plants are propagated in a carefully controlled environment which is free of disease *organisms*.

ASEXUAL PROPAGATION The same as *vegetative propagation*. Plants are produced by a method which does not involve seeds.

AXIL The angle where a leaf joins a stem.

AXILLARY BUD A bud growing in an *axil*.

BACTERIA Single celled *micro-organisms*. Some are useful *decomposers*, others cause disease.

BALANCED FERTILISER A *fertiliser* which contains approximately equal amounts of N, P and K.

BAND PLACEMENT A method of applying *fertiliser* in which machinery is used to place *fertiliser* under the surface of the soil in bands beside plant rows.

BASE DRESSING Applying *nutrients* to the soil before a crop is planted.

BIENNIAL A plant which takes two years to complete its life cycle.

BIOLOGICAL CONTROL A method of pest control which makes use of natural enemies feeding on the pest.

BOTTOM HEAT Warmth supplied underneath plants to help roots to grow.

BRASSICA A member of the cabbage family.

BUD A young undeveloped shoot. It contains either immature leaves or flowers.

BUDDING A method of grafting using a bud instead of a large piece of *scion* wood.

BULB A structure in which stem and leaves are adapted for underground food storage and which can be used for *vegetative propagation*.

CALCIUM An element needed by plants for good growth. It is supplied in *superphosphate* and *lime*.

CAMBIUM Actively growing layer of cells in a stem or a root.

CARBON DIOXIDE The gas needed by plants for *photosynthesis*.

INORGANIC FERTILISER A *fertiliser* obtained from natural mineral deposits or manufactured from inorganic materials. An example is *superphosphate*.

INSECTICIDE A substance used to kill insects.

IRRIGATION Supplying water to plants.

JUVENILE STAGE The young stage of a plant. Some trees have a very long juvenile stage.

KEY A series of questions designed to help the user identify a plant.

LATERAL A branch, stem or *bud* growing from the side of a plant.

LAYERING A method of *vegetative propagation* in which a stem is made to form roots while it is still attached to the parent plant.

LEACHING The process in which water dissolves *nutrients* and washes them away from the soil.

LEADER The central upward growing shoot of a tree or shrub.

LEGUME A member of the same plant family as peas and beans.

LIME A *calcium* compound that neutralises *acid* soil.

LOAM A fertile soil that is a good mixture of sand, silt and clay.

LONG-DAY PLANT A plant that requires long periods of light and short periods of darkness in order to flower.

MANURE Faeces and urine of animals, used as *fertiliser*.

MEDIA/MIXES Mixtures of materials used for growing in containers.

MICRO-ORGANISM Microscopic living thing.

MIST A very fine spray of water.

MONOCOTYLEDON A plant which grows from a seed and which has one seed leaf. Its leaves have parallel veins.

MULCH A covering over the soil surface, used to keep water in and weeds out.

MYCORRHIZAL FUNGI Useful *fungi* which live in association with the roots of some plants.

NATIVE PLANT A plant which grows naturally in a country and has not been imported from another country.

NEMATODE Small worm which lives in soil and can be a pest.

NITRATES The form in which nitrogen is most freely available to plants.

NPK RATING The percentage of *nitrogen* (N), *phosphorus* (P) and *potassium* (K) in a *fertiliser*.

NITROGEN A plant *nutrient* which is particularly important for leaf production.

NITROGEN-FIXING BACTERIA *Bacteria* which are able to turn *nitrogen* from the air into a form that plants can use.

NODE Where a leaf joins a stem.

NUTRIENTS Elements needed by plants for growth.

OFFSET A small plant growing from an older plant which can be detached and grown separately.

ORGANIC FERTILISER *Fertiliser* obtained from plant or animal material, for example bonedust.

ORGANIC MATTER Plant or animal material which is added to soil to improve its structure and, after *decomposing*, its *nutrient* content.

ORGANISM A plant or an animal.

OVULE The tiny structure in the female part of a plant which contains an egg cell.

PAN A hard layer of clay beneath the topsoil.

PARASITE An *organism* that feeds on another living *organism*.

PATHOGEN An *organism* which causes disease.

PEAT Partly decayed plant material from swamps which is used in container *media* and added to soil to improve its *structure*.

PERENNIAL A plant which lives for three or more years.

PERLITE A bulky, light-weight material used in *media*.

PERMANENT WILTING POINT When any water in the soil is held too tightly for plants to be able to use it.

PESTICIDE A substance used to kill pests.

PETIOLE The stalk of a leaf.

pH A measure of how *acid* or how *alkaline* something is.

PHLOEM The tissue inside a plant that carries food for the plant.

PHOSPHORUS A plant *nutrient* which is especially important for healthy shoot and root growth.

PHOTOSYNTHESIS The process by which green plants make their food.

PISTIL The female parts of a flower.

PLUMULE The first shoot to emerge from a *germinating* seed.

POLLEN Male reproductive cells of plants.

POLLINATION The transfer of *pollen* from an *anther* to a *stigma*.

PORE SPACE The space between soil particles which contains air and water.

POTASSIUM A plant *nutrient* which is especially important for flower and fruit production.

POTTING UP The process of moving a *cutting* or *seedling* from where it was grown, into a pot.

PREDATOR An animal which kills other animals for food. Some predators are useful for *biological control* of pests.

PRICKING OUT Moving *seedlings* from their first container to another with more space.

PROPAGATION Producing new plants from seeds or by *vegetative* methods.

PROSTRATE PLANT A plant which grows flat along the ground.

PRUNING Removing plant parts by cutting them off.

PUMICE SAND Sand used in potting *mixes*.

QUICK–RELEASE FERTILISER A *fertiliser* which dissolves soon after it is added to soil and releases its *nutrients* into the soil.

RADICLE The first root to emerge from a *germinating* seed.

RESPIRATION Chemical reactions inside living cells from which the cells obtain energy.

RHIZOME A thickened storage stem that grows just under the soil surface.

ROOT STOCK The part of a *grafted* plant that forms the root system.

RUNNER A shoot that grows horizontally, producing new plants at the *nodes*.

SATURATED SOIL Soil in which all the *pore spaces* are filled with water.

SCARIFICATION Chipping the seed coat to help the seed *germinate*.

SCION A shoot or *bud* from one plant that is *grafted* on to another.

SECATEURS Short *pruning* shears.

SEEDLING The young plant that has grown from a seed.

SHORT-DAY PLANT A plant that requires short periods of light and long periods of darkness in order to flower.

SIDE DRESSING Applying *fertiliser* alongside plants.

SIMPLE FERTILISER A *fertiliser* which contains only one plant *nutrient*.

SOIL STRUCTURE The way soil particles clump together in groups.

SOIL TEXTURE The proportions of sand, silt and clay that are in the soil.

SPECIES A group of plants or animals which look similar and can interbreed in nature to produce fertile offspring.

SPHAGNUM MOSS Very absorbent moss which secretes an antibiotic substance and is used as a *germination* medium.

SPUR A short flower–producing side branch on an older branch of a fruit tree.

STAKING Supporting a tall plant with a pole, or stake.

STAMEN The male part of a flower. *Pollen* is produced in the *anther* at the tip.

STIGMA The sticky tip of the female part of a flower.

STOCK Has the same meaning as '*root stock*'.

STOCK MATERIAL Plants from which parts are removed for *vegetative propagation*.

STOLON The swollen stem tip that forms when some types of shoots touch the ground. It develops roots.

STOMATA Tiny pores on the surface of leaves through which gases can pass and water vapour is lost.

STOOL Similar to a '*crown*'. The base of the shoots in a *herbaceous perennial* plant which can be divided to form new plants.

STOPPING The removal of the *terminal bud* at the tip of a stem so side shoots will grow strongly.

SUBSOIL The layer of soil beneath the topsoil.

SUCCESSIONAL CROPPING Growing two or more crops on one piece of land in the same growing season.

SUCCESSIVE SOWING Making frequent sowings of plants over a period of time to ensure a fresh supply of new plants at all times.

SUCKER A shoot that grows away from the parent plant off an underground root or stem.

STRATIFICATION Chilling seeds in order to break their *dormancy* so they can *germinate*.

SUPERPHOSPHATE An *inorganic fertiliser* which supplies plants with *phosphorus* and *calcium*.

TERMINAL BUD The *bud* at the tip of a shoot.

THINNING 1. The removal of some plants from a row; 2. The removal of some young fruit from a fruit tree; 3. Cutting out branches to prevent a tree becoming too bushy.

TILTH Well cultivated soil.

TOPDRESSING Applying *fertiliser* to the surface of an area.

TRACE ELEMENT An element that is needed in only small amounts by plants.

TRANSPIRATION Loss of water vapour from the leaves of plants.

TRANSPLANTING Moving a *seedling* or older plant from one place to another.

TUBER A swollen underground stem or root.

TURGID Containing plenty of water. The opposite of '*wilted*'.

UREA An *inorganic fertiliser* rich in *nitrogen*.

UTILITY AREA A place in a garden where useful things are, for example rubbish bin and clothes–line.

VARIETY A group of plants within a *species*. A *cultivar* is a *variety* that has been produced by man.

VEGETATIVE PROPAGATION/REPRODUCTION Producing new plants by any method that does not involve seeds.

VERMICULITE An *inorganic media* ingredient.

VIABLE SEED Seed that is alive and capable of *germinating*.

VIRUS An extremely small disease causing *micro-organism*. There is no effective treatment against viruses.

WEED An unwanted plant.

WILTED Leaves and stems have partly collapsed and drooped because of lack of water in the cells.

WINDBREAK A planting or a structure erected to protect plants from wind.

WRENCHING The practice of cutting the roots of a tree or a shrub growing in the open ground to encourage increased rooting so the plant can be safely *transplanted*.

XYLEM Tissue that carries water inside plants.

Index