Introduction

What will you say when asked to define the word *plant*? Perhaps you will think about trees, flowers, leaves, wood, vegetables, fruits and grains such as maize, sorghum, rice and wheat. You may also decide to say that plants are usually green, do not normally eat other living things and do not move from place to place. Since plants are a familiar part of our everyday lives, we may not think about what makes them unique or vital to human life. Why do we need plants in order to survive? Why can plants survive without us? The answer to these questions is simply, **photosynthesis.** This amazing process produces food and oxygen that supports almost all life on Earth. As you work through the unit you will find out more about this process and other plant processes and why you need to know about them..

Plants are our primary source of food. Humans were originally hunter-gatherers, moving around from place to place, eating anything they could find. About 13,000 years ago humans began to live in the same place all the year-round, raising animals and cultivating crops. Early farmers saw that some types of crop plants could be cultivated more successfully than others. Over time they learnt when to plant, how to nurture (care for) plants to get a successful harvest and also store seed for planting in the next year.

Plants also provide many other products such as medicines, fuel, shelter, building materials and paper products. Our focus in this module is however on plants as a source of food and what these plants need from the environment to provide us with the best crop for maximum health.
This unit consists of the following sections:

2.1 A plant and its environment.

2.2 Plant nutrition and soil fertility.

2.3 Important decisions for your food garden

2.4 Finalize your food garden design plan

Specific Outcomes and learning outcomes

The specific outcomes for this unit are to:

- Introduce and present options relating to viable farming practices for households using a learning group approach.
- Facilitate the refinement of an annual plan for the household food production system and value-adding.

The table below shows you the **learning outcomes** that you will notice are linked to the four sections that are addressed in this unit and to the list of assessment activities for this unit. A time estimate is shown for the completion of each activity. This will help you to plan the use of your time. When you have completed the activities, write down the actual time you spent on them.

Learning outcomes	Assessment Activities	Actual time spent
2.1 A plant and its environment 2.2 Plant nutrition and soil fertility 2.3 Important decisions for your food garden 2.4 Finalize your food garden design plan	**Workbook activities** 2.1. Factors that influence the growth of a plant (30 minutes) 2.6. Addition of phosphorous or lime to soil (4 hours) 2.9. Companion planting (1.5 hours) 2.10 Crop rotation plans (1.5 hours) 2.11 A farmer experiment for planting a range of plants (4 hours) 2.12 Finalizing your design plan for action (3 hours) **Assignments** Assignment 2: Information for this assignment is contained in Tutorial Letter 101 (3hrs)	

Key Concepts

Abiotic factors Biotic factors Limiting factor Photosynthesis Respiration Transpiration Pollination Fertilization	Nutrients Cross-pollination Self-pollination Gaseous exchange Stomata Soil acidity Soil alkalinity Nitrogen fixing Macro-nutrients	Legumes Microclimate Windbreaks Diversity Mixed cropping Crop rotation Companion planting Succession planting

Start-up activity

A well-known gardening magazine had the following to say about vegetable gardening:

> Keeping a vegetable garden needs dedication. This means vegetables require daily attention, but rather than regarding this as work; make it a pleasing time to wind down your day in the vegetable garden. It is good therapy to check on the daily growth, get rid of pests, stamp on snails or pick healthy vegetables you have grown yourself.

(Adapted from SA Garden. September 2008)

Reflect on what is said in the article and write two or three sentences on your reflection.

………

………

………

………

2.1 A plant and its environment

A plant's environment is the surroundings of the plant and includes everything around the plant that influences its growth.

Activity 2.1 Factors which influence the growth of a plant

Complete this activity on your own or in groups in the workbook

Aims:

- Identify factors which influence the growth of the plant
- Reflect on how the survival needs of plants are similar to those of humans.

Time: 30 minutes

What you must do

1. Think about any plant in its environment. The plant can be a crop plant on a farm, a vegetable plant in a food garden or a plant in nature.
2. Write down a list of everything in the environment that influences the plant. Write a separate list of living factors (things) and non-living factors that influence the plant.

Living factors	Non-living factors

3. Which of the non-living factors that you named is necessary for the survival of the plant?
4. How does the survival needs of a plant compare to the needs of a human? Draw your own table with two columns. In the first column, show the needs of plants. In the second column, show the survival needs of humans.
5. Write a paragraph to say how the needs of plants and humans are similar and how they are different.

Comments on Activity 2.1

The factors in the environment, which influence a plant, can be divided into two groups:

- Biotic factors, which are all the living things that influence the plant.
- Abiotic factors, which are all the non-living things that influence it.

2.1.1 Biotic and abiotic factors in a plant's environment

What are some of the biotic factors in a plant's environment?

There are many biotic factors (living organisms) that affect a plant. Examples are:

- Some insects pollinate the plant and some insects feed on it.
- Birds eat the seeds and fruit and use the plant parts to make nests.
- Some animals eat the plant or spread the seeds from place to place in their fur.
- Plants compete with each other for water, sunlight and nutrients from the soil.
- Microorganisms such as fungi, bacteria and viruses, some of which cause plant diseases.
- Certain bacteria benefit the plant.
- Humans may kill the plant or protect it.
- Soil animals such as earthworms enrich the soil.

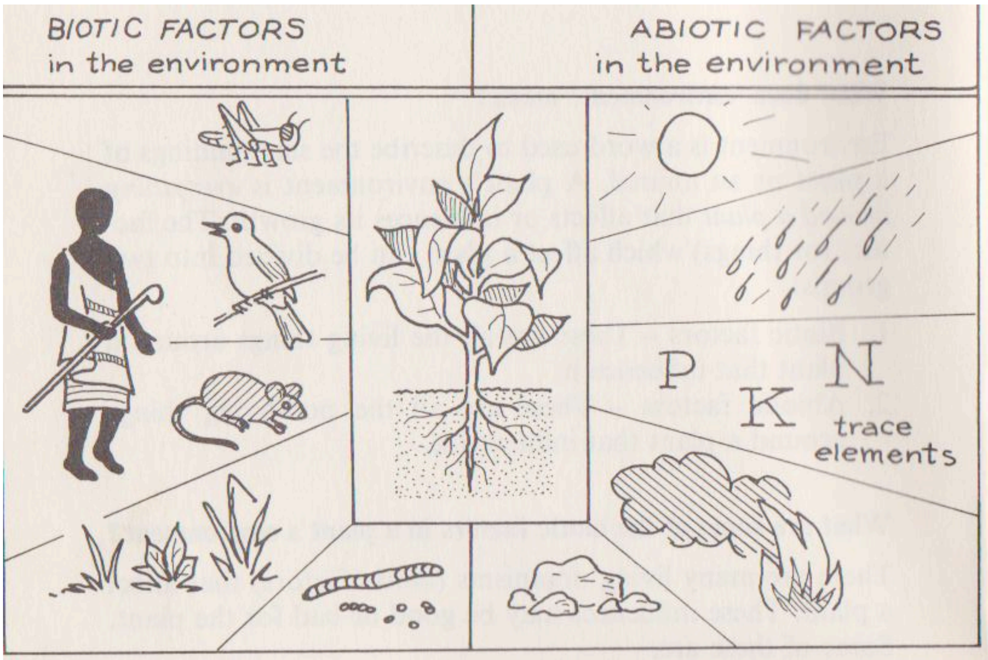


Figure 2.1 A plant's environment

What are some of the abiotic factors in a plant's environment?

There are many abiotic factors (non-living things) that affect a plant. Examples are rain, fire, wind, hail, rocks, temperature, light, nutrients and minerals in the soil, gases in the air (such as oxygen and carbon dioxide) and chemicals (such as insecticides that kill harmful insects).

When comparing the factors that humans and plants need to survive, you will notice that they are similar in many ways. Caregivers know what their families and other people need for survival. The principles of caring for plants are similar!

Table 2.1 Survival needs of plants and humans

For survival a plant needs…	For survival we need…..
A **habitat** (home) where the plant gets everything it needs for survival. Plants in your garden need dedication.	A **habitat** (home), where we are protected, loved and get what we need for survival.
Water makes up about 90% of the plant body. It provides mechanical support to the plant. Water is needed for most reactions inside the plant. The plant gives off water vapour during a process called *transpiration.*	**Water** makes up 70% of the human body. It is needed for most reactions inside the body. Water is also needed for getting rid of wastes in our body.
Sunlight is the energy source that plants use to produce their own food (carbohydrates) through the process of *photosynthesis.*	**Sunlight** provides warmth. The action of sunlight on the skin produces Vitamin D. Sunlight can also improve people's mood.
Air contains a mixture of gases including carbon dioxide and oxygen. Carbon dioxide is used for photosynthesis during the day. Oxygen is a byproduct of photosynthesis and is released into the air. Plants use oxygen to break down carbohydrates to produce energy for its needs. (This process is called *respiration*).	**Air:** When we and animals inhale (breath in) our lungs use oxygen from the air. Oxygen is used to break down food stored inside our cells. This process is called *respiration* and it releases the energy in food, which our bodies need. The carbon dioxide produced during respiration is released into the air when we exhale (breath out). Plants in turn, use this carbon dioxide for photosynthesis and put oxygen into the air. Air is thus cycled between humans and plants. Plants are therefore vital for cleaning the air for humans
Nutrients: Plants are called producers because they make their own food during photosynthesis. Plants however need to get nutrients like nitrates and phosphates from the soil, for the activities in the plant, which they take up through their roots. Plants are at the base of the food chain. No other life, except for some bacteria, can exist without plants.	**Nutrients:** The human body cannot make its own food like the plant body can. We are consumers.This means we get our energy by consuming plants or animals. Our bodies' break down the food we eat and energy is released. This energy is used for work, growth and repair of the body. Humans are at the top of the food chain.
Note: If we apply too much fertilizer or supplement nutrients like nitrates and phosphates in the soil at one time, the pant will die.	People are similar, for example a baby requires small amounts of food at a regular time. Giving a baby a week's supply of food at one time will lead to its death, as the baby cannot use all the food at once.

(Adapted from Rand Water: Home and Garden: Water wise gardening)

Why is the environment important to a farmer/gardener?

We can summarize by saying that the more we know about the environment in which we plan our farming system, the bigger chance we have of being successful.

Each kind of plant has a specific requirement for growth:

- Certain nutrients must be present in the soil.
- There must be the right amount of water available.
- The temperature range must be just right; not too cold or hot.
- Enough light for photosynthesis must be present.

If these conditions are not right the plant will not grow well or may not grow at all.

Not only do plants need factors such as healthy soil, light, water and air, but they also need these factors in the correct amounts. They need the right balance of each in order to grow well. This is called the *limiting factor principle,* which states that:

> Too much or too little of any abiotic factor (non-living factor) can limit or prevent the growth of an organism, even if all the other factors it needs are at the right level (optimum level).

An example to explain the limiting factor principle would be: if a gardener plants a certain plant in an area where it receives too little light, it will not grow even if it is planted in good soil and gets enough water and air. If the plant receives enough light but not enough water it will also suffer. It is therefore very important that we address the survival needs of the plants that we grow in our food or any other garden. Only when we do this are we able to grow good, healthy plants to enhance food security.

You will gain a better understanding of the needs of plants, including specific crop plants and how to address these needs, as you work through this unit and the other units in this module.

2.1.2 Plant parts and their functions

You are now aware of the factors in the environment that influence the growth of a plant and that these factors link to the natural resources available in your area. To understand how a plant uses these factors for healthy growth you also need to know what the body of a plant consists of, and what each part does. Most flowering plants, including the crops we plant to provide vegetables and fruits in our homestead gardens or on our farms have four main parts; flowers, leaves, stems and roots. The following figure shows you these parts and also shows you the functions of these parts.

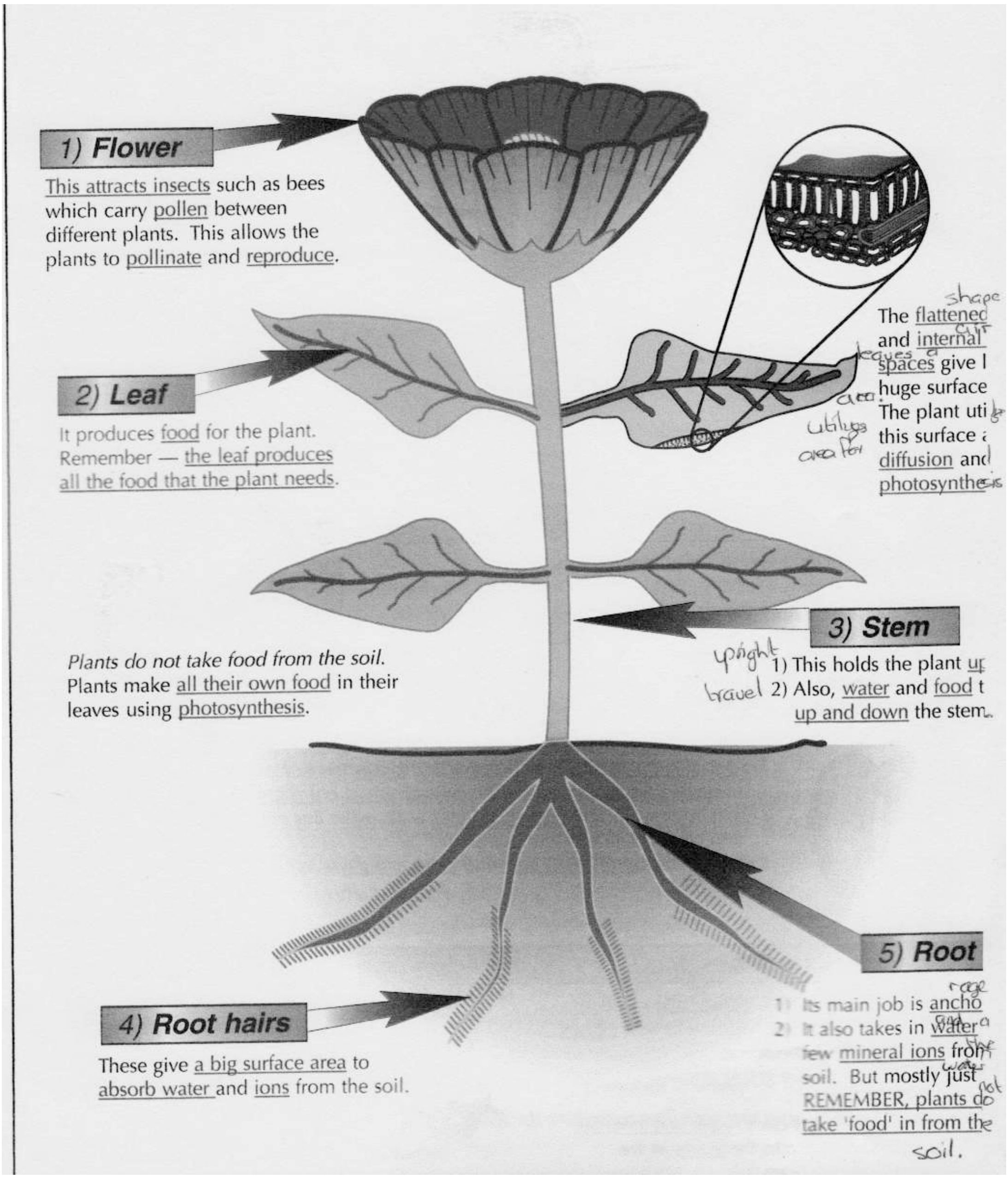


Figure 2.2 The different parts of a plant have different functions
(Adapted from GSCE handbook, p 22)

Activity 2.2 The functions of the plant parts are important to gardeners

Complete this activity on your own or in groups in the study guide

1. The plant shown in Figure 2.2 is a flowering plant. Do crop plants like maize, pumpkins, sweet potatoes or beans have the same parts as the potato plant?
   Explain your answer by choosing any vegetable plant and name its parts with the function of each part.

……………………………………………………..………………………………………………

……………………………………………………..………………………………………………

……………………………………………………..………………………………………………

……………………………………………………..………………………………………………

……………………………………………………..………………………………………………

2. Reflect on why it is important for the gardener to know about the functions of the different plant parts.

……………………………………………………..………………………………………………

……………………………………………………..………………………………………………

……………………………………………………..………………………………………………

Comments on Activity 2.2
Why is it important for any gardener to know what the different parts of a plant are and what the functions (jobs) are of each part? The answer to this question is simple. If we want to be successful in growing vegetables or fruit to enhance food security, we need to understand what the job of every part of the plant is and what the plant needs to grow well and provide us with a good harvest.

2.1.3 The flower and how it forms seeds and fruit

When you give someone flowers, you do not usually think of them as reproductive structures but they are. Flowers attract insects and other animals, which in turn help to distribute pollen and seeds. In some vegetables, herbs and flowers, the male and female parts are in the same flower. These are called *complete flowers.*
Exceptions are:

- The cucurbits such as pumpkins, melons, gourds, cucumber have the male and female parts on different flowers, but on the same plant. The same situation applies to maize.
- Asparagus and papaya. Male flowers are on one plant and the female flowers on another.

What is pollination and fertilization?
Pollination is the process that takes place in the flowers of plants when pollen from the male parts of the flower (stamen = filament and anther) is deposited on the female parts (pistil = stigma, style and ovary)). Insects and birds and other animals help in this process by transferring pollen from the stamens to pistils of plants (See figure 2.3 to learn about the parts of a flower).

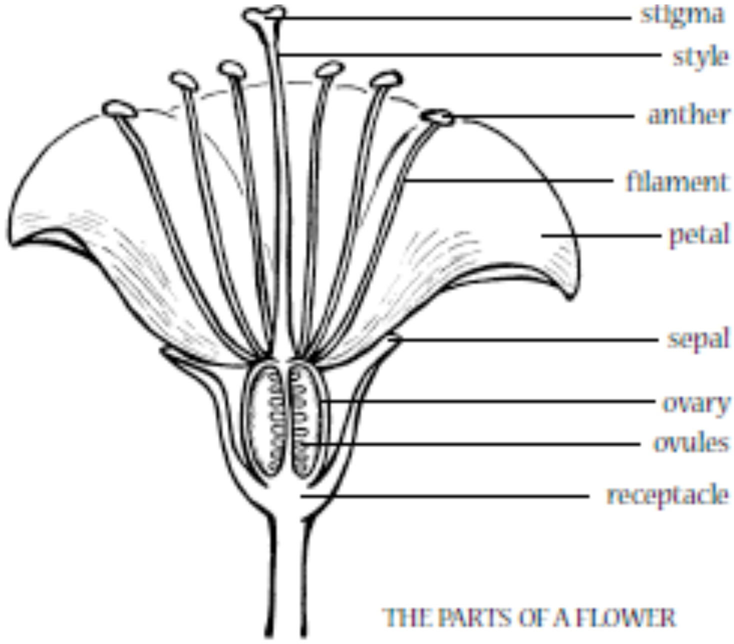


Figure 2.3 The parts of a flower
(Adapted from Stimie, *et al* . 2010).

The pollen grain that was carried to the stigma, germinates to produce a pollen tube that grows down through the style to the ovary where fertilization takes place. **Fertilization** happens when a sperm in the pollen joins with an egg in an ovule.

After fertilization the ovule becomes a **seed.** After fertilization and seed development, the ovary and sometimes, other parts of the flower grow bigger to form a **fruit.** The seeds are found inside the fruit for example in oranges, apples and peaches.

What are seeds?

Seeds are the product of sexual reproduction in land plants. A seed is an embryo surrounded by nutritious tissue which is used by the embryo as it develops.

Types of pollination

Two important types of pollination that take place and which you must be aware of are **self-pollination** and **cross-pollination**.

What is self pollination?

Here, pollen is transferred from the male to the female part of the same flower. Crops that self-pollinate are: tomatoes, lettuce, capsicum (green pepper) and okra. Beans and peas self-pollinate even before the flower has opened.

Lettuce plant with seed head

Generally, different kinds of plants that self-pollinate can be grown quite close together. It is still a good idea however to separate different varieties of the same plant (e.g. different varieties of lettuce) from each other, as some pollen can still cross from one plant to the other. Why is this important?

What is cross-pollination?
When pollen is transferred from one flower to another on the same plant, or to the flower of another plant of the same type, it is known as *cross- pollination.* Cross pollinated plants produce more varied offspring that are better able to cope with a changing environment.

Pumpkins are an example of crops where cross-pollination takes place. If you have two different types of pumpkin, planted close together, they will cross with each other. The seed that is produced will grow and produce a plant with a fruit that is a mixture of the two types of pumpkin you have grown. This happens with all cross-pollinated crops.


Onion plant seed

Other examples of cross-pollinated crops are: Brinjal (eggplant), cabbage, carrot, chilli, kale, leeks, maize, onions and spinach (swiss chard).
Many grains (such as sorghum and maize), grasses (such as Napier fodder and sweet reed or imfe) and trees are cross-pollinated and are dependent on the wind for pollination.

How is pollen carried between flowers?

Pollen picked up by the wind can travel many kilometers on air currents before coming to a rest. Except for wind, pollen is also carried between flowers by bees, other insects, birds and bats. All these animals, especially bees, play a very important role in pollination and should therefore not be killed without a very good reason. Being afraid of them is not a good reason!

Activity 2.3 Identify different types of seed

Complete this activity on your own or in groups in your workbook

For this activity you need to go to a shop that sells seed and if possible speak to gardeners and farmers in your area who keep their own seed

Make a list of at least 10 different types of crops/ vegetables that can be grown from seed. Write down the name of the crop (e.g. tomato) and the name of the variety (e.g. Floradade).

1. Decide whether your crop self-pollinates or cross- pollinates. Or ask the farmer you are interviewing.
2. Now make a few comments about what this means in terms of sowing seed of that specific variety.

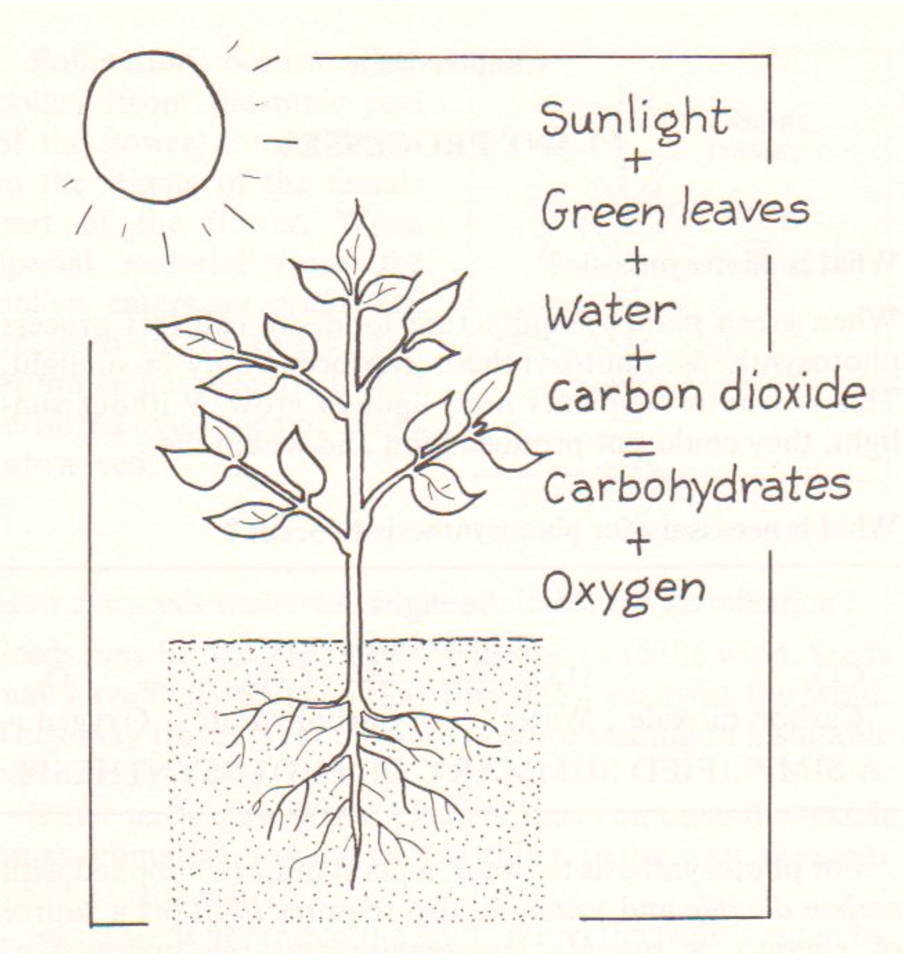
Comments on Activity 2.3
Comments you could have made in terms of keeping seed of a specific variety could be that Floradade is a self-polllinating crop and can thus be grown quite close to other tomatoes without being pollinated by them.

2.1.4 The leaf and photosynthesis

From prior learning you know that photosynthesis takes place mainly in the leaf of a plant, but what happens during this process and how does it take place?

What is photosynthesis?

Only green plants and a few other small living things can make their own food inside their bodies. Humans and other animals cannot make food inside their bodies and have to ingest (eat) food to survive. The process that allows plants to make food inside their bodies is called **photosynthesis.** The food that the plant makes is a carbohydrate called glucose (a simple sugar), which we examined in Module 4.
What does a plant need for photosynthesis to happen?



We must protect plants, not only crop plants but also indigenous plants. They provide us with oxygen to breathe.

Figure 2.4 Four things are needed for photosynthesis to happen
(Adapted from GSCE Handbook, page 24)

Scientists write the process of photosynthesis as the equation:

$$\text{Carbon dioxide + water} \xrightarrow[\text{Chlorophyll}]{\text{Light energy}} \text{glucose + oxygen}$$

When you carefully look at the equation you will notice that not only glucose is produced during photosynthesis, but also the gas oxygen. Some of the glucose is used to release energy inside the plant, some is used for growth, and the rest is stored, for example in the form of starch, e.g. in potatoes. Oxygen is a by-product of photosynthesis and is given off by the plant into the atmosphere. The rate at which photosynthesis occurs is important.

Why is the rate at which photosynthesis happens important?

The rate of photosynthesis means how slowly or how quickly it takes place.
The faster the rate of photosynthesis (up to a certain point), the more food is produced in the plant. The slower the rate, the less food is produced.
The rate of photosynthesis is affected by three factors (things):

1. The amount of light

The chlorophyll in the leaves uses light energy to perform photosynthesis. Light must be in plentiful supply for photosynthesis to take place. Not enough light limits (slows down) the rate of photosynthesis and the plant will grow poorly or die.

2. The amount of carbon dioxide

As with light, carbon dioxide must be in plentiful supply. If not the rate of photosynthesis will slow down and the plant will grow poorly or die.

3. The temperature

For photosynthesis to take place, the temperature must not be too low or too high. In winter when it becomes very cold, or when it is very hot (45°C) photosynthesis does not take place and the plant can die.

Activity 2.4 Measuring the rate of photosynthesis

The rate of photosynthesis can easily be measured. Figure 2.5 shows the set-up for an experiment to measure the rate of photosynthesis of Elodea (a plant that grows in water). When Elodea is photosynthesizing it releases bubbles of oxygen into the water.

Complete this activity on your own in this study guide

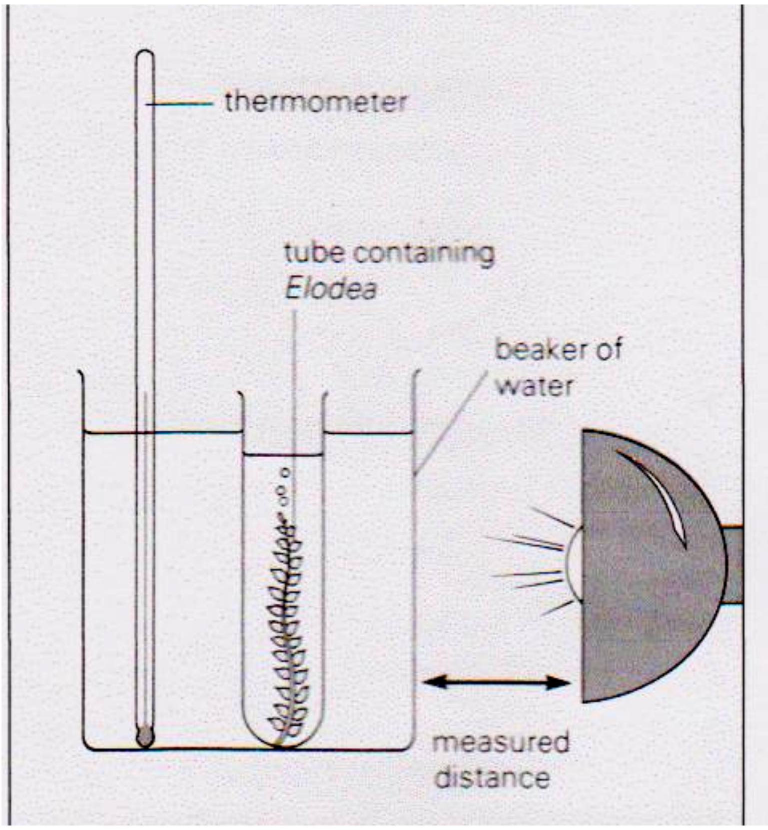


Figure 2.5 Water plant in a tube of water (Adapted from Biology, 1992)

Three students carried out an experiment to find out how photosynthesis is affected by changing certain conditions. They measured the *rate* of photosynthesis by counting the number of bubbles produced each minute by an aquatic (water) plant. Each student used the same length of water plant.

- Mpho carried out her experiment in the middle of the room, using a lamp as a source of light.
- Jim worked near the window.
- Risa placed aluminium foil around the tube containing the plant.

The results of their experiments are shown in the table below.

Table 2.2 Measuring the rate of photosynthesis

	Number of bubbles given off each minute
Mpho	25
Jim	34
Risa	2

(Adapted from Biology, 1992)

Questions

1. Why is the number of bubbles different for each student?

……..………

………..…

2. Name the gas in the bubbles……………………………………………………………………………

3. Why did the students use the same length of water plant?

……………………………………………………………………………………………………….………

4. The students concluded that the rate of photosynthesis increased by increasing the amount of light. Do you agree with their conclusion? Explain your answer.

……..………

………………………………………………………………………………………………..………………

Comments on Activity 2.4

Because the students all worked in places where the amount of light varied, the amount of oxygen given off, and therefore the number of bubbles observed were different.

What other processes in plants must you be aware of?

Photosynthesis is not the only important process that takes place in a plant. There are two others, which a farmer or gardener need to be aware of. These two processes are respiration and transpiration.

What is respiration?

Humans and other animals need energy because they are active and move around. Plants however, do not move from one place to another, so why do they need energy? Plants need energy to:

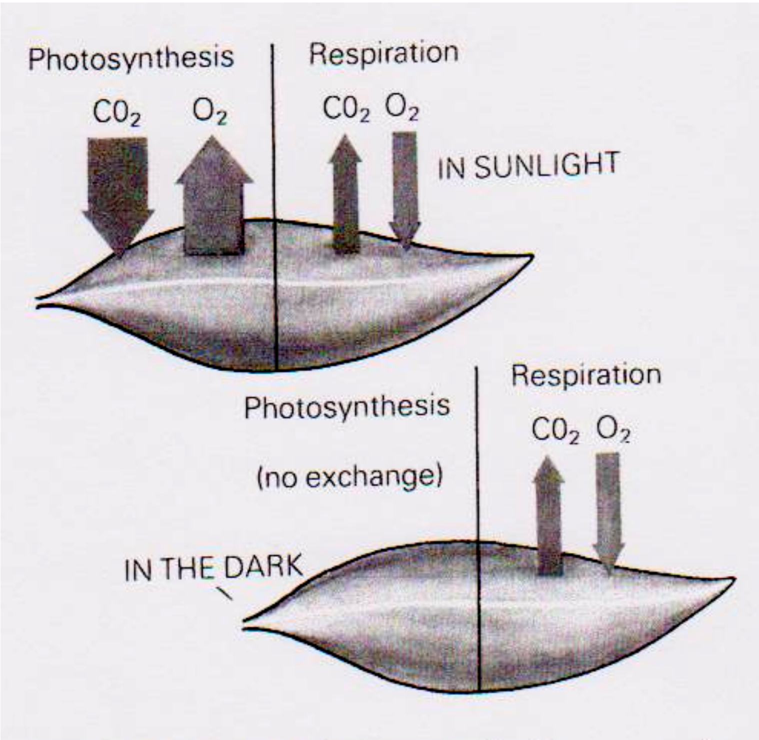
- Build up other more complex substances from the glucose made during photosynthesis. Examples of these complex substances include sucrose that is stored in fruits, lipids stored in seeds, starch stored in potatoes.
- Move substances from one part of the plant to another.

- Allow for growth, cell division and many other processes to take place.

The energy to do all of the things above does not come straight from the sun. It is obtained by releasing the energy 'locked up' in the sugars that were built up during photosynthesis. The process during which sugars are broken down to release energy is called *respiration.*

During respiration, sugars react with oxygen to make carbon dioxide and water and in doing so energy is released. All living things respire, but only plants can store the energy of sunlight by making sugars during photosynthesis.

When does respiration take place?
Respiration happens all the time in every living cell. In plants the processes of photosynthesis and respiration take place *at the same time*, causing the oxygen and carbon dioxide to flow in opposite directions. The rate of respiration in the plant is always the same, but the rate of photosynthesis depends on the amount of light.



Desert plants

Why do plants that live in very dry areas have less stomata on their leaves than plants living in areas with high humidity?

Figure 2.6 Gas exchange in a leaf
(Adapted from Biology, 1992)

What is transpiration?
You will recall that we examined the process of evapotranspiration in Module 3. On the surface of the leaves of most plants are thousands of very small holes called *stomata.* Gases are able to pass in and out through these holes. Gases like carbon dioxide in the air which is needed by the plant for photosynthesis, enter the leaf through these holes. Oxygen is produced during photosynthesis and moves out of the leaf through these holes. Large amounts of water vapour also move out of the leaves through the holes. The loss of water vapour from a plant is called *transpiration.*

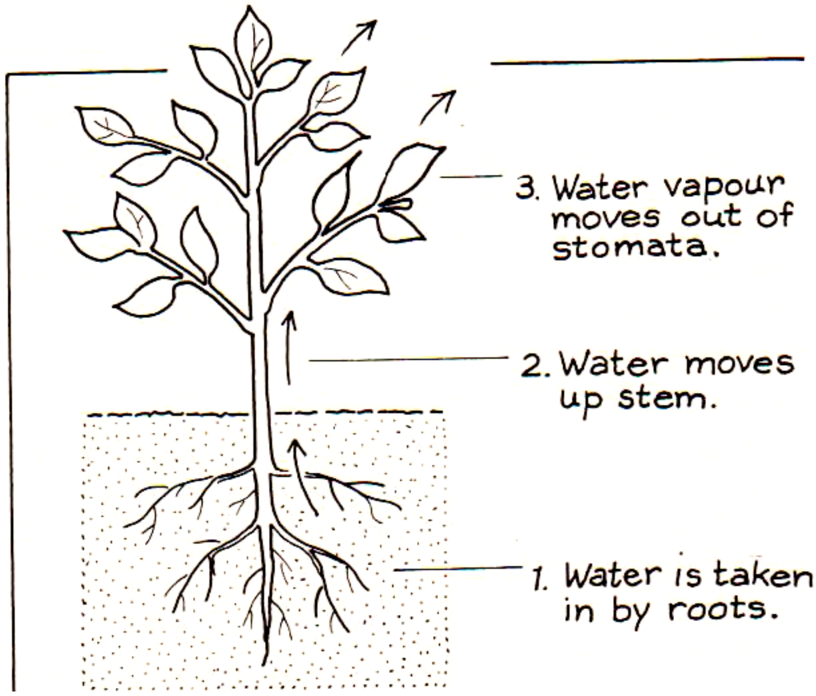


Figure 2.7 How does transpiration take place?
(Adapted from *Plant growth and Environment)*

Why is transpiration important to a plant?
Transpiration is partly responsible for the movement of water, from the roots where it is taken up, to the rest of the plant. This water contains nutrients from the soil. As the water moves through the plant it carries the **nutrients** needed by the plant to build substances like protein. Transpiration also keeps the plant surface cool.

What causes the loss of water by plants?

There are five main things that determine the *rate* of transpiration:

- **Temperature.** High temperatures increase the rate of water loss (transpiration) by plants. This is why plants wilt (hang down) in hot sun.
- **Humidity:** If there is already a lot of water vapour in the air (if the air is humid), the rate of water loss will be slower.
- **Light:** Light causes the stomata to open and so increases the loss of water vapour from the plant.
- **Atmospheric pressure**: The lower the pressure of the atmosphere, the greater the loss of water from the plant. This means that plants at higher altitudes, for example on a mountain, lose water by transpiration more rapidly than do plants at lower altitudes.
- **Air movements or wind**: Wind increases water loss by blowing away the water vapour on the surface of a leaf.

Activity 2.5 Observing transpiration

Complete this activity on your own in this study guide

1. Take two leaves of the same size from the same tree.
2. Smear the surface of one leaf with Vaseline. Leave the other leaf without Vaseline.
3. Place both leaves where they will not get any moisture.
4. Examine the two leaves after three or four days.

Questions

1. Which leaf has wilted most?

………

2. Explain why the one leaf wilted more than the other one.

………

………

3. Why is it important for a farmer or gardener to know about transpiration?

………

………

Comments on Activity 2.5

It is important for a farmer or gardener to know about transpiration because when a plant loses large amounts of water through transpiration, it will require a lot of water to replace this water loss. If this water is not replaced, the plant can die. It is best to water your plants early in the morning or late in the afternoons, instead of in the middle of the day when the rate of transpiration is higher.

2.1.5 The root and the uptake of nutrients

In this section we examined the functions of the flower and the leaf in some detail. You also know that one of the functions of the root is to take up nutrients dissolved in the water in the soil. What are the nutrients in soil and why are they important to healthy plant growth? The answers to these questions are the topic of the next section.

Do plants take in food?

Plants make their own food inside the leaves. Plants only take up nutrients and water trough the roots

2.2 Plant nutrition and soil fertility

In Module 3 we examined soils. We looked at different types of soil (sandy, loam and clay) and learnt how to tell them apart. We considered soil structure, texture and soil components. We also looked broadly at farming/gardening practices that affect the soil and things that can go wrong. We will now look at soil fertility. This is important for a homestead gardener because a plants' growth is greatly influenced by the fertility of the soil in which it is growing.

Soil fertility

Refers to the nutrient content of the soil which sustains plant growth

2.2.1 What nutrients do plants need from the soil?

(Adapted from Kruger, *et al.* 2009)

Plants absorb sunlight, oxygen and carbon dioxide from the air and water and nutrients from the soil.

Soil nutrients are chemical substances or elements in the soil that are needed by a plant for normal growth and development. Soil nutrients enter the plant through root hairs in a very dilute water solution. (Refer to Figure 2.2)

Under natural conditions the nutrients in soil come from:

- Very slow weathering (breaking down) of the rocks from which soil is made.
- Decomposed organic matter (dead plant and animal material).
- Legumes (plants such as beans and peas) that can 'fix' nitrogen.

Nitrogen 'fixing'

You will learn more about this in the next section.

To grow best, plants need adequate (the right amount) of different nutrients.

Table 2.3 Nutrients and their role in the growth and health of plants

Nutrients needed by plants	Role of the nutrient
N= Nitrogen:	Essential for the growth of leaves and stems
K= Potassium:	Increases disease resistance and quality of fruits and grain
P= Phosphorus:	Promotes early maturity and root growth
Ca= Calcium:	Essential for plant cells to divide (cell division)
S= Sulphur:	Used by the plant to make amino acids, proteins and vitamins
Fe= Iron:	Helps in chlorophyll formation for photosynthesis
Si= Silica:	Helps plants to absorb sunlight and fight fungal diseases.

A large range of nutrients is important for plants. Certain nutrients are needed in small amounts and are therefore called *micronutrients*. *Macro-nutrients* are those nutrients needed in larger quantities by growing plants. These nutrients determine whether your plants are going to grow well or not. They are nitrogen (N), phosphorus (P) and potassium (K). In this unit we will focus on the macronutrients.

Nitrogen (N)

How do you know if your plants need more nitrogen?

You will know your plants need more nitrogen when the leaves are turning yellowish, instead of being a strong bright green. Plants also show stunted growth.

How can you add nitrogen to your soil?

Nitrogen is found in most animal manure (cattle, sheep, pig, goat, chicken and rabbit). The most nitrogen is however in chicken and goat manure. Animal manure must be dried before being used in the garden otherwise they can scorch (chemically burn) the plants.

Nitrogen is also found in legumes

Legumes are plants such as beans and peas that form nodules (small knots) on their roots. Inside these nodules are certain bacteria that 'fix' nitrogen. Nitrogen in the air cannot be used by plants or animals. 'Fixing' nitrogen means changing the nitrogen in air into a form that can be taken up by plant roots. Thus, legumes make their own nitrogen with the help of the bacteria in the nodules. After the roots of the plant die, the nitrogen is released into the soil and can be used by surrounding plants. This is one reason why farmers plant legumes.

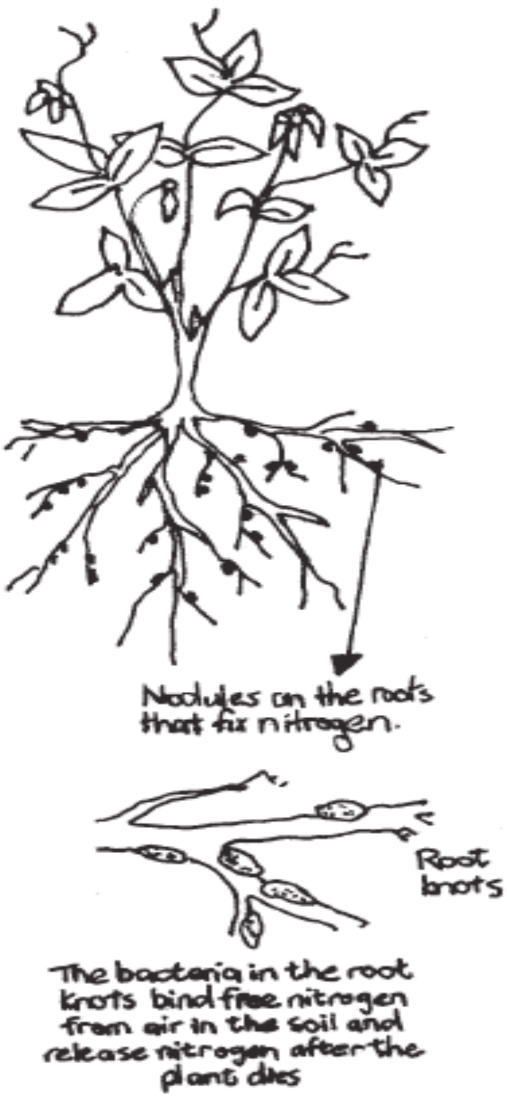


Figure 2.8 Root nodules with bacteria that 'fix' nitrogen
(Adapted from Kruger, et al., 2009)

Phosphorus (P)

How do you know if your soil needs more phosphorus?
You will know your plants need more phosphorus when they do not grow as fast as they should. The leaves may also start to look reddish or pinkish, especially around the edges. If your plants are small and will not grow even after compost or manure is added, then you almost certainly have a severe phosphate deficiency. This can also be caused by acidity in the soil.

How can you add phosphorus to your soil?

Most of the soils in South Africa are poor in phosphorus. It is slightly difficult to add phosphorus to the soil in an organic way, as most of the sources are somewhat tricky to work with. They include urine, bone, hair, feathers and blood. Usually we add these as ingredients to compost.

Natural rock phosphate can be added directly to the soil. This is also not easily available. Another good source of phosphorus is bone meal. You can usually buy this from an agricultural supply store, but it is not cheap.

One other way to add phosphorus to your soil is to place bones in a fire for a few hours. You can then grind them into a powder. This powder can be spread on your garden beds or your compost heap.

Figure 2.9 Heating bones in a fire to make them easier to grind to a powder that contains high amounts of phosphate.
(Adapted from Kruger, et al., 2009)

Potassium (K)

How do you know if your soil needs more potassium?
You will know your plants need potassium when your plants become brittle (break easily when touched) and the leaf edges become brown and dry. When fruit do not form properly, you should also suspect a lack of potassium. Other signs include a yellowing around the veins of the leaves. This could also be caused by diseases - so it is difficult to be sure.

From: Useful Plants for Land Design, Pelum

How can you add potassium to your soil?
Good sources of potassium are chicken manure and fresh wood ash. Never use ash from coal, as this is very poisonous to the soil and plants. Another good source of potassium is a plant known as comfrey. This plant has large hairy leaves and grows in wet shady places. The leaves contain a lot of potassium. These can be used to mulch your vegetable beds and also to make liquid feeds/manures for your plants.

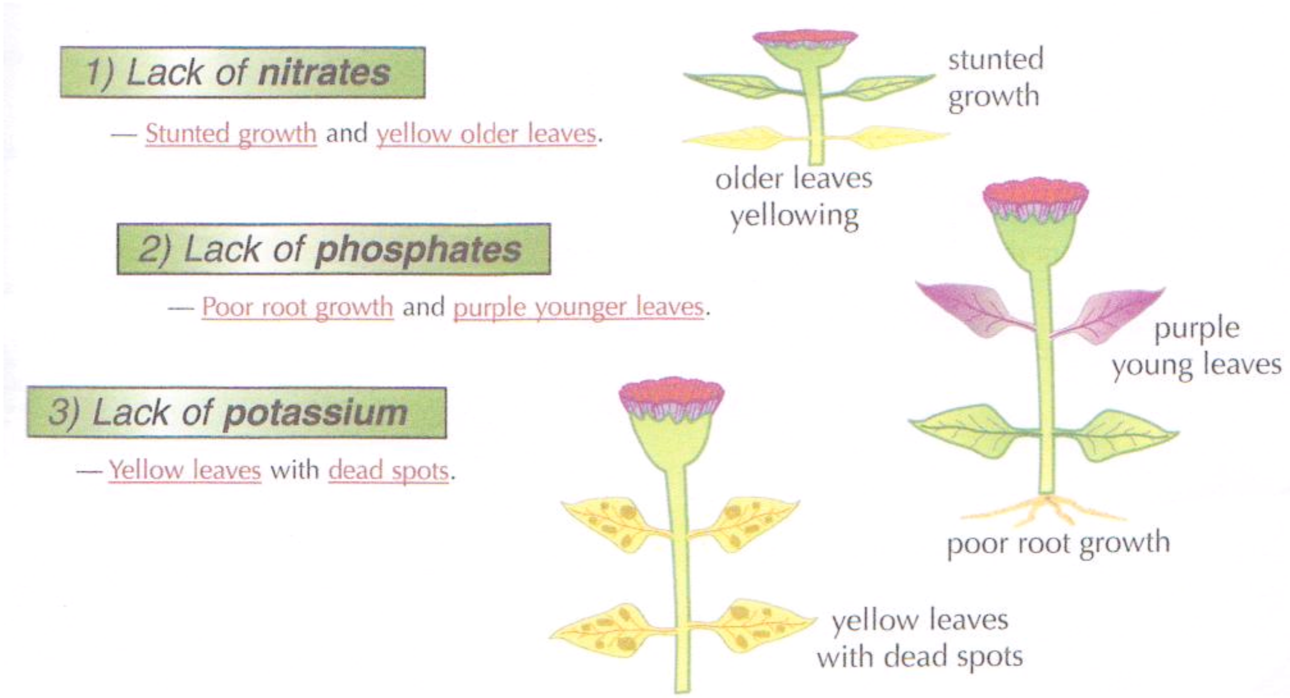


Figure 2.9 Lack of these nutrients cause deficiency symptoms
(Adapted from GSCE Handbook, page 27)

Organic soil improvement methods such as adding compost to your soil was addressed in Module 3 and we will also examine more methods in the next unit.

2.2.2 What is soil acidity and soil alkalinity?

Soil Acidity

The nutrients needed by plants to grow are dissolved in the water inside the soil. We can compare this to salt or sugar dissolved in a glass of water. Soil acidity is when the soil is sour (acid). It is a bit like a glass of water that has vinegar dissolved in it.

How is soil acidity measured?

With a number system called a **pH scale.** The highest level of acidity is number 1. Soil with pH of 4 is very acidic. Number 7 indicates no acidity and soil is neutral. Above 7 to 14 the soil is alkaline

How does soil become acidic?
Water passing through soil slowly washes out many of the nutrients. In soils where this happens for long periods of time the soil becomes acidic. When farmers or gardeners add chemical fertilizers to the soil over a long period of time this can also make the soil acidic. Soil can also become acidic in a few years if crops are grown on it year after year and the nutrients are not replaced.

How does acidic soil affect plants?

- If there is too much acid in the soil the root system of a plant develops poorly and as a result the plant struggles to take up water and nutrients.
- If the soil is very acidic some forms of nutrients are changed. These new forms are almost impossible for the plant to use. Phosphorus is one of the minerals that cannot be used by plants when the soil is acidic, even if it is present in the soil.

How do you know if your soil is acidic?

You will know your soil is acidic if you provide compost or manure for your plants and enough water, but they still do not grow. The plants remain small and stunted.

How will you solve the problem of acidity?

- It is possible to make the soil less acidic by adding a lot of compost and other organic matter to the soil over a period of a few years.
- Another practical and reasonably quick way of dealing with soil acidity is to add **agricultural lime** to the soil. Lime is a crushed and powdered rock rich in calcium and magnesium. Lime can be bought and is either a white powder or grey granules.
- Usually lime is added 2-3 months before planting your crops as it is slow acting in the soil. It needs to be dug into your soil, at least as deep as the roots are growing. For vegetables, this is 30-60cm deep. For field crops like maize and sorghum that have deep roots, this is from 60cm to 1 meter deep.

Activity 2.6 Addition of phosphorus or lime to soil

Complete this activity in groups or on your own in the workbook

Aim: Assist a farmer to experiment with the effect of phosphorus or lime on plant growth.

Time: 4 hours

You will need

- small quantities of lime and super phosphate
- sticks/ stakes to mark our your plots.

What you must do:

1. Planning

1.1 Discuss the issue of acidic soil with your household farmer or farmers.

1.2 Fill in the Small Scale Experiment Plan below (as we discussed in unit 1) with the farmer. You will go through the questions, work out the solutions (in this case addition of phosphorus and lime) and decide how you will observe and monitor the experiment. (There is an example in your workbook of how this plan may end up looking and a Plan for you to fill out).

SMALL SCALE EXPERIMENTAL PLAN

- What is the problem?
- What is a possible solution?
- Why will this solution solve the problem?
- How will I test this solution step by step?
- What will I look for and what will I measure?
- How will I measure the results or outcomes?
- How will I compare my experiment to my usual way of farming?

2. Layout and implementation

2.1 Measure out 4 plots of the same size. Make the plots about 1 metre long and 1 metre wide.

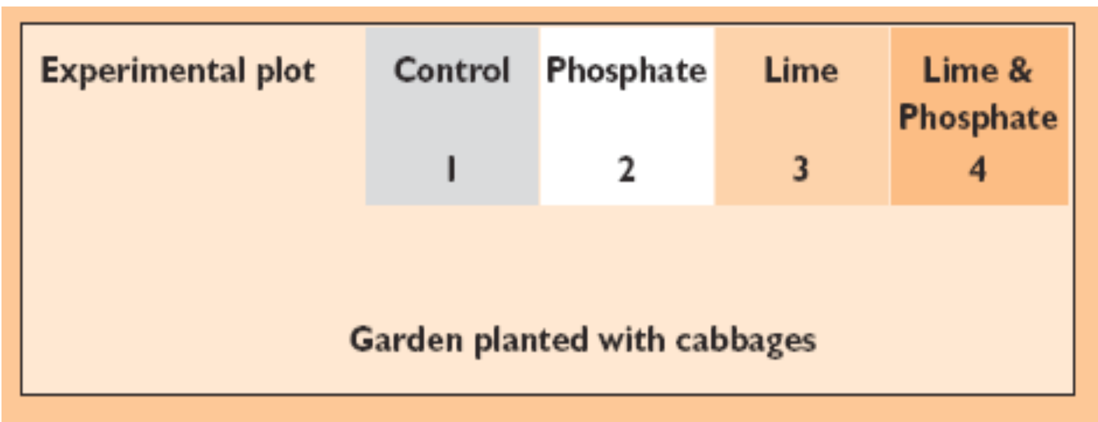
2.2 Be sure to mark out your plots with sticks/stakes, so that you will know throughout the season where your plots are.

- **PLOT 1:** This is your control plot. Prepare and plant this plot in your normal way.

- **PLOT 2:** Prepare the plot in your normal way and then add 2 big spoons full (20 grams) of super phosphate. This is spread evenly over your soil and is then dug into the soil. Then plant in your normal way.

- **PLOT 3:** Prepare the plot in your normal way and then add one big tin (jam tin – 400 grams) of lime. This is spread evenly over your soil and is then dug into the soil. Then plant in your normal way.

- **PLOT 4:** Prepare the plot in your normal way and then add 2 big spoons full (20 grams) of super phosphate **and** one big tin (jam tin – 400 grams) of lime. This is spread evenly over your soil and is then dug into the soil. Then plant in your normal way.
  Below is an example of what your experiment might look like.



3. Monitoring

3.1 Every week the farmer will need to monitor (check) and see in which plots the plants grow better, and give you feedback.
3.2 So you will need to follow-up with them how the monitoring is going and ensure that they are filling in the form correctly.
3.3 Look at the plants' growth (size), their colour (bright green or yellowish) and their health (are there signs of diseases, spots or discoloration). A monitoring form is provided in your workbook.

4. Reflection

4.1 Reflect on this activity and write answers to the following questions:

- What worked well?
- What did you find most difficult?
- What changes would you make to the experiment y in the future?
- What have you learned from your experiment?

Soil Alkalinity

Alkalinity is a condition of the soil caused by the presence of certain chemicals. It often happens in hot dry areas such as the Karoo. Water in the soil dissolves plant nutrients and other substances. Under hot dry conditions, the water evaporates and the dissolved chemicals are left behind. When this happens over and over again, the chemicals build up and may even form a crust on the surface of the soil. When this happens we say the soil is *alkaline* (soapy). When soil is alkaline the chemicals build up in the soil as opposed to being washed (or leached) out as happens in acidic soils.

How does alkaline soil affect plants?
Alkaline soils are more harmful to plants than acidic soils. Almost no crop will grow in alkaline soils.

Can alkaline soils be treated so crops can be grown in them?

- Yes, add gypsum or sulphur to the soil.
- Irrigate the soil with sprinklers to wash soluble chemicals out of the soil.
- Dig drainage ditches that will carry the water with dissolved chemicals away.

Activity 2.7 Experiment to demonstrate the formation of alkaline soil

Complete this activity on your own in this study guide

1. Dissolve ordinary table salt in water. Pour it into a flat dish.
2. Place the flat dish without a lid in a window sill and leave it for a few days.

Questions

1. What happened to the water after a few days?

   ……………………………………………………………………………………………………..
   ………………………………………………………………………………………………………

2. What do you observe in the dish after the water evaporated?

   ………………………………………………………………………………………………………
   ……………………………………………………………………………………………………..

3. Write a conclusion in which you link what you know about soil alkalinity to what you observe happens in your experiment.

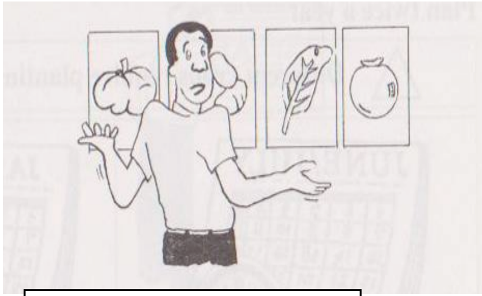
   ……………………………………………………………………………………………………
   ……………………………………………………………………………………………………

Comments on Activity 2.7

After the water had evaporated, you observed a thin layer of salt on the bottom of the dish. Something similar can happen in the upper layers of the soil, causing the formation of alkaline soil.

2.3 Important decisions for your food garden

In Module 3, Unit 3 you designed a draft garden design plan. In this section you will make additions to your plan, by also taking climate into consideration, by choosing your crops, by considering crop mixes and compiling a planting schedule.



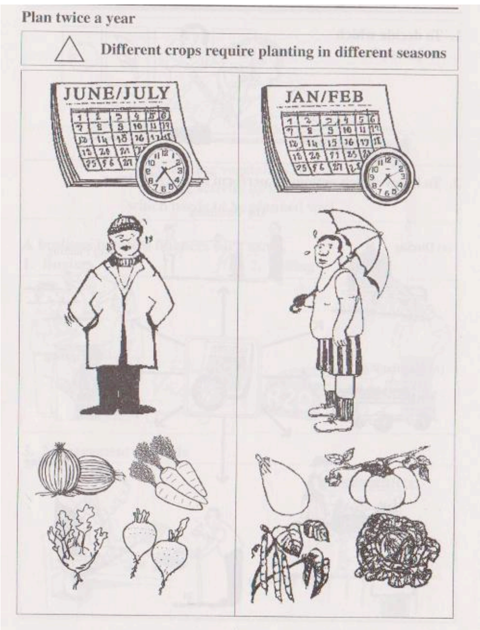
Take climate into consideration

Decide which crops to plant

IMPORTANT DECISIONS FOR YOUR GARDEN

Compile a planting schedule

Consider crop mixes and companion planting



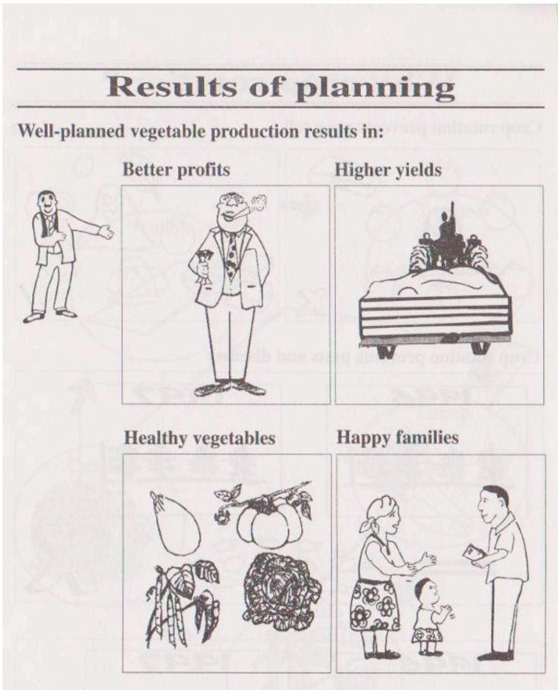


Figure 2.10 Finalize your design plan

2.3.1 Consider climate

People are often unsure what exactly is meant by the word *climate*. Climate is the average weather, usually recorded over a 30-year period, for a particular region and time period. Climate is not the same as weather. Climate is the average pattern of weather for a particular region. A study of climate would include recording elements such as rainfall (also called precipitation), humidity, evaporation, temperature, wind, hail and sunlight.

What is weather?
It is a specific condition of the atmosphere at a particular time and place. Weather changes from hour to hour, day to day and season to season.

Table 2.4 Some elements of climate

Climatic elements	Comments
Rainfall (We examined rainfall and evaporation in Module 3: Unit 1, Refer to that module if you need to refresh your memory.)	Sufficient rain to ensure enough water for our plants is one of the main requirements for successful gardening.
Temperature	Temperature is measured with an instrument called a **thermometer** in degrees Celsius (°C). It is usually placed in the shade and not in the sun. Extreme heat, cold and frost can all have a negative impact on crops.
Wind	Heavy winds blow away water vapour, resulting in loss of water from leaves and soil. You need to consider prevailing winds in your area.
Hail	Hot air pushes water droplets up high into the air were the droplets freeze to form hail. Hail damages plants when it fallsto the ground. Hail damage is a real threat in the northern parts of the country.

Does rainfall and temperature determine which crops can be grown in an area?

The answer is yes, as both rain and temperature will determine if a plant will grow in an area or not. If there is not enough rainfall the plant will not grow. If there is enough rain but it is too hot or cold the plant may still not grow.

Aspect and sunlight

We examined the topic of aspect in Module 3. Refer to it again if you need to.

We can summarize by saying that aspect considers the direction the homestead faces in relation to the sun (north, east, west or south). This has an effect on how much sun a particular area of the homestead will get:

1. North facing slopes get the most sun and are the best for planting vegetables. They are also the hottest and driest parts.
2. East facing slopes get morning sun and are still good for growing vegetables.
3. South facing slopes get the most shade. They are the coldest and wettest parts. In areas where frost occurs, these slopes will have a lot more frost than the north facing slopes. In areas that are very hot and dry, these are the best parts of the garden to grow food and plant fruit trees.
4. West facing slopes get afternoon sun – they are cooler than north facing slopes, but drier than south facing slopes.

Aspect and wind direction

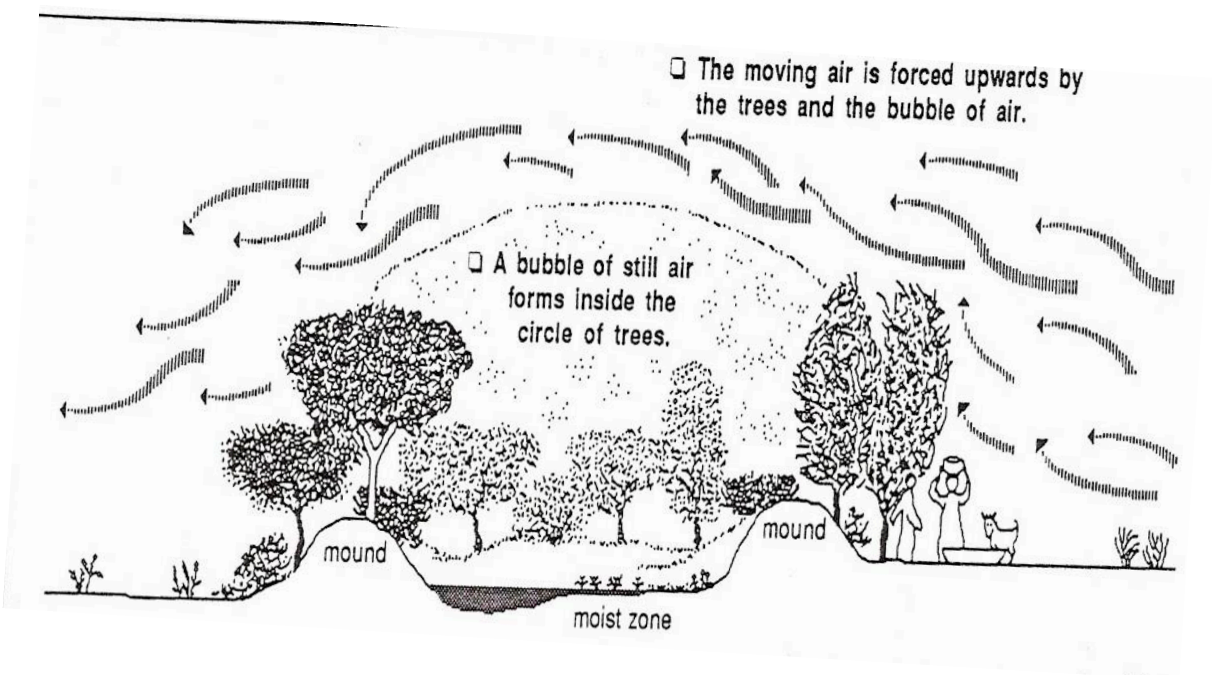
It is possible to combine what you know about aspect with the wind direction in the area. Find out from which direction the dry hot or dry cold winds (that damage crops) come from. Now you can plant trees and other crops (mostly perennial plants and bushes) in a way that will serve as a windbreak and also create an improved microclimate in the garden.

Microclimate
Refers to the climate of a small area. It may be different from the surrounding climate because of aspect, tree cover (or absence of tree cover), or exposure to winds.

Activity 2.8 Analyze examples of microclimates created by planting trees and bushes

Complete this activity on your own in this study guide

Below are 2 examples of micro-climates that have been created by planting trees. Look closely at these drawings and then answer the questions which follow.



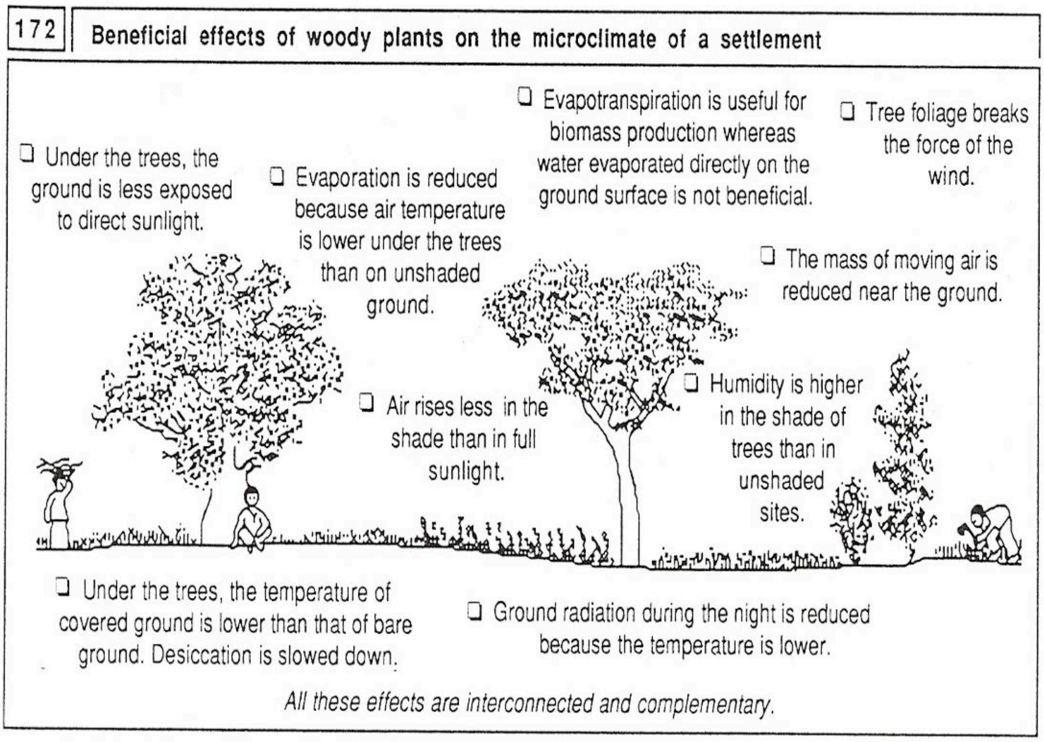


Figure 2.11 Two examples of micro-climates created by planting trees

(H du Preez and P de Leener, 1992)

Questions:

1. What effect do the trees have on the landscape? Name at least 3 things that are shown in the two drawings.

……

……

……

……

2. If trees are planted in a straight line they act as a windbreak. If they are planted in a circular pattern or dotted around the landscape, do they still act as windbreaks? Explain your answer.

……

……

……

Comments on Activity 2.8

Trees create a micro-climateby blocking the force of wind and so act as wind breaks. Secondly trees create shade and air rises less in the shade than in full sunlight.

Trees in a circular pattern will effectively act as a windbreak. Trees dotted around the landscape do act as wind breaks, but to a lesser extent.

Farmers/gardeners cannot change the climate, so what can they do to improve the chances of raising good crops?

1. Choose crops suited to the conditions of the area.
2. Plant crops at the appropriate (right) time of the year when temperature and rainfall will be right for the crop.
3. Plant good seed. This means choosing a variety of seed that is known in the area.
4. Protect crops from wind by growing windbreaks. Use fast growing indigenous trees or plants for this purpose if possible.
5. Cultivate the soil to get air to the roots and allow water to soak into the soil.
6. Eliminate weeds that compete with the crop for water and nutrients (see Unit 3).
7. Protect the crop from pests and diseases (see Unit 3).
8. Consider aspect, ridges and valleys when deciding where to plant crops.

2.3.2 Choose your crops carefully

When we think of vegetable gardens, we usually think of crops such as onion, spinach, cabbage, tomatoes and a few others. However, you need to decide which vegetables are suitable for the climate in your area, as some crops do better under certain climatic conditions.
You also need to choose crops that:

- Provide food on a continuous basis (there is always something to eat).
- Provide food that is wholesome and nutritious (there is enough different types of food to fulfil your dietary needs and preferences).

What are examples of vitamin-A rich crops?

Butternut, pumpkin, orange-fleshed sweet potato and carrots

For this to be possible, we need to think of combining many different types of crops (vegetables, fruit, herbs) and plants (medicinal, protective, windbreaks, fodder for animals). We also need to think of including animals (small livestock are an easy option – chickens, ducks, rabbits, pigs and goats). Then we need to combine all of this into a farming system that can manage itself to a certain extent and support us in the process.

Let us briefly review what we did in Module 4 when we examined principles of nutrition. This will help us to start our diversification process in the garden.

Five food groups

In South Africa food types has been grouped into five groups. You can refer to Module 1 and Module 4. You should eat from each of these groups every day. The five food groups and the South African food based dietary guidelines are tools that can assist the households in selecting a variety of seeds to plant. This is not always possible for poor households. But making a garden and selecting a variety of seeds to plant one can increase the diversity of plants producing diverse diet consisting of nutritious food to the household.

Plant a diversity of plants

You will remember that diversity means "many different kinds/types". Below are some suggestions of what is possible in terms of increasing the diversity of crops we grow in our gardens and thus the diversity of food we eat.

FOR CONTINUITY: We want to be able to have something in the garden to pick and eat throughout the year. (We need to wait a long time for cabbages and onions). We can include crops such as:

- Spring onions/ bunching onions
- Garlic chives
- Leeks
- Parsley
- Coriander
- Fennel
- Lettuce
- Kale, broccoli, cauliflower (for leaves as well)
- Mustard spinach
- Marrow (for leaves as well)
- Sweet potato (especially the orange fleshed ones that are rich in vitamin A)
- Brinjals (egg plant)

FOR PROTEIN: We want to grow crops that can add protein to our diets, especially for the young children (ages 1-5 years). We can include crops such as:

- Turnip greens
- Sugar beans, jugo beans
- Cowpeas
- Peanuts
- Peas

We also need to include small livestock such as chickens, ducks, rabbits, goats and pigs in our farming system.

FOR VITAMIN C AND VITAMIN A: We want to be able to eat fresh green and yellow fruit and vegetables every day. This is very important for children and sick people. We can include crops such as:

- Tree tomatoes
- Granadilla, gooseberries
- Paw-paws, mango, banana, avocado
- Peaches, apricots, plums
- Oranges, naartjies, lemons
- Guavas
- Butternut, pumpkins of various types

We want to grow a range of fruit, so that there is fruit to eat throughout the year.

Figure 2.12 Tree tomatoes

Drying of fruit and vegetables

Processing of food in this way helps to ensure continuity of food supply. Dried vegetables can be stored for two years or more before being used.

A system of drying racks made with and covered with shade cloth/ hale netting is suitable for drying fruit and vegetables. Drying of almost anything is possible!! (Pioneered at Dundee Agricultural Research Station).

Top Right: racks with tomatoes, brinjals, naartjies, green, red and yellow peppers drying.
The vegetables and fruit are covered with a layer of netting for hygiene reasons

Bottom Right: Bottles of dried vegetables; including from left to right; Peppers, sweet potato, ground chillies and brinjals.

Figure 2.13 Drying of fruit and vegetables

When considering good nutrition, continuity and processing of food, we also want to create as much diversity in our gardens as possible. In Module 6 we will learn more about food processing and managing food resources. Diversity ensures a natural balance in the garden. We want to create a living soil, use water efficiently and minimize pest and disease attacks on crops.

2.3.3 Consider crop mixes

One way in which to contribute towards achieving higher yields, healthy vegetables and happy household members, is to use good planting practices. By good planting practices we mean mixed cropping / inter cropping and or crop rotation.

What is mixed cropping?

Mixed cropping involves planting various crops together in one plot (vegetable garden). Crops can be **rotated.** This means that different crops are planted in the same place at different times.
When planting a number of different crops together we need to consider the following:

1. **Nutrient consumption**: Mix crops together that consume or use different amounts of nutrients. Some plants are heavy feeders and need a lot of nutrients. Some are light feeders and some are nitrogen fixers (they provide nitrogen to the soil and other plants). A good example here is the traditional practise of planting maize and beans together. Maize is a heavy feeder, while beans are light feeders that also fix nitrogen in the soil.

2. **Root depth:** Plant deep and shallow rooted plants together to ensure that they do not compete for nutrients and water. A good example here is planting maize and pumpkins together. Maize is an upright plant that has a deep rooting system and pumpkin is a creeping plant with a shallow rooting system. They do not compete for space either below or above the ground.

3. **Insect repellent plants:** Some crops have a unique smell that repels some kinds of insects. For example, onion has a specific smell that butterflies dislike. If onions are planted with cabbage, this will reduce the attack from insects. Combinations like onion and cabbage are called *companion plants.* Companion planting is an effective pest prevention measure.

4. **Timing:** Some crops have a longer life cycle than others. It is possible to plant crops that mature quickly in-between crops that take longer to mature. In this way one crop can be harvested while the other crop is still growing and competition is reduced. An example is planting radish, mustard spinach and potatoes together. Radish matures quickly and is harvested within 6 weeks of planting. The leaves of mustard spinach are harvested for 2-3 months. This reduces competition with the potato plants that are now growing large. Potatoes are harvested after 3.5 - 4 months. A combination such as this also includes the aspects of rooting depth, nutrient consumption and insect repellent properties.

5. **Shade tolerance:** When tall crops such as fruit trees and other perennial plants are also grown in a garden you need to plant shade tolerant crops. **Comfrey, lettuce** and strawberries are examples of shade tolerant crop plants.

Below are some more examples of mix cropping or companion planting in a vegetable garden.

In the beds

Plant carrots and onions together: Carrots protect against onion fly and onions protect against carrot fly. Carrots root more deeply than onions and are harvested earlier giving the onions the space they need to mature.

Plant cauliflower or cabbage, lettuce, fennel and onion together: This combination gives complete control of aphids and diamondback moth (*shown on the right)* on the cauliflower. It takes into account nutrient consumption, rooting depth, insect repellent properties (onion and fennel), timing and shade tolerance.

Plant tomatoes, onion or garlic and carrots together: This combines insect repellent properties, nutrient consumption, rooting depth, timing and disease control into account. Tomato plants are scattered so that do not touch each other, which reduces the incidence of early and late blight.

Plant swiss chard (spinach) and beans together: This combination takes into account nutrient consumption, rooting depth and disease control on the chard. Planting the chard in alternate rows with beans reduces the incidence of bacterial spot on the chard.

Many different combinations are possible. Below are two more examples:

Left: Swiss chard inter-planted with fennel and garlic chives
Right: A bed with onions, cabbage, lettuce and swiss chard planted together.

Figure 2.14 Crop mixes

What is companion planting?

There are a number of crops that grow well together and some that do not. The practice of placing plants together that grow better together than separately is called *companion planting.* The companion plants have a synergistic effect on each other's growth.

Synergy means that together the plants grow better than they would separately. These relationships can be very complex and many of them are not yet well understood. What we can do as gardeners and farmers is to experiment with different combinations of companion planting and closely observe whether there is a synergistic effect or not.

The tables below show you which crops that can be grown together and those which should not. Other gardeners and farmers have suggested the combinations based on their own observations.

Table 2.5 Plants that grow well together

SOME PLANTS WHICH GROW WELL TOGETHER:

Beetroot	–	Onions
Carrots	–	Peas, Lettuce, Onions, Tomatoes
Onions	–	Beetroot, Strawberries, Tomatoes, Lettuce
Eggplant	–	Beans
Cabbage	–	Potatoes, Beetroot, Onions
Green Peppers	–	All vegetables
Lettuce	–	Carrots, Radishes, Strawberries, Cucumbers
Pumpkin	–	Mealies
Swiss Chard	–	Strawberries
Tomatoes	–	Onions, Carrots
Mealies	–	Peanuts, Peas, Beans, Cucumber, Pumpkins, Potatoes
Sunflowers	–	Cucumbers
Beans	–	Potatoes, Carrots, Cabbage, Most other vegetables




Table 2.6 Plants that do not grow well together

PLANTS THAT DO NOT GROW WELL TOGETHER:

These are some plants which do not grow well together. Try to avoid putting them in the same beds. Try and experiment for yourself.

Beetroot	–	Pole Beans
Onion	–	Peas and Beans
Cabbage	–	Strawberries
Pumpkin	–	Potatoes
Tomatoes	–	Potatoes and Cabbage
Beans	–	Onions
Sunflowers	–	Potatoes

Table 2.7 Advantages and disadvantages of crop mixes

ADVANTAGES of crop mixes	**DISADVANTAGES of crop mixes**
Efficient use of space below and above ground	Looks "untidy"
Reduces and avoids pest and disease build-up in the soil and in the garden	Can make harvesting of crops more difficult
Reduces weeds	Some shading may occur if plants are not spaced well
Covers the soil and uses nutrients in an effective manner. Building of a healthy, living soil is possible.	Weeding can be more time consuming initially, as crops may be scattered, rather than being planted in rows.
Plants support each other in a synergistic relationship that protects against pest and disease attack and increases vigour and growth.	
Efficient use of water	Some plants may be over or under watered depending on their life cycle. For example, some plants may be seeding while others are still growing.

Activity 2.9 Companion planting

Do this activity in groups or on your own in your workbook

Aim

Practice choosing companion planting combinations

Time 1.5 hrs

What you must do

1. Work in groups of 3-5
2. Make a large drawing of a garden with a number of different beds
3. Make a list of all the crops you would like to plant. Include in this list new crops you may want to experiment with (including medicinal species and herbs). Look at the Vegetable planting guide in your resource pack for this module to be sure you are planting crops suitable to the season and area you live in.
4. Add different combinations of crops to your beds, according to the examples given above and the table on companion planting.
5. How does each of these combinations support each other? Is it through nutrient consumption, insect repellant properties, rooting depth, timing, shade tolerance or something else?

What is crop rotation?

Crop rotation is the term used to describe the order of crops grown on one piece of land over several years. If we plant potatoes every year on the same piece of land, this is called mono cropping and it is not rotation. If we grow potatoes one year, beans the second year and pumpkin the third year, then we have a three year rotation. Once we have gone though the rotation, we would begin over again with potatoes.

Crop rotation is a good idea because:

1. It prevents or stops the accumulation (build-up) of insects and diseases. If the same crop is planted some insects and diseases will increase every year. An example is nematodes on tomatoes and Swiss chard. Nematodes are very small worms that we cannot see with the naked eye. They live in the soil and feed on the roots of your plants, damaging them.
2. Different crops use different nutrients in the soil. In this way you do not overuse some of the nutrients, while not using others.
3. The soil can be covered all year round by plants thus preventing soil erosion.
4. Some crops add nutrients such as nitrogen to the soil. Examples are beans, peas, broad beans, soya beans, peanuts, cowpeas, lucerne and clover.
5. There is no build up of specific weeds.

There are a number of different crop rotation systems that can be used.

Below is an example of a system that is easy to use and remember.

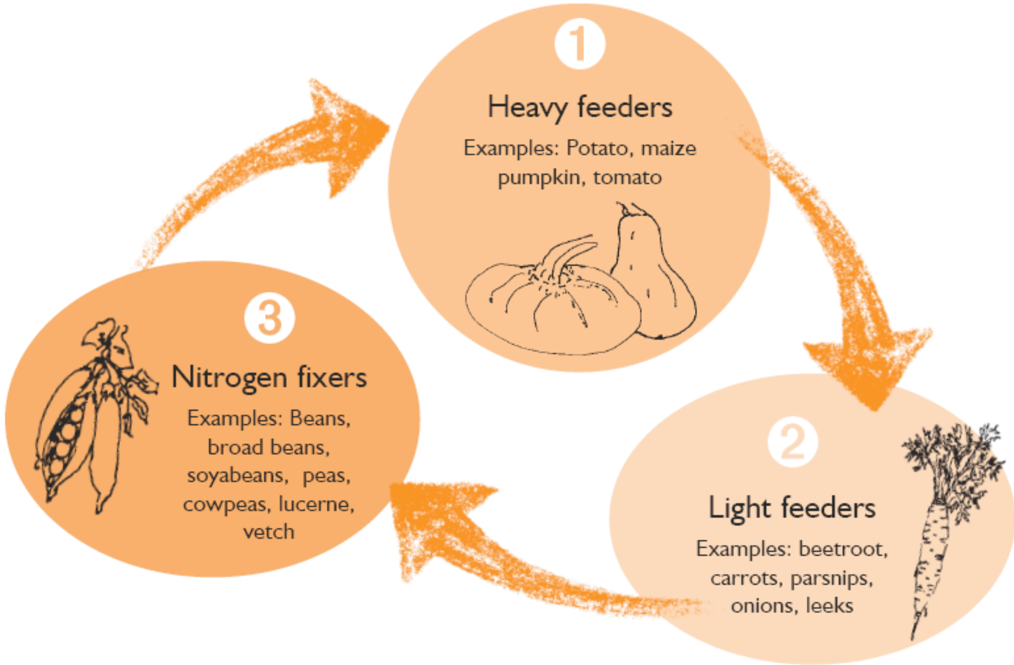


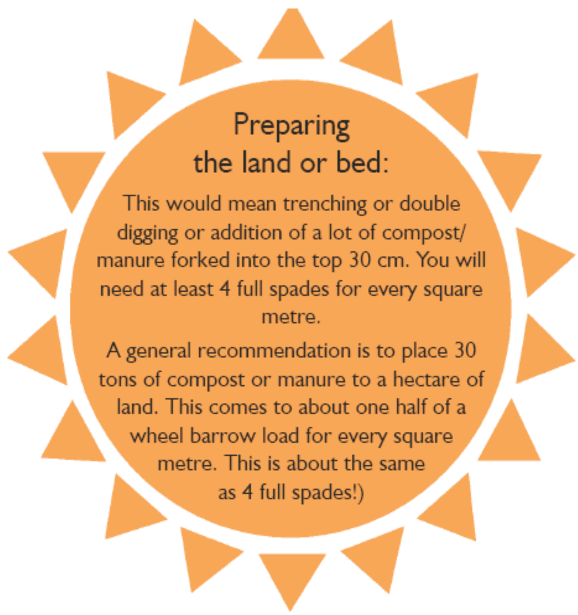
Figure 2.15 Example of a crop rotation system

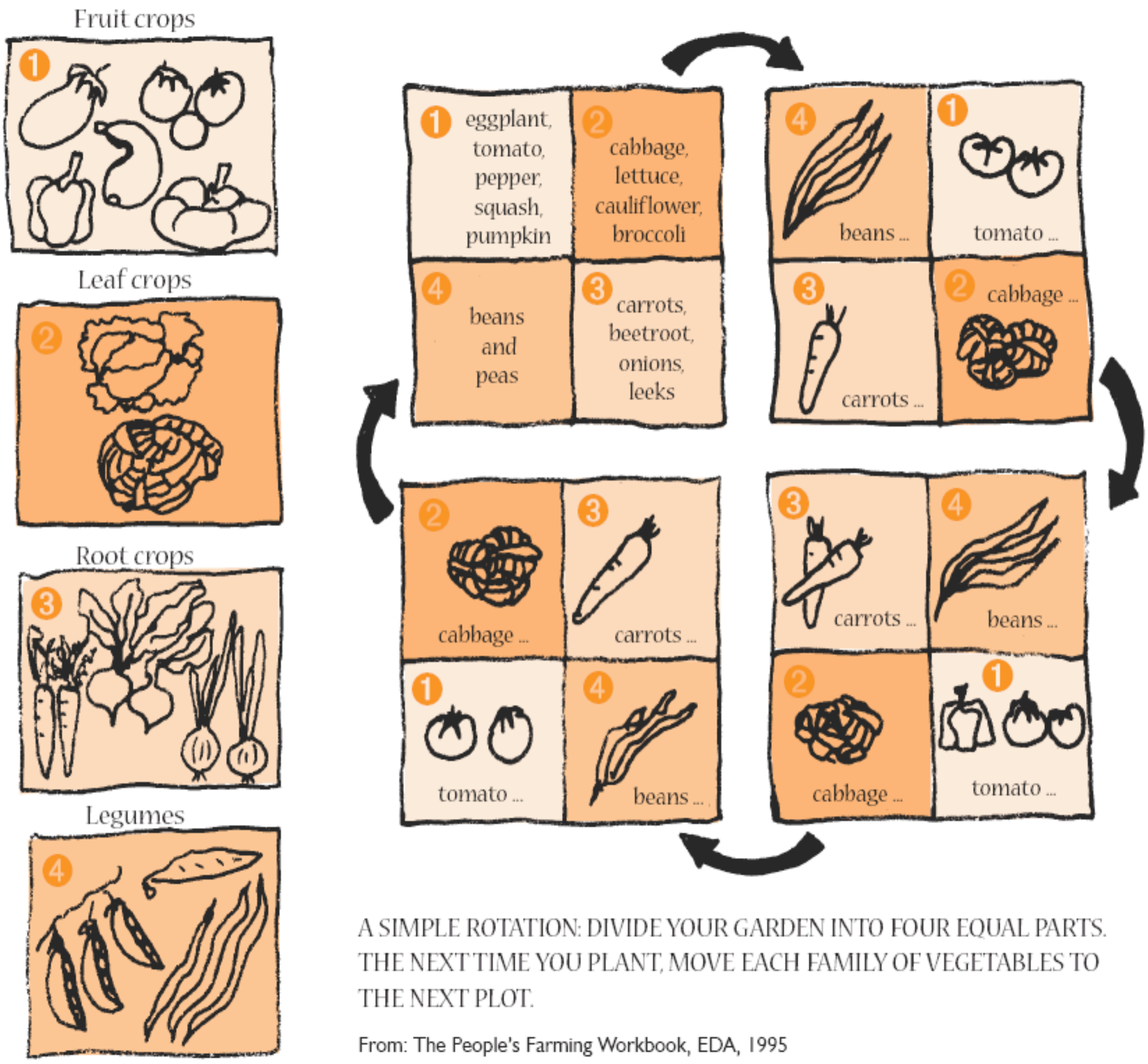
- In the first season after applying compost and or manure, heavy feeders (crops that need many nutrients) or nitrogen consumers are planted.
- In the second season the light feeders are planted
- In the third season legumes (nitrogen fixers) are planted.
- This is followed by another application of compost or manure and the cycle is repeated.

In trench beds, where the organic matter is decaying slowly in the soil, you may want to start with legumes, move on to heavy feeders or nitrogen consumers and then move on to light feeders. This is because during the decaying process plant nutrients will take a while to become available for use by plants. The legumes can fix most of their own nitrogen and are thus a better starting point.

An alternative crop rotation system

An alternative system is presented below:
Prepare the land or bed well. Put a lot of compost or manure in your bed (4 full spades/ square meter). Then start by planting a fruiting crop. These plants need the most food. Leaf crops need less and can follow fruit crops. Then root crops can follow leaf crops without much addition of plant food. Root crops like fertile soil, but do not like fresh manure or compost. It has to be well rotted. Then, nitrogen fixers can follow, with addition of little or no plant food. Then you need to prepare the land well again. Start once more with fruiting crops.





A SIMPLE ROTATION: DIVIDE YOUR GARDEN INTO FOUR EQUAL PARTS. THE NEXT TIME YOU PLANT, MOVE EACH FAMILY OF VEGETABLES TO THE NEXT PLOT.

From: The People's Farming Workbook, EDA, 1995

Figure 2.16 An alternative crop rotation system

Table 2.8 Advantages and disadvantages of crop rotation

We summarise this section with the advantages and disadvantages of crop rotations.

ADVANTAGES of crop rotation	DISADVANTAGES of crop rotation
No build up of pest and diseases	Without a plan, either drawn or written on paper, it is difficult to remember which crop is to follow
Soil nutrients are used effectively	It can be tricky to decide which rotation to follow when inter-planting is also used.
Soil moisture is used effectively	
A healthy living soil can be built up over time	

Activity 2.10 Crop rotation plans

Do this activity in groups or on your own in your workbook

Aim: Practice developing crop rotation plans

Time: 1.5 hrs

What you must do

1. Work in groups of 3-5.
2. Make a list of all the crops you would like to plant. Include in this list new crops you may want to experiment with (including medicinal species and herbs).
3. Now decide which of the two crop rotation systems presented above you would like to use.
4. Design a crop rotation system, using your list of plants and taking into account the different seasons when crops are planted

2.3.4. Plan a planting schedule

Table 2.9 below shows you an example of a planting schedule for vitamin A rich vegetables. The location of the garden and the climate of the area are important factors to consider when planning a garden. Factors to take into consideration are:

- Temperature, rainfall, sun, wind and frost influence vegetable crops. Some crops prefer higher temperatures and other need a cool climate. The planting dates for specific vegetables therefore depend on the climate. (Refer to the vegetable planting guide in your resource packs)
- Vegetables prefer full sun, and need a minimum of 6 hours sun per day.

Table 2.9 Planting schedule for vitamin-A rich vegetables in mild winter areas
(Adapted from Faber, Laurie & Venter, 2006).

Crop (plot sizes in brackets)	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mrc**	**Apr**	**May**	**Jun**	**Jul**
Sweet potato (2.5 X 2.4 m)		Plant cuttings	Plant cuttings	Plant cuttings	Plant cuttings	Plant cuttings						
Carrot (2.5 X 1.75 m)	Sow seeds	Sow seeds	Sow seeds	Sow seeds			Sow seeds	Sow seeds	Sow seeds	Sow seeds	Sow seeds	
Spinach (2.5 X 1 m)	Plant seeds	Plant seeds	Plant seeds	Plant seeds			Plant seeds	Plant seeds	Plant seeds	Plant seeds		
Butternut (2.5 X 3 m)	Plant seeds	Plant seeds	Plant seeds	Plant seeds								

You will have to work out your own planting schedule for your area. (You will do this in Unit 3 of this module).

2.4 Finalize your food garden design plan

In Unit 3 of Module 3 (Natural Resource Use) you designed a draft plan for a homestead food garden, taking low input principles (LEIF) into consideration. The following table serves as a summary of all the steps you should follow when you start and maintain a food garden. This is the focus of unit 3 of this module as well.

Your main task in this section is to finalize your food garden design plan, by also incorporating the important decisions you made in the section above.

The large column of Table 2.10 below shows you the steps you need to take and general information about each step. The small column shows you the module number and unit number where you can get more information on the topic.

Table 2.10 Steps for starting your food garden

Steps for planning your garden	Where to find information
Step 1: Ensure that appropriate inputs and equipment are available The following are needed: • Natural resources e.g. soil and water; other resources e.g. labour, time and finances • Basic tools e.g. a spade and garden fork for digging, a rake for seedbed preparation and levelling the soil, a hoe for weed control • Agricultural inputs e.g. seed, manure; organic materials for plant protection	Module 3
Step 2: Determine the size of the garden A vegetable garden with a size of 10m X10m to 10m X 15m is usually big enough to supply a household of 6 to 8 people with a range of vegetables and fruit. It takes at least three hours a week to maintain a 10m X 10m garden and four hours to maintain a 10m X 15m garden, excluding sowing, planting and harvesting.	Module 3 and 5

Step 3: Decide on the location of the garden Is the soil suitable? Beware of potential drainage problems. Is the soil acidic or alkaline? Use lime for acidic soil. Is irrigation water available? Vegetable crops need at least six hours of sunlight per day. Is the garden close enough to your home? Does the area slope too much? What are the prevailing wind conditions? Consider the aspect of the garden (N,S,E,W) What are the rain water harvesting (RWH) options?	Module 3, Unit 3 Module 5, Unit 2
Step 4: Find information on the climate of your area Determine the average winter and summer temperatures, annual rainfall, relative humidity, does the area receive frost in winter? Is the area very windy?	Mod 3, Units 1,3 Module 5, Unit 2
Step 5: Plan the layout of the garden Make a sketch of the garden to scale and divide it into plots. Make sure that the paths between the beds are wide enough for easy movement of people and implements. Include RWH, planting of trees (fruit and other) and your mixed cropping system (companion planting or crop rotation)	Mod 3,Unit 3 Module 5, Unit 2
Step 6: Fence the garden Fencing is important especially if there are animals like chickens and goats in the vicinity, as they can cause a lot of damage to the garden. It is possible to use local poles and thorny brush if wire is not available.	
Step 7: Prepare the soil Before a crop can be planted the soil needs to be prepared properly. This is necessary to ensure that the conditions are favourable for seed germination and establishment, root penetration, and water retention and drainage. Clear away any obstructions like stones, etc. Remove all the weeds. Decide on the bed designs to be used. Collect materials such as manure, grass, ash, green material such as weeds etc to prepare the beds.	Mod 3,Unit 3 Module 5, Unit 2 Resource pack: ‘Make Good Soil” ‘Compost; Nature’s fertilizer” ‘Bed Design”
Step 8: Choose and plant the crops Choose crops with high nutritional value.	Mod 5,Units 2, 3 ‘Vegetable planting guide”
Step 9: Apply mulch Organic material such as grass or old dry crop material should be spread over the bare soil to reduce erosion and conserve water.	Mod 3,Unit3 Mod 5, Unit 3

Step 10: Weed your garden Keep the garden free of weeds at all times. Weeds compete with your vegetables for soil nutrients and water.	Mod 5,Unit 3
Step 11: Irrigation Water your garden well after planting or sowing. Keep the soil moist during seed germination and establishment. Practice good water management, i.e. water when necessary and at the right time (not during the hottest part of the day). Make use of grey water and water harvesting.	Mod 3, Unit 3 Module 5, Unit 3
Step 12: Control pests Make sure that you have correctly identified the pest or disease before controlling them. You could be wasting resources and time by using the wrong measures. Sometimes nutrient deficiencies are mistaken for diseases.	Mod 5, Unit 3
Step 13: Harvest During this step you can now enjoy the fruits of your hard labour!	Mod 5 Unit 3 Mod 6, Unit 2
Step 14: Store your harvest You need to ensure that your harvest is protected against fungi, bacteria, insects and other threats.	Mod 4 Unit 3 Mod 6, Unit 2
Step 15: Keep records Keep accurate records of planting dates, emergence dates, the date of the first and last harvests, yield, and quality of the crops, fertilisation, pests and diseases. This information is important and will help you to improve on any mistakes and to help with planning for the next year.	Mod 5 Unit 3 Mod 6 Unit 3

Activity 2.12 Finalizing your design plan for action

Complete this activity on your own or in groups in the workbook

Aim:
Linking all aspects of garden design in order to put your plan into action

Time: 3 hours

What you must do

1. We have now examined everything that is needed in order to start a successful food garden.
2. Table 2.10 (Module 5, Unit 2 - above) gives you detailed information on the steps you need to follow to start your food garden.

3. Use the information in your previous modules, as well as table 2.9, to complete the table in your workbook. You need to indicate how YOU would go about planning your garden, following all the steps.

Steps for planning your garden
Step 1: Ensure that appropriate inputs and equipment are available Supply the information for your situation.
Step 2: Determine the size of the garden Supply the information for your situation.
Step 3: Decide on the location of the garden Supply the information for your situation.
Step 4: Find information on the climate of your area Supply the information for your situation.
Step 5: Plan the layout of the garden Supply the information for your situation.
Step 6: Fence the garden Supply the information for your situation.
Step 7: Prepare the soil Supply the information for your situation.
Step 8: Plant the crops Supply the information for your situation.
Step 9: Apply mulch Supply the information for your situation.
Step 10: Weed your garden Supply the information for your situation.
Step 11: Irrigation Supply the information for your situation.
Step 12: Control pests Supply the information for your situation.

Concluding remarks

Congratulations! You have travelled three quarters of the road towards enhancing food security in households. This journey started in Module 1 and has prepared you in various ways to reach the point where you can guide households to finalize and implement a design plan for a food garden. With dedication from yourself and the household members, the seeds sown will grow into vegetables which will provide them with food on a continuous basis and food that is wholesome and nutritious. The next unit will examine the various ways to maintain the garden that you have developed not without sweat, but with great enthusiasm.

Some examples of different beds

Left: Preparing a keyhole garden in Steelpoort Limpopo (Adapted from Kruger, 2010)

Right: Doing double dinging in a garden in Steelpoort, Limpopo. (Adapted from Kruger, 2010)

Left: Packing a deep trench bed with layers of dry matter, manure, ash and soil in Qumbu, EC. (Adapted from Kruger, 2009)

Right: Filling a tower garden with the soil, ash and manure mixture after constructing the central column of small stones in Qumbu, EC (Adapted from Kruger, 2009)