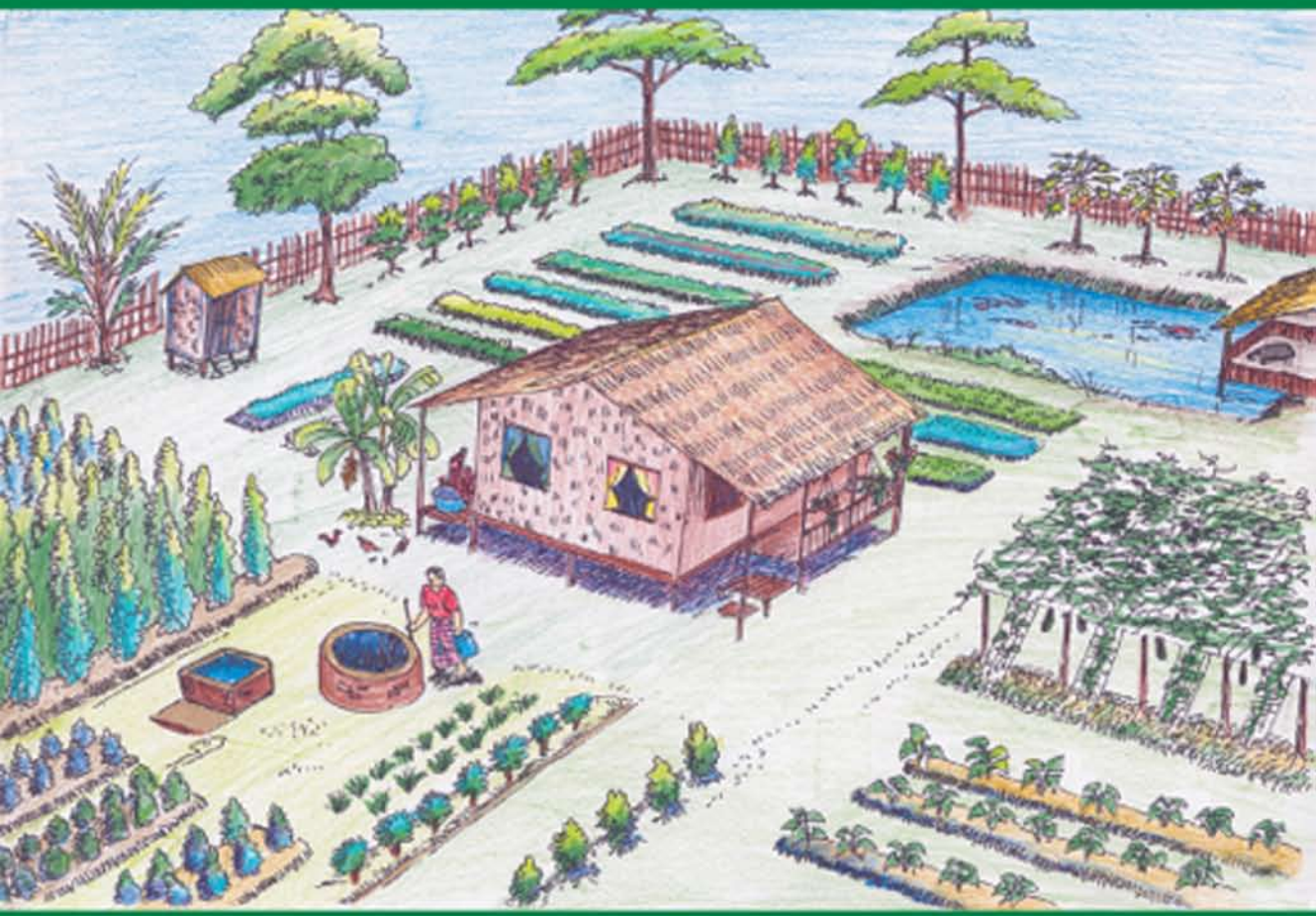
CAN
HANDBOOK

COMMUNITY AGRICULTURE NUTRITION
CAN



David Saw Wah

CAN HANDBOOK

English Edition

David Saw Wah

2007

Community Agriculture and Nutrition - Handbook

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About this Handbook

This Handbook is designed for both farmers and students to use in the field and during training. It is divided into eight sections, each one containing several topics and all illustrated with large clear pictures. The Handbook can be read from beginning to end or each topic can be read separately. Space is provided for readers to take notes and to add their own local knowledge.

Name: Date:

Location:

Introduction

Our people have always been farmers. Farmers of the river lands, of the mountains, and of the forests. Due to civil war in Burma, more and more of us have migrated from our native lands and many now live in refugee camps along the Thai-Burmese border.

The Royal Thai Government, its citizens, and non-government organisations have been very generous in their support to us. We have food, shelter, health care and education, and for this we are very thankful. But while we have been living in refugee camps we have slowly been losing our heritage, our wisdom, and our ways. For our children, rice comes from a warehouse, not grown on our own land by our own hands.

In 1999, I asked the organisations that were already supporting us if they could help me look for ways to teach our children about agriculture and to help us live more self-sufficiently. The result of this is now called the CAN Project (Community Agriculture and Nutrition). This Handbook is the latest step in its ongoing development over 7 years with refugees and internally displaced people along the Thai-Burma border.

There are many good books and resources on sustainable agriculture and we have learnt much from them. However refugees are constrained in their agricultural practices due to limited access to land, water and other resources. This Handbook attempts to present a summary of simple adaptations of ideas found in other books, manuals and resources on sustainable agriculture.

This Handbook is not a textbook as such, but a compilation of different subjects for people to pick and choose. We know that it is not complete and I would ask anyone with ideas or suggestions to forward them so we can keep on learning. In the year 2000 I wrote a draft CAN Handbook. Then Jacob Thomson and I wrote the first CAN curriculum in 2001. Since then it has been used in training with nearly 5,000 school children, teachers, villagers, and staff of community-based and non-government organisations. Needless to say, since the first curriculum was drafted, we have had many experiences, learnt many lessons and made many changes.

In appreciation and thanks for supporting me in the development of the CAN Project over the years, as well as for this latest Handbook, there are many people I must recognise.

The first are the villagers and farmers of my own Karenni State. Books can teach us many new ways, but local people have taught me many of the old ways.

Christine Munro (formerly from the Canada Fund for Burmese Refugees) who provided the demonstration garden and seeding funds for the beginning of the CAN Project. Christine recognised that big is not always good, and small is often best.

Steve Thompson (Images Asia) who contributed many ideas and materials that have made the CAN Project possible.

Helen Stannard (formerly from World Education) whose energy and organisational skills helped build the foundation of the CAN Project.

Shimpei Murakami whose book, *Lessons From Nature*, taught me many new lessons.

Glenda Kupczyk-Romanczuk for her kind permission to use her book, *Environment Words,* for many of the definitions and explanations of technical terms used in this Handbook.

Klaus Prinz who, with many decades of agriculture experience in SE Asia, has generously reviewed technical components of this Handbook.

Jacob Thomson (formerly from World Education and the Thailand Burma Border Consortium), without whom this Handbook and the CAN Project could not have begun or been developed. Jacob has been with me since 1999 as advisor and friend.

Thra Yo Shi Ya and Thra Al Ree No (KnDD) who have been a steady influence and kept me on course over many, many years.

There are many other people whose names cannot be mentioned, but their ideas and innovative practices are being used in CAN training with communities within and outside the refugee camps.

Finally, I would like to thank the following organisations for their financial and logistical support of the CAN Project: Canada Fund for Burmese Refugees; Thailand Burma Border Consortium; World Education; International Rescue Committee; Jesuit Refugee Service; Images Asia and ZOA Refugee Care.

This book is dedicated to the memory of Saya Nya Reh, Thra Ba Ko and Thra Po Kwa Gyi, who were key members of the original CAN training team of 2000 and who have since passed away.

David Saw Wah

Karenni Development Department
December, 2006.

Foreword

Food Security is defined as *physical and economic access by all people at all times to sufficient, safe, and nutritious food needed for an active and healthy life. Its essential elements are the availability and utilisation of food and the ability to acquire it.* *(World Food Summit, Rome 2002)*

In early 1999, Mr. David Saw Wah presented to non-government organisations his vision of a project that would enhance food security in refugee and IDP communities along the Thailand Burma border areas. This vision was based on a profound understanding of the context in which refugees in Thailand live: a restricted environment with limited options for sustainable food procurement and livelihoods.

David developed his vision of a community-based agriculture project focusing on appropriate technology to grow nutritious foods in small spaces using local materials. He conducted extensive applied research to determine methods that could be used in this environment, and that could be accessible to all refugees and IDPs.

In collaboration with several NGOs, David developed and conducted training for refugee trainers and communities in the Karenni camps in Northern Thailand. The project has flourished and now is active in most refugee camps along the Thailand Burma border. Furthermore, it is used among internally displaced persons living inside Burma.

In addition to hands-on agriculture training, David included theoretical agricultural instruction and nutrition instruction, and used a series of detailed flipcharts to guide the trainees. From these trainings and materials the Community Agriculture and Nutrition - CAN - Handbook was born.

Over the years, the CAN Handbook has blossomed into a major publication. It provides extensive instruction on how to use proven agricultural techniques for maximum output and nutritional value. The CAN Handbook is a valuable resource for both trainers and end-users alike.

It was with great honour that David asked me to write the nutrition section for the CAN Handbook. I, and all who are familiar with his work, continue to be inspired by David's commitment to enhance food security for refugees and IDPs.

Andrea M. Menefee, MPH RD

Nutritionist, Thailand Burma Border Consortium
December 2006.

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CAN 1

Section 1: Soil

Types of Soil
pH of Soil
Living Soil
Soil Nutrients
Soil for Seed Raising

Soil

There are many different types of soil and it can be difficult to describe all of them. The important thing to know is that all soils are made up of solids, organic matter, air and water. In this topic we talk about solids and four simple ways to describe soils.

Solids

Soils are made up of tiny pieces of rocks and minerals. These are the parents of the soil. Over many thousands of years, erosion and living organisms have broken down the rocks into smaller pieces (particles). Depending on the size, we can divide the particles into sand, silt or clay. Different soils have different characteristics. (See Table on Pg. 3)

Sand: Particles of rocks or minerals that have a diameter between 0.05 mm and 2 mm are called sand.

Silt: Particles of rocks or minerals that have a diameter between 0.002 mm and 0.05 mm are called silt.

Clay: Particles of rocks or minerals that have a diameter smaller than 0.002 mm are called clay.

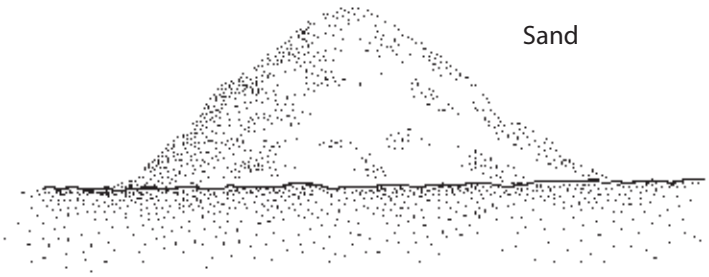


Fig 1.1: Sand

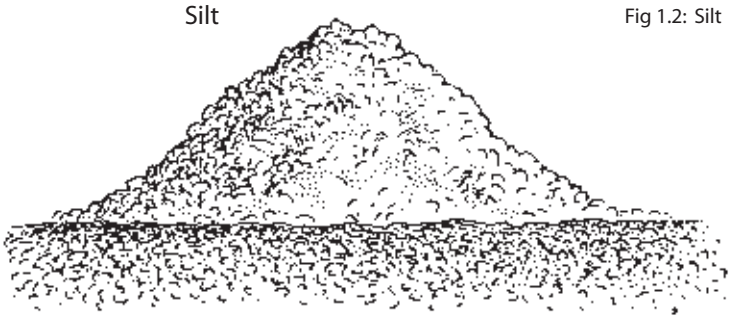


Fig 1.2: Silt

Soil Type	Amount of Sand	Characteristics
Sand	80% - 100%	• Big particles with large spaces for water and air between them. • The large spaces in sandy type of soil mean that water drains away very quickly. As the water is lost it also takes away organic matter and nutrients. Most types of plants do not grow well in sandy soils.
Silt	40% - 60%	• A balance of particles and spaces for air and water. • Rich in humus. • High water holding capacity. • High in nutrient holding capacity.
Clay	< 20%	• Small particles and small pore spaces. • Low air content. • Good water holding capacity. • Good nutrient holding capacity.
Loam	Generally; 40% sand 40% silt 20% clay	• A good balance of particle size and pore space. • Loose texture. • High air content. • Good drainage. • Good levels of organic matter means good moisture and nutrient holding.

Clay

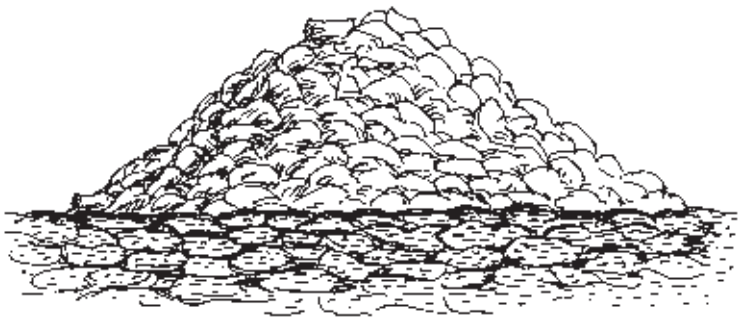


Fig 1.3: Clay

Acidity and Alkalinity

pH is a measure of how acidic or alkaline a soil is. The pH scale is measured from 1 to 14, where 1 is the most acidic and 14 is the most alkaline. 7.0 is the neutral point where there is just as much acid as alkali. (See scale below)

The pH of soil affects what nutrients become soluble in the soil. Soluble means that nutrients are available for plant roots to absorb. Most nutrients become soluble in slightly acidic conditions. Slightly acidic soil also provides a good environment for the micro-organisms that convert nitrogen from the atmosphere into a form that is available to plants. Slightly acidic conditions are also preferred by organisms that decompose plant tissue and make humus. Most crops prefer slightly acidic soils with a pH between 6.5 and 7.0. There are however plants that prefer more acidic or alkaline soils.

If the pH of a soil is very acidic or alkaline, some nutrients become insoluble and can not be taken up by the roots of plants. Other types of nutrients become more soluble in these conditions and can reach toxic levels in the soil. Very acidic or alkaline conditions will also affect soil micro-organisms and their ability to convert nitrogen and break down organic matter.

Measuring Soil pH

It is possible to buy equipment or machines that can test soil pH, but these are usually expensive. In some places, government agricultural officers can test soil for farmers. One of the best ways to find out the pH of soil, however, is to ask older farmers in your area about the soil.

Changing Soil pH

Keeping soil at neutral or slightly acidic pH is an important part of maintaining the health and fertility of the soil. If we believe that our soil is too acidic or alkaline, there are several ways we can improve it:

- *Soil acidity:* This can be reduced by adding crushed limestone, dolomite, wood ash, or egg and snail shells.
- *Soil alkalinity:* This can be reduced by adding organic matter. This is because organic matter contains acidic material and produces acids as it decomposes. Sulphur can also be added to soil to increase acidity.

Overview

As we learnt on page 2, soil is made up of solids, organic matter, air and water. In this topic we will talk about organic matter.

Organic Matter

Organic matter means anything that is alive or has been alive. In the soil this can mean fallen leaves, plant roots, bark, earthworms, insects, fungi, algae, bacteria and many others things. All types of organic matter work together to keep our soil alive.

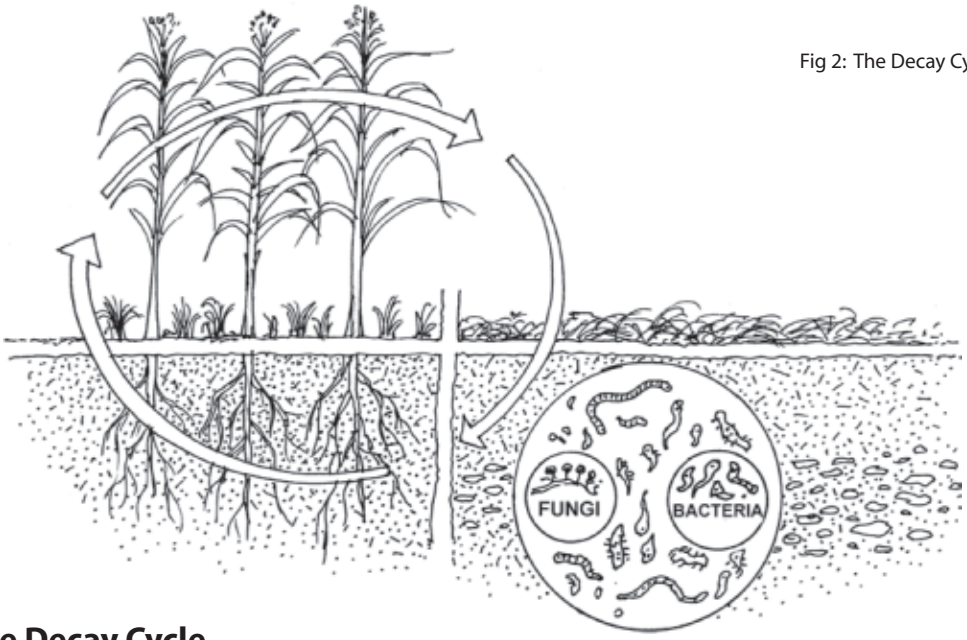


Fig 2: The Decay Cycle

The Decay Cycle

When plants and animals die they are returned to the soil through decay. Decay is the process where things are broken down into very small pieces by water, heat and organisms. In the soil, organisms such as ants, beetles, millipedes, earthworms, bacteria and fungi feed on the dead and dying tissues of plants and other organisms. What they consume is broken down into smaller and simpler pieces for other organisms to use. For example, imagine a leaf falls off a plant. A beetle on the ground then comes and eats some of the leaf. The beetle then produces waste, and bacteria in the soil feed on some of the beetle's waste. An earthworm moving through the soil feeds on some of the bacteria's waste. The same plant that lost the leaf then feeds on some of the earthworm's waste which contains the nutrients it needs for further growth. In this way we can see how organic matter is shared and re-used by many organisms in the soil. In a healthy living soil nothing is wasted.

Nutrients

Plants are living organisms. All organisms must:

- Find and keep a place to live.
- Gather food.
- Compete with other organisms.
- Fight off enemies.
- Resist pests and diseases.
- Reproduce to create new generations.

To do all these things successfully, all organisms need good nutrition to stay healthy. Just as animals need good, nutritious food, plants need good, nutritious soil. In this topic we will look at the nutrients plants need to stay healthy.

Proportion of Nutrients Needed by Plants

Macro-Nutrients		
1	NITROGEN (N)	1.5%
2	POTASSIUM (K)	1.5%
3	PHOSPHORUS (P)	0.2%
4	MAGNESIUM (Mg)	0.2%
5	CALCIUM (Ca)	0.2%
6	SULPHUR (S)	0.2%
Micro-Nutrients		
7	CHLORINE (Cl)	0.1%
8	IRON (Fe)	0.01%
9	MANGANESE (Mn)	0.01%
10	ZINC (Zn)	0.004%
11	BORON (B)	0.003%
12	COPPER (Cu)	0.0003%
13	MOLYBDENUM (Mo)	0.00015%

Macro-Nutrient	Function	Deficiency Symptoms
Nitrogen (N)	• Increases leaf and stem growth and gives dark green colour to plants. • Regulates the use of Phosphorus and Potassium. • Makes plants less susceptible to attack by pests and diseases. • Increases the protein content of some plants.	• Old and sometimes new leaves turn pale and yellow. • Stunted growth. • Sandy soils and some soils in areas with high rainfall usually do not have enough nitrogen.
Potassium (K)	• Increases the resistance of plants to disease. • Produces stiff stalks and stems. • Helps to move food from leaves to roots. • Builds strength and drought resistance. • Increases grain plumpness and growth of fruit and root vegetables.	• The lower leaves have spots and are curled. The edges look like they have been burned. • The stem of the plant is weak and can bend easily. • The fruit is small and shrivelled. • The plant suffers from diseases and insect attacks.
Phosphorus (P)	• Makes plants more drought resistant and hardy. • Quickens maturity. • Helps seed and fruit formation. • Increases legume growth and helps legume nodule formation. • Stimulates root formation.	• Leaves look dull and have yellow edges. • The undersides of leaves and the stems have a purple colour. • Plants do not flower or fruit well.
Magnesium (Mg)	• Helps plants build chlorophyll. • Important for the take up of nitrogen, phosphorus and sulphur. • Helps manage water levels within plants. • Used in the process of building proteins in plants.	• Leaves are pale between the veins and can have a purple or red colour. They are thin, curled and can be easily damaged. • Small branches on trees are weak and have brown spots.
Calcium (Ca)	• Needed by plants to take up nitrogen. • Used in the process of building proteins in plants. • Helps plants mature and produce good levels of seed.	• Leaves are curled and bent and can have an unusual dark green colour. • The buds of flowers do not develop well and drop off too early. • The stem of plant is weak and can bend easily. • The roots of the plant do not develop properly.

Sulphur (S)	• Important for proteins and vitamins. • Helps plants take up nutrients such as potassium, iron, calcium and magnesium.	• Pale or yellow leaves, especially for new growth.

Micro-Nutrient	Function	Deficiency Symptoms
Chlorine (Cl)	• Important for photosynthesis.	• Restricted root growth. • Leaves turn brown, wilt and die.
Iron (Fe)	• Gives plants their deep green colour because it is used to build chlorophyll. • Needed to carry oxygen within plants.	• New shoots and tips die back starting from the top. • Leaves are pale or do not fully develop. • Small branches die back or have brown spots. • Fruits can have a sour taste (onions are very soft).
Manganese (Mn)	• Helps plants build chlorophyll. • Used to build vitamins. • Helps plants use nitrogen and carbohydrates.	• Leaves are discoloured and have dead spots. • Buds do not develop properly and drop off early. • Small branches die back or have brown spots.
Zinc (Zn)	• Important for producing seed. • Used in the process of building proteins in plants. • Helps manage water levels within plants.	• Old and sometimes new leaves turn pale or yellow and have rolled edges. • Stunted growth. • Can affect nitrogen fixation in legumes.
Boron (B)	• Important for the development of roots and the formation of fruit and seeds. • Important for water uptake and transport within plants, also important for the transport of starch and sugar. • Used in the process of building proteins in plants.	• Leaves turn yellow, but the largest veins stay green. • Stems are short and thin. • Can reduce a plant's ability to take up other nutrients.
Copper (Cu)	• Helps plants make chloro-phyll for photosynthesis. • Important for the take up of iron.	• Young leaves have spots and die back. • The plant and fruit develop very slowly. • In tomatoes, leaves and stems can appear blue-green.

Molybdenum (Mo)	• Necessary to allow bacteria around plant's roots to take nitrogen from the air. • Used in the process of building proteins in plants.	• Leaves are thick, curled and can be easily damaged. • Buds die early. • Short stems. • Fruits and roots are discoloured, have strange shapes and can be cracked. • Can affect nitrogen fixation in legumes.

NOTES

Soil for Seeds

Good healthy soil is very important for good germination and healthy seedlings. Soil for seeds must have a good balance of air, water, organic matter, and nutrients. In this topic we will talk about how to make good seed soil.

When growing seedlings to transplant, it is very important to keep them growing strong and healthy. Strong transplants will increase yields.

A good soil mix for seed beds is *one* (1) part sand to *three* (3) parts topsoil. If compost or well-rotted manure is available, some should be added to the mixture or spread on top of the finished soil.

Seeds for transplants can also be sown in well-prepared seed beds that have been smoothed with a rake and have added manure or compost. Seed beds are usually made 1.2 m wide and can be any length. The seeds are sown in rows 10-15 cm apart, across the width of the bed.

Materials:

- 2 parts Compost or sifted dried cow or buffalo manure.
- 1 part Good forest or garden topsoil.
- 1 part Rice husks, saw dust, crushed charcoal, or crushed dried leaves.

Fig 3: Soil for Seeds

Procedure:

1 Collect the materials and put in a place sheltered from rain and strong wind.
2 If we are using dried cow or buffalo manure, we will need to sift this through a basket or screen first. Be sure to have an old cloth or plastic sheet to catch the material as it is sifted.
3 Mix all of the materials thoroughly in a container or on the cloth or sheet.
4 Leave for one hour to settle.
5 Put the soil into the seed-raising container .
6 Pour water over the seed bed. Check to see that water drains out of the soil well.
7 Wait 24 hours before planting seeds.

Note:

After filling the container, some people pour boiling water over the soil (Figure 4). This will kill insect eggs and some diseases that can harm the seeds. Unfortunately, the boiling water can also kill beneficial organisms and so this procedure is recommended only if your soil has experienced serious pest problems in the past.

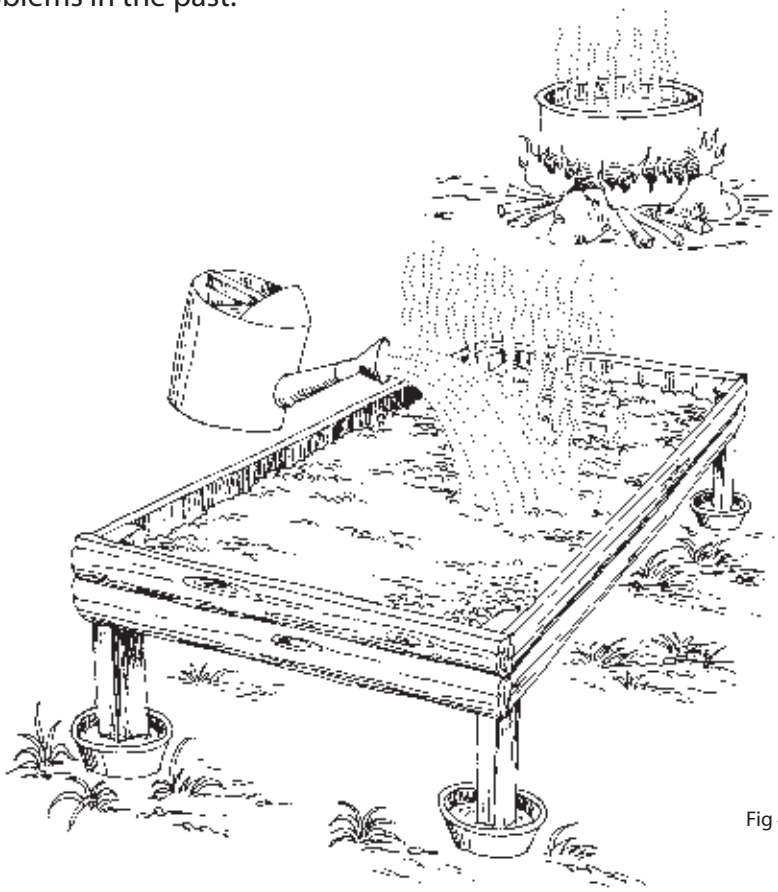


Fig 4: Pouring Boiling Water

NOTES

CAN 2

Section 2: Seeds

Seed Raising Containers
Banana Fibre Pots
Selecting and Saving Seed
Germination

Seed Raising

The early stages of a plant's growth determine how well it will develop and survive in the future. Healthy young plants have a better chance of becoming healthy mature plants with good yields. Seed raising beds and containers help to manage light, heat and moisture levels to increase the chance of healthy seedlings. Many types of plants can be grown in beds or containers until they are mature enough to be transplanted to the field or the garden.

Seed Beds

Seed beds are garden beds that are specially prepared for raising seedlings for transplanting. The soil is best made of one part sand to three parts topsoil, with compost or well-rotted manure added to improve fertility (See Section 1: Soil). Seed beds are best made near homes so that they can be managed easily, and should be no more than one metre wide so that it is not necessary to walk on the soil surface.

Seed Box

A seed box is a special container for growing seeds. Germination and care of seedlings is usually easier in a seed box.

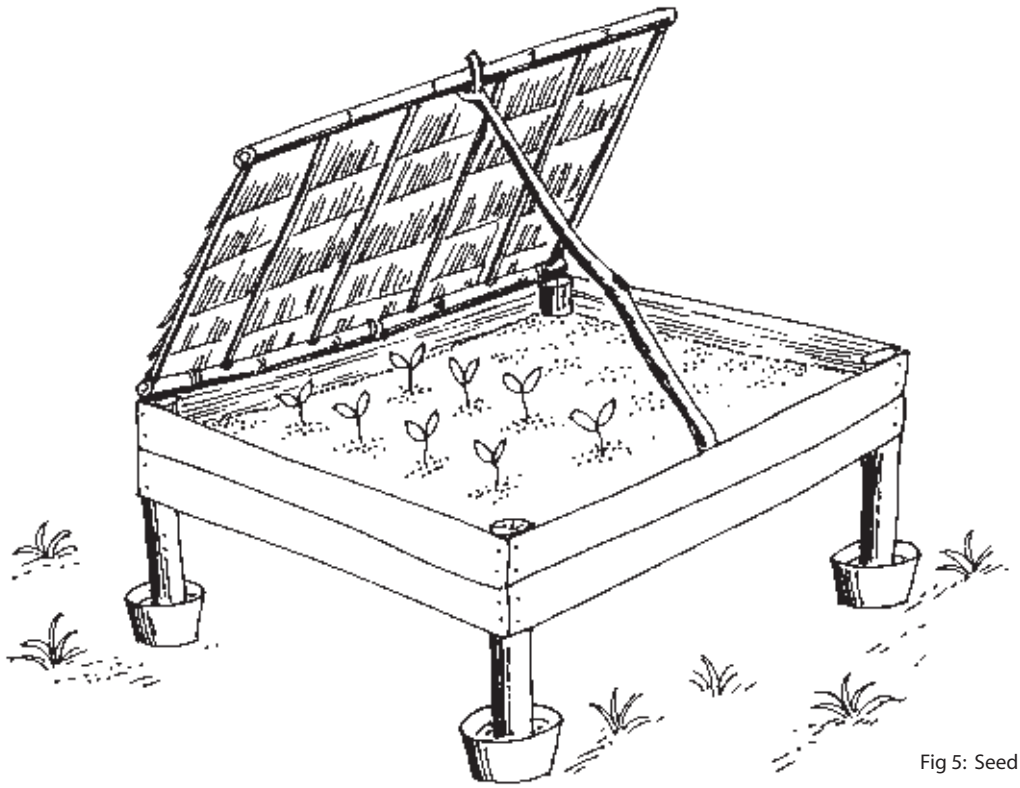


Fig 5: Seed Box

The seed box in Figure 5 has a lid that makes it easy to cover and protect the seeds from hot sun and heavy rain. The bottom of this seed box can be made from split bamboo. The gaps between the bamboo will allow water to drain out of the box. The bottom is covered with rice straw or dried grass to stop soil from falling through. The seed box is about 8-10 cm deep so that there is enough soil for seedling roots to develop. A seed box 0.5 x 1.0 m is enough for a large vegetable garden.

It is better to keep seed boxes above the ground. This makes it easier to control fungus that can damage your seeds. Seed boxes can be put on tables, shelves, or hung from trees. We can stop ants climbing up into the box and eating the seeds if we stand the legs in tins of water.

Other Types of Seed Raising Containers

If we do not have the materials or space to make a seed box, we can use many different types of containers instead (Figure 6). Always remember:

1 Be sure to clean the container thoroughly before using it.
2 Be sure to put enough small holes in the bottom of the container to let water drain out.
3 Always try to use good soil or compost in the containers.
4 Make sure the soil is not too shallow or the seedlings' roots will not have enough space to grow.

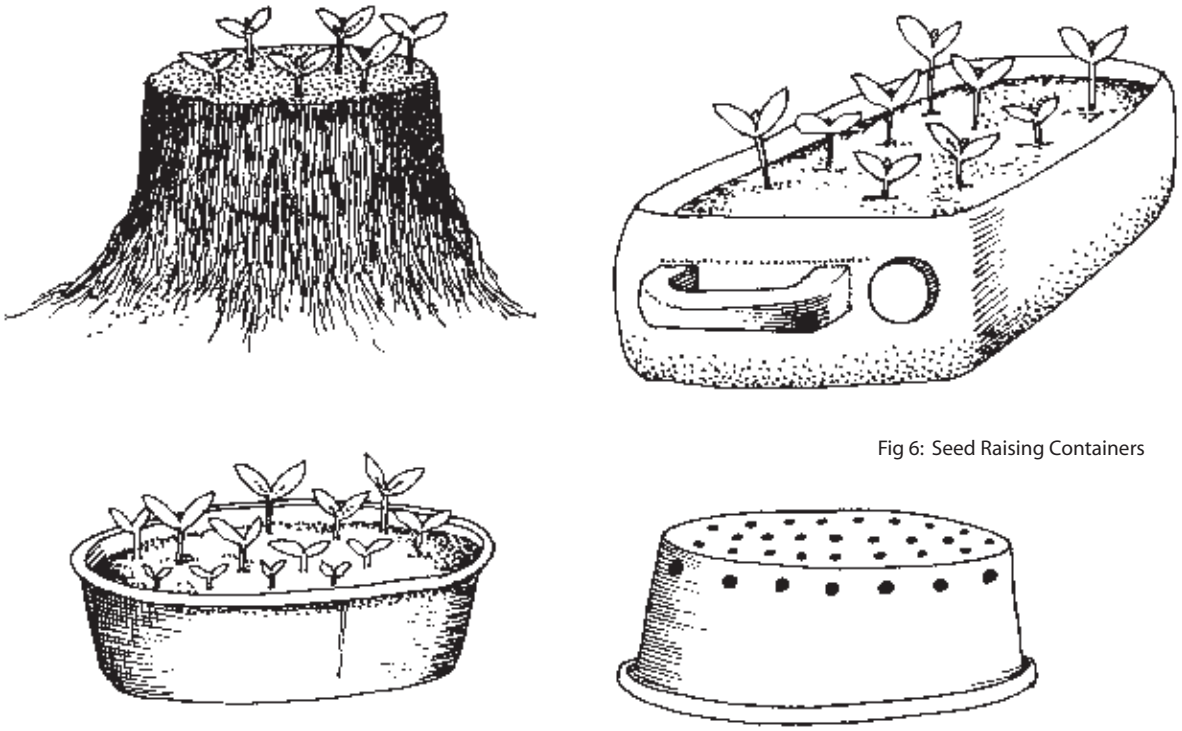


Fig 6: Seed Raising Containers

Spacing and Thinning

It is very important that seeds are not planted too close together. The closer they are, the more seedlings will have to compete for nutrients and water. They will become weaker and be more affected by disease and transplant shock. Different species need different amounts of space.

As they germinate, weaker seedlings should be removed *(thinned)* to provide the healthier seedlings with enough room to grow. Seedlings should be thinned when they have 3 or 4 leaves, and each seedling should have 5-10 cm between it and other seedlings in the bed.

Care and Watering

When seedlings are grown during the hot part of the year, build a simple roof to protect them from being burnt by the sun and to conserve moisture. In the wet season, this roof can also be used to protect seedlings from heavy rain. The roof should give shade and protection, but should not be too thick or the seedlings will receive no sunlight. Simple roofs can be made from old mosquito nets or grass weaving. Seedlings should be slowly exposed to more and more sunlight one week before transplanting.

Seed beds should never be allowed to dry out completely, but should be watered lightly in the mornings and early evenings. Never water during the hottest part of the day (See Section 4: Growing Crops). Over-watering or watering late in the evening at sunset can cause damping-off disease in young seedlings. (This is a fungus disease that likes cool moist conditions). Watering with liquid compost or liquid manure once a week can produce stronger seedlings. Watering should be gradually decreased to harden the plants to prepare them for transplanting.

NOTES

Fibre Pots

The best way to grow perennial plants and trees is in pots. Individual seedlings can stay in pots until they are well developed and are easy to transplant. Banana fibre pots are cheap and simple to make. As the pots degrade in the soil they provide valuable nutrients for growing plants.

Materials:

- Fibre from banana trunks.
- Rope or twine from banana trunks, hibiscus, or any other kind of plant, that will last for at least three months.

Procedure:

1 Collect some fibre from banana trees. Flatten out and dry for two to three days.
2 Once the fibre is dry, soak in water until it is soft again (15–30 minutes).
3 Collect a post or log about 60 cm long with a diameter of about 10 cm. Bury it halfway in the ground.
4 Decide how tall the pot will be and mark this on the post.
5 Cut the banana fibre into pieces four times as long as the height of the mark on the post. (Figure 7.1)
6 Place the fibre over the post. (Figure 7.2)

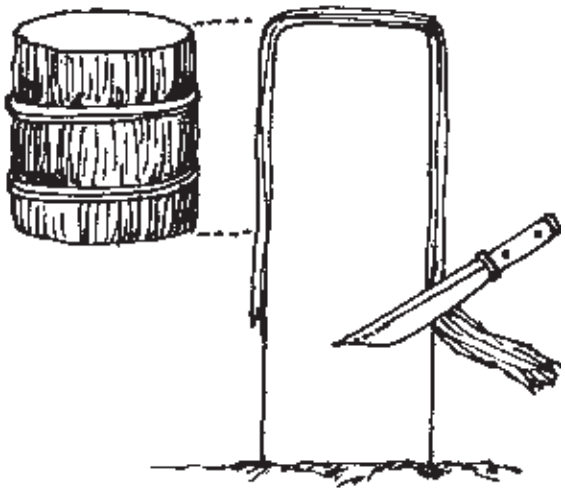


Fig 7.1: Cut Banana Fibre

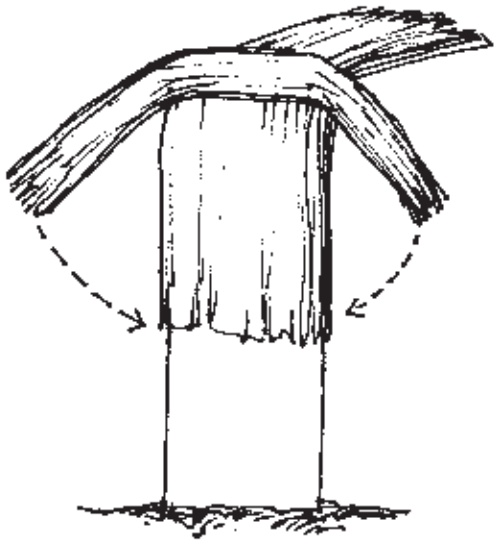


Fig 7.2: Place Banana Fibre

7 Tie the fibre halfway along its length. (Figure 7.3)
8 Fold the fibre upwards but make sure it does not slip or become loose. The bottom of the pot should be flat. (Figure 7.4)

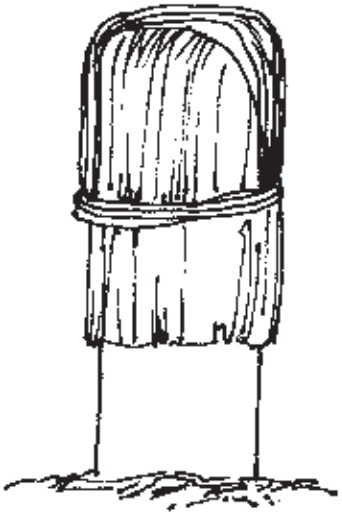


Fig 7.3: Tie Banana Fibre

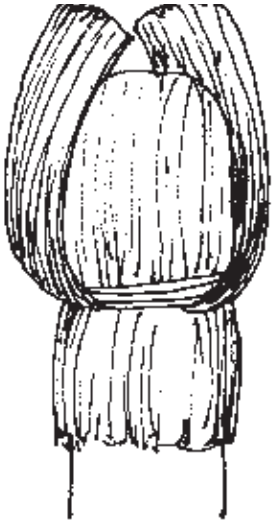


Fig 7.4: Fold Banana Fibre

9 Tie the pot 2 cm from the bottom and again 2 cm from the top.
10 Cut off any extra pieces of fibre and remove the pot gently from the post. (Figure 7.5)
11 On the same day, fill the pot with good seed soil so that it does not loose it's shape. The seeds can be planted later.

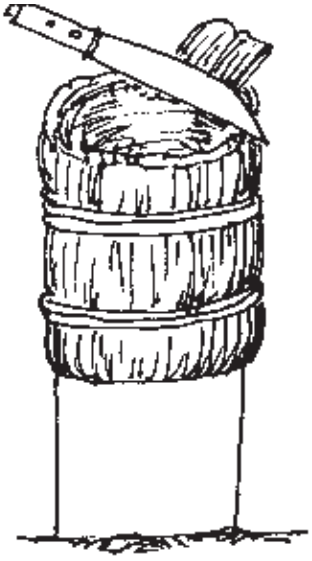


Fig 7.5: Trim & Remove Banana Fibre

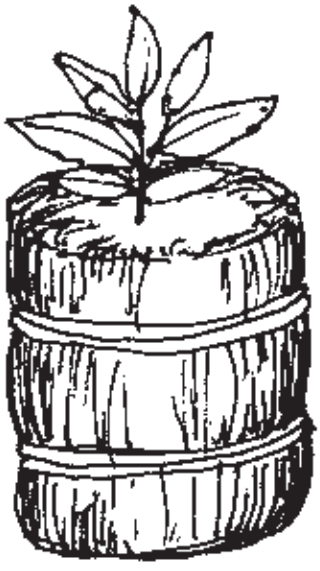


Fig 7.6: Banana Fibre Pot

Overview

Seeds are alive so we need to protect them from damage. We need to be careful that seeds do not rot or are eaten by insects or animals. The best way to save seeds is by:

- Sharing seeds with our community.
- Growing seeds every season.
- Storing seeds in good containers.

In this section we will talk about how to choose good quality seeds and how to store them from one growing season to the next.

How to Save Good Quality Seeds

First we should choose the plants that we want to take seeds from.

1 Choosing and marking seed plants:

Seed plants should be:

- *Strong and healthy:* Choose plants that have good growth and are not suffering from too much pest or disease attack.
- *Good yielding:* Choose plants that have produced large, good quality fruit. Look for fruit that has good shape and colour, and tastes good too.

When you have chosen one or two plants from each species in the garden, mark them with a piece of string or twine. This mark reminds us not to harvest the fruit from these plants because we want to keep the seeds for next year. Make sure to tell your family so that no one harvests the fruit by mistake.

Fig 8.1: Seed Plant

2 Collecting Seeds:

When the plants we have marked become mature, it is time to collect the fruit. It is important that we:

a *Make sure the fruit is mature:* The fruit should look wrinkled and for some species, the seeds should rattle inside when we shake them.

b *Make sure the fruit is dry:* Try to collect seeds in the early afternoon on sunny days. Wet fruit and seeds can rot easily.

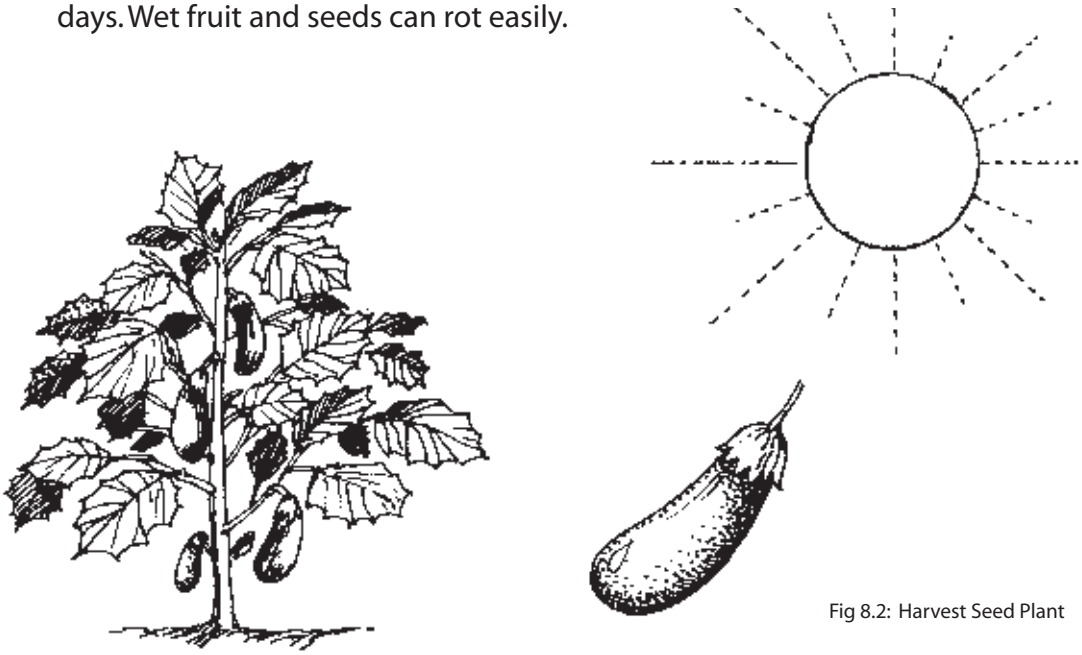


Fig 8.2: Harvest Seed Plant

3 Preparing Seeds:

When we are drying and preparing the seeds we must separate good seeds from bad seeds. We must dry the good seeds as soon as possible to stop them from rotting. Seeds of different species have to be dried in different ways. Preparing seeds that will last for a long time is simple:

a *Harvest the fruit and seeds from the marked plants:* Separate seeds from fruit as soon as possible. Seeds from plants with fleshy fruits like tomato and cucumber must be washed first. Seeds from plants like onion and legumes do not have to be washed.

b *Dry the seeds:* We should dry the seeds in sunlight if we can (Figure 8.3). If we are collecting seeds in the wet season, we can dry seeds by spreading them on a tray and placing it on a shelf above a cooking fire - but make sure they do not get too hot. The seeds will be dry when their coat is hard.

c *When the seeds have dried, spread them out on a tray or cloth:* Separate good seeds from bad seeds. Good seeds have a normal shape, are not scratched or damaged, and show no signs of insect or fungus damage. Bad seeds can be used to make compost if they are put in at the beginning of the decomposition process.

d *Mix the seeds:* When the good seeds have been collected, we should mix them with materials that can stop insect and disease attack. Examples include cold ash from cooking fires, dried neem leaves or crushed seeds, turmeric powder, and dried lemongrass.

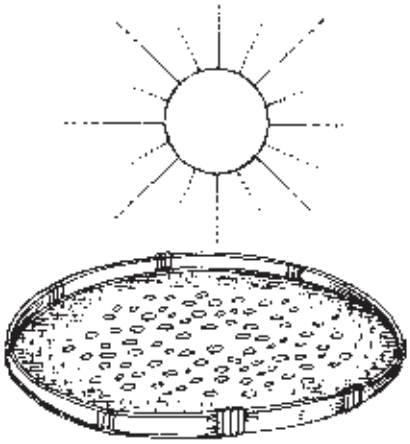


Fig 8.3: Drying Seeds

4 Storing Seeds:

To make them last longer seeds should be kept in a clean, dry, dark, cool place. The best way is to keep seeds in an airtight container in a place that we can check regularly. One way to keep seeds is in bamboo containers:

a Collect bamboo containers. How big and how many depends on what is available and how many seeds we need to store. Choose only mature bamboo and smoke it on a shelf above a cooking fire a few days before use.

b Fill the bamboo container with 1/3 ash or dried, crushed neem leaves, lemon grass, etc.

c Fill the container with seeds until about 3-5 cm from the top. Add more ash or neem to the top of the seeds. Put the lid on.

d Gently roll the container around to make sure the seeds mix well with the ash.

e If available, seal the lid with resin, wax or oil, etc.

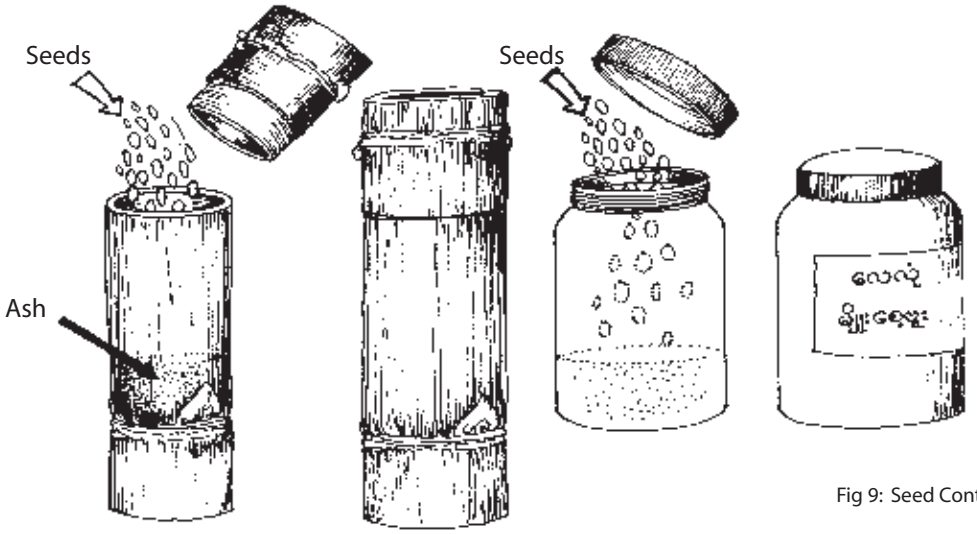


Fig 9: Seed Containers

5 Recording and Labelling Seeds:

It is easy to forget details about the seeds we are storing between growing seasons. By recording and labelling our seeds we can better plan and manage our cropping and reduce wastage. See example below:

Label Information	Sample
Record Number:	KN 9
Type of Plant:	Mung Bean
Collection Date:	29/12/2005
Collection Place:	Yoshiya's Garden
Collector's Name:	Ko Reh
Note:	This seed is third generation

NOTES

Overview

Seeds of different plant species can germinate in different ways. But all seeds need air, heat and moisture for good germination. When preparing for germination we must remember the following things:

1 Seed beds must be carefully planned so that they receive the right amount of sun and shade for the species that is going to be grown.
2 The soil in the seedbeds must be properly prepared. (See Section 1: Soil)
3 Seeds should be pre-treated if needed.
4 Seeds should not be kept too wet or too dry.
5 Seeds should be protected from predators such as birds, ants and other insects.

Pre-Treatment

Some types of seeds need to be treated before they are planted. Pre-treatment makes many species of seeds germinate more successfully and can help ensure strong early growth.

- The seeds of fleshy fruits such as tomatoes should be cleaned before they are stored or planted. If we do not clean them, insects, bacteria or fungi decay the flesh and many seeds could be lost.
- Some other seeds have very hard, thick coats that help protect them in natural situations. But if we want to grow them on our farms, this coat can also prevent air and moisture from entering the seed and reduce germination. For these types of seeds, we can often increase germination by making a scratch in the seed coat with a very sharp knife before we plant them.
- For other types of seeds germination can be increased by soaking them in cold water for 12 hours, or in boiling water for a few minutes.

Viable Seeds

If seeds have been kept for over one season, or if we receive new seeds from somewhere else, it is a good idea to test some of them to see how well they germinate. Seeds that germinate are called *viable*. It is very important to test the viability of seeds are if we are sowing a large garden or field. We can waste a lot of time and energy planting non-viable seeds that germinate poorly. Then it might become too late in the season to plant another crop. In this topic we will talk about two simple ways to test for viable seeds.

Floating Seed Test

This is a very easy and quick way to test for viable seeds. Many farmers use this method to test rice seeds before planting their fields.

Materials:

- A jar or container. Glass or plastic through which we can see is better.
- Water.
- Seeds (one species at a time).

Process:

1 Fill the jar with water.
2 Pour some seeds into the jar.
3 Stir the seeds with a stick or spoon. Separate seeds that stick together. (Figure 10)
4 Keep for five minutes.

Conclusion:

Old or damaged seeds will float to the top of the jar. These seeds should be collected and burnt or used in making new compost.
The seeds that sink to the bottom of the jar will be viable seed. We should only plant the viable seed.

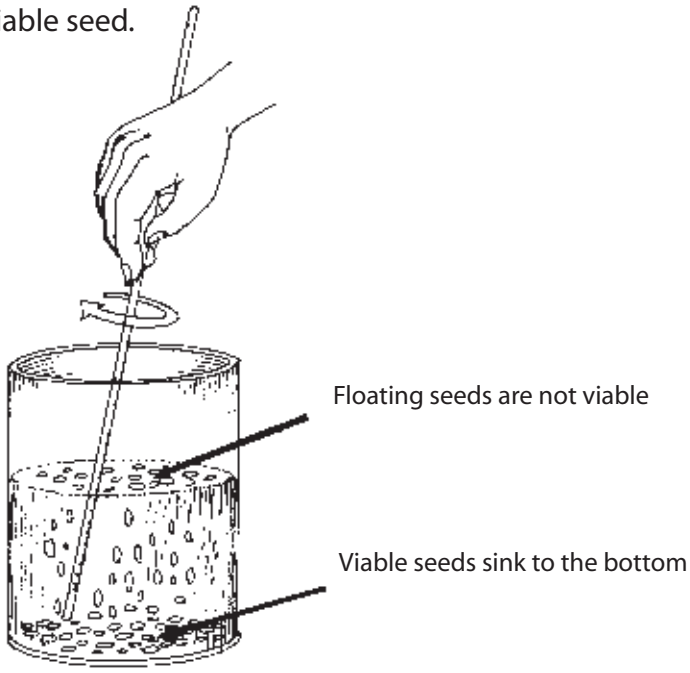


Fig 10: Seed Water Test

Paper Seed Test

The following test takes some time to prepare but it is more accurate than the floating test. It gives us a better idea about how many seeds are likely to germinate and about the health of seedlings. This is a good activity to do with students.

Materials:

- A tray or plastic sheet.
- Paper (tissue paper is best, but we can use plain paper or newspaper).
- Water.
- A small sprayer or something to flick water with.
- Seeds (minimum 25 seeds if possible).

Process:

1 Put the tray or sheet in a shaded area protected from wind and rain.
2 Put two or three sheets of paper on the tray and spray water on it until it is slightly moist. The paper should never dry out, but should not be so wet that it starts to rot.
3 Put the seeds in rows with even spaces (Figure 11.1). If you are using 25 seeds, make five rows of five seeds each. If you are using 100 seeds, make ten rows of ten seeds each.
4 Completely cover the seeds with more paper and wet again. (Figure 11.2)

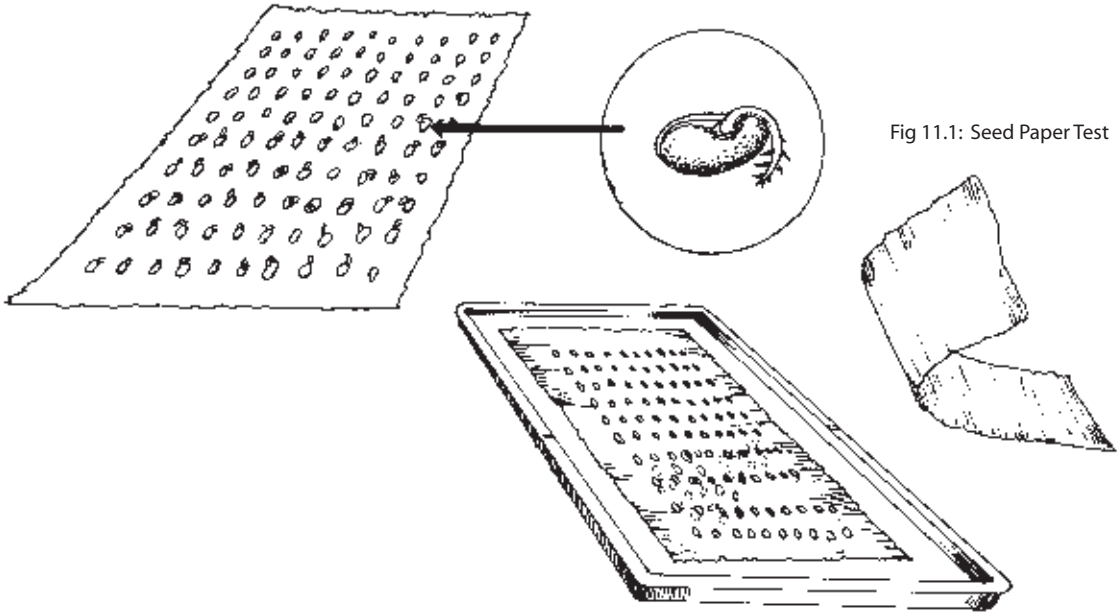


Fig 11.1: Seed Paper Test

Fig 11.2: Place Paper on Top of Seeds

Conclusion:

Check the tray every morning and every evening. Spray more water when needed to make sure the paper never dries out.

Most garden vegetables will germinate in 3-10 days. Every time you check the tray, count and record the number of seeds germinated. Look carefully at how the seeds open and how the roots and first leaves develop. This practice helps us to understand more about the crops we grow.

NOTES

CAN 3

Section 3: In The Field

Selecting A Site

It is not always possible to choose the perfect place to build a garden or farm. But if we do have a choice, the following factors can help us to grow better crops.

- *Close to home:* We do not have to walk far and we can see our plots every time we leave the house. Crops are easier to water, weed, and harvest. It is easier to control insects and disease and to protect crops from animals.
- *A good source of water:* In the dry season, vegetables need water every day. Grow your crops near a pond, a stream, a well, a tap stand, or water jar where you wash. Try not to use an area that floods in the wet season.
- *The sun:* Vegetables need sunlight to make them grow, but hot sun at midday and early afternoon can kill young vegetables and dry out the soil. An area that has some shade for part of the day is the best.
- *The soil:* Clay soil is hard to dig and can become waterlogged. Sandy soil has poor fertility and dries quickly. A dark, good smelling soil will be rich in organic matter. This is the best soil to use but it can not be found everywhere. If a place with good soil is not available, we can improve our soil using raised beds, mulch and compost. (See Section 5: Fertilisers and Pest Control)
- *The wind:* Strong wind can damage taller crops and dries the soil. Try to choose a place that is protected from the strongest winds. If none is available, living fences and alley cropping can be used to form windbreaks. (See Pg. 53: Agro-Forestry)
- *A small area:* The smaller the garden or farm, the easier it is to build and maintain. A small fertile garden around the home can provide nearly all of the fresh vegetables a family needs. It can always be made bigger later.
- *A fence:* In most areas, crops need to be protected from livestock. Chickens, goats, pigs, and buffaloes can cause a lot of damage in a short time. If possible, choose an area that can be easily fenced or has some fencing already. This can save a lot of time later on.

Planning a Site

It is important to have a plan of what you will grow and where you will grow it.

1 General Plan:

a Spend some time walking around the site you have chosen to grow crops. Where does the sun rise? Where is the water source? What part of the land is sloping? What is growing there now?

b Draw a map or picture of the land. Mark north and south. Draw where you think you will build the fence, the gate, the compost pile, the pathways, and the beds.

2 The Crops:

- To use the land efficiently, we also need to plan what crops we will grow and where and when we will grow them.
- In open areas that receive a lot of sunlight we can grow plants like mustards, onion, tomatoes, rozelle, lettuce and beans.
- In shady areas we can grow plants like taro, sweet potato, pineapple and ginger.
- In moist areas around tap stands, water jars, toilets and kitchens we can grow plants like kang kong, lemongrass, and bananas .
- In areas too small for beds we can grow plants like papaya, banana, *Sesbania*, and *Moringa*.
- In rocky areas we can grow all types of vegetable crops in compost bags. (See Pg. 44: Container Planting)
- Along fences we can plant trees like *Leucenea, Gliricidia, Azardirachta,* etc. In about two years these trees will become a living fence. (See Pg. 53: Agro-Forestry)
- Fences, buildings, and mature trees can be used to grow climbing plants like beans, luffahs, bitter gourds, and pumpkin.

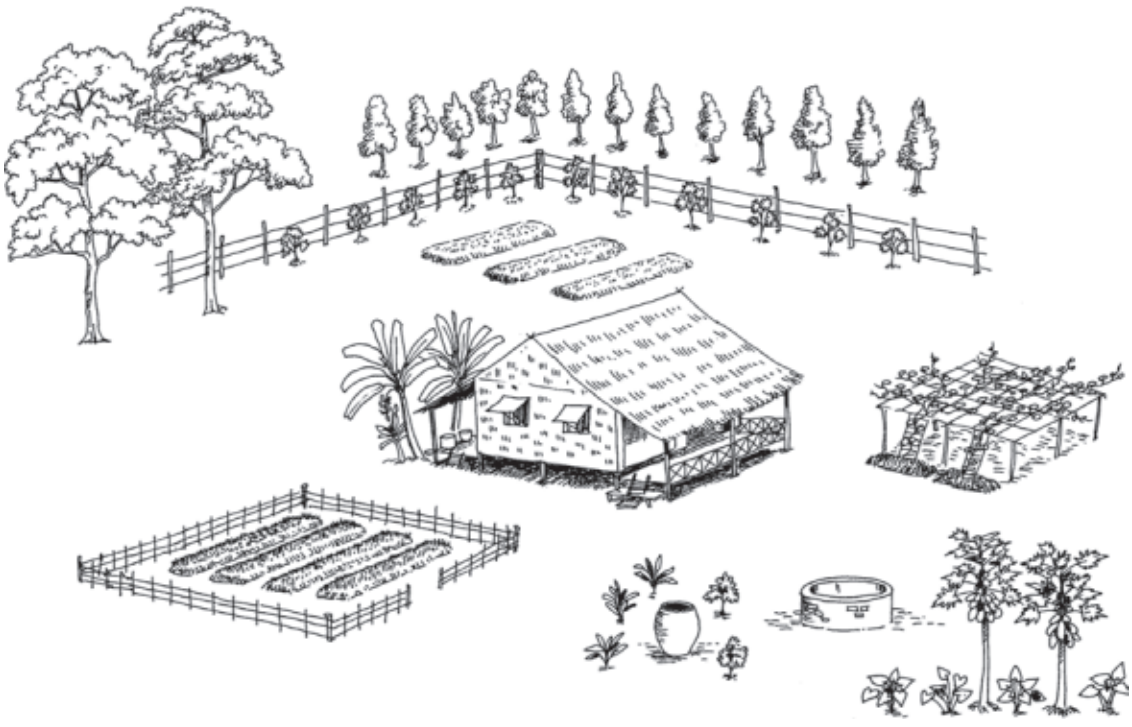


Fig 12: Crop Garden

3 Things to Remember:

- Every space can be used. Different types of beds can be used in different places. Different plants can be grown in different situations. Good fertile soil with enough water can grow crops all year round so that there is always something to harvest.
- Crops grown by your community for many years are adapted to local conditions. They have better resistance to pests and diseases than seed bought from a shop, and people will have experience about how to grow and prepare them.
- Crops that are nutritious and can be harvested over a long time are very important for our health.
- Homes, gardens, farms and forests provide all the resources we need to grow successful crops. There is no need to use chemical fertilisers or pesticides. Using them can damage our environment and our health.

Fig 13: Raised Beds

NOTES

Overview

A raised bed is an area to plant crops that has been raised higher than the surrounding ground. The bed is raised to improve soil fertility, allow good drainage, and to make it easier to manage crops. There are several types of raised beds and they are very important in organic farming systems. In this topic we will explain how to make and maintain raised beds.

Raised Beds and Pathways

- We can use soil, compost and old garden waste to make raised beds. Raising the soil makes it looser and this helps plant roots to spread and collect nutrients. Because the beds are higher than the surrounding ground, it also allows water to drain out easier and this stops the roots from drowning. The beds should be 15 cm to 30 cm tall.
- If we stand on the soil it becomes compacted and hard and this makes it difficult for plant roots and water to spread. To make sure the soil stays loose, raised beds should be between 1.0 m to 1.5 m wide. If the bed is this wide, we can plant, weed, fertilise, control insects, and harvest without needing to stand on the soil.
- Between the raised beds we should make pathways about 0.5 m wide. These pathways give us a place to walk and work. There is no need to waste dry leaves, grass and weeds that we collect from the garden. We can put them onto the pathway along with old rice straw, roof thatch and rice hulls. This organic matter will quickly decay and can be used to fertilise the beds.

Fig 14: Making Raised Beds

Overview

Gardens, farms and forests provide materials that can be used to make simple raised beds. Such things as logs, bamboo, garden waste, leaf mulch and compost can make beds that are very fertile and easy to maintain.

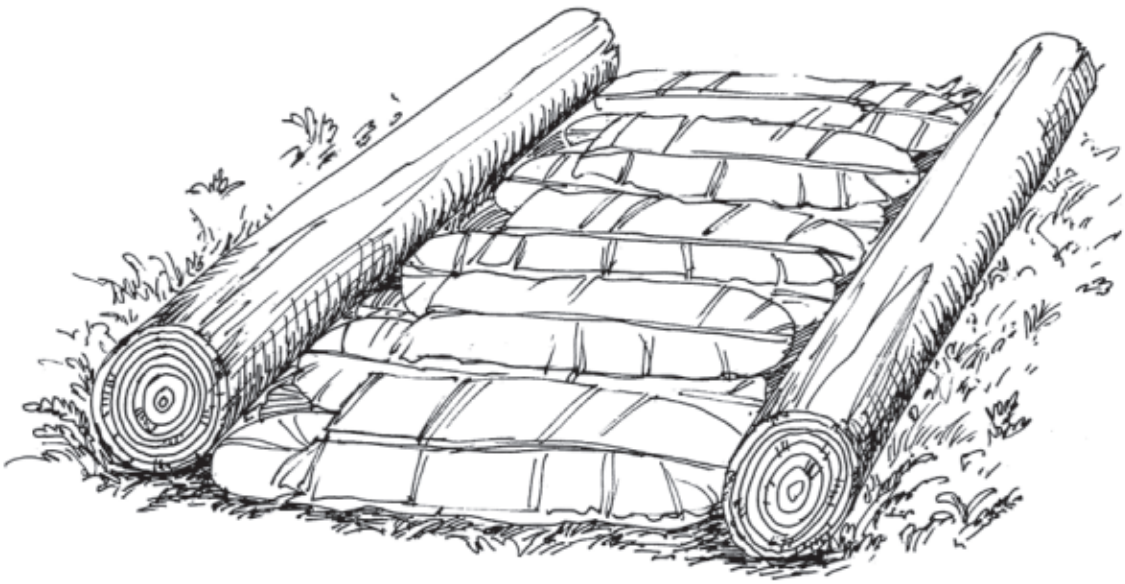


Fig 15.1: No Dig Bed

Logs, Waste and Compost

Beds of logs, waste and compost are very similar to normal raised beds. They should be 15 cm to 30 cm tall and between 1.0-1.5 m wide. There should be pathways between each bed about 0.5 m wide.

1 Choose the site for the bed. Select an area with good sun and not likely to flood. Use logs, stones, bamboo, banana or coconut trunks, etc., to build the sides of the bed. (Figure 15.1)
2 Put down a thick layer of large leaves like banana. This layer should be 5-10 cm thick and will break down to add organic material to the soil.
3 On top of the leaves, put a layer of mulch such as dry leaves, old thatch, dry grass or rice husks. This layer should also be 5-10 cm thick.
4 On top of the mulch, put a layer of compost or rotted manure (5-10 cm). (Figure 15.2, Pg. 33)

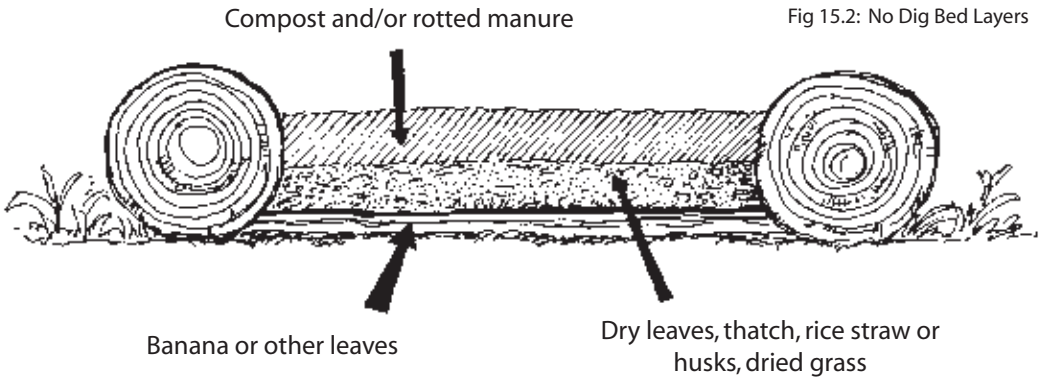


Fig 15.2: No Dig Bed Layers

5 On top of the compost or manure, sprinkle a small amount of cold ash from a cooking fire. Too much ash can be bad for plants, so only use two or three handfuls depending on the size of the bed and spread it very thinly over the surface.
6 If needed, add another layer of compost / manure / leaves, until the bed is full. It is good if the top of the layers is slightly higher than the sides of the bed because the materials will sink as they decay.
7 Add a layer of mulch (See Section 4: Growing Crops) to the top of the bed to prevent rain damage and help conserve nutrients.
8 Water the bed thoroughly. It is best to wait for about one week before using the bed, but slow geminating seeds can be planted after 24 hours if needed.

NOTES

Double-Dig Beds

Overview

Double digging is a way of increasing soil fertility by preparing very deep crop beds. The deeper we dig into the soil, the more nutrients are available for plant roots. Double-dig beds can support many more plants than normal crop beds, so they are very useful in situations where there is not much space for gardens.

In double-dig beds the soil is dug down to at least 60 cm. The hard subsoil is made loose so that plant roots can spread into it and use its nutrients. This helps the plant roots to grow down instead of spreading wide and competing with neighbouring plants. A deep root system also reduces the need for watering because the deeper soil holds water for longer. We can improve the soil's fertility even more by adding manure or compost when preparing double-dig beds.

In double-dig beds plants grow so closely together that they shade the surface of the soil, like living mulch. This keeps the soil cool and moist, and when the plants are large enough, the shade helps prevent weeds from growing.

Procedure:

1 Choose and mark the site for a double-dig bed the same as you would for a normal bed. The only thing to remember is that the soil should not be too rocky. Clay or sandy soils can be used but we will need to add a lot of compost and manure. (Read point 12 on Pg. 38 for how to fertilise Double-Dig beds before you start digging).
2 Dig and loosen the soil down to 30 cm deep, breaking up clods and removing large stones. Level the surface with a rake or the side of your hoe.

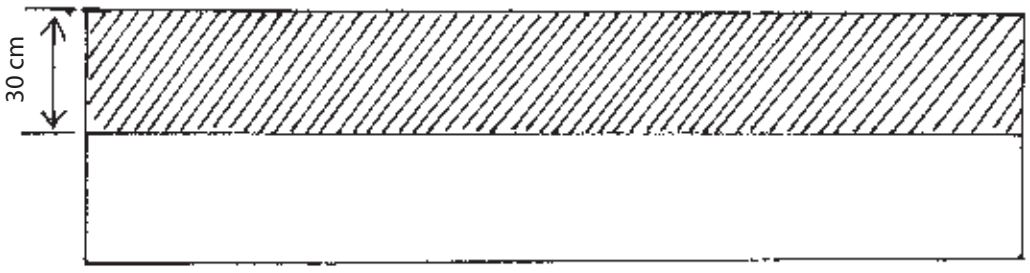


Fig 16.1: Dig and Loosen

3 Spread a 5-10 cm layer of compost or rotted manure evenly over the surface of the soil.

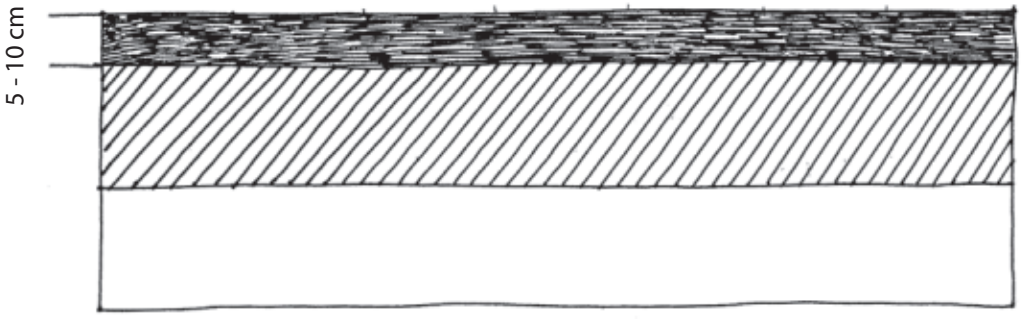


Fig 16.2: Spread the Compost

4 Use bamboo or sticks to divide the length of the bed into strips about 50 – 70 cm wide.

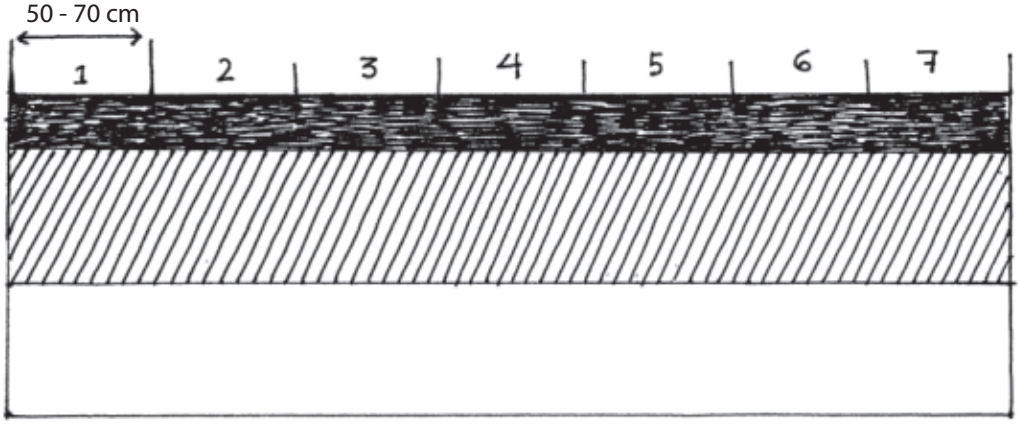


Fig 16.3: Divide the Bed

5 In the first marked section (Strip 1), remove the soil that you have already dug and loosened in Step 2. Carefully put this soil on one side of the bed.

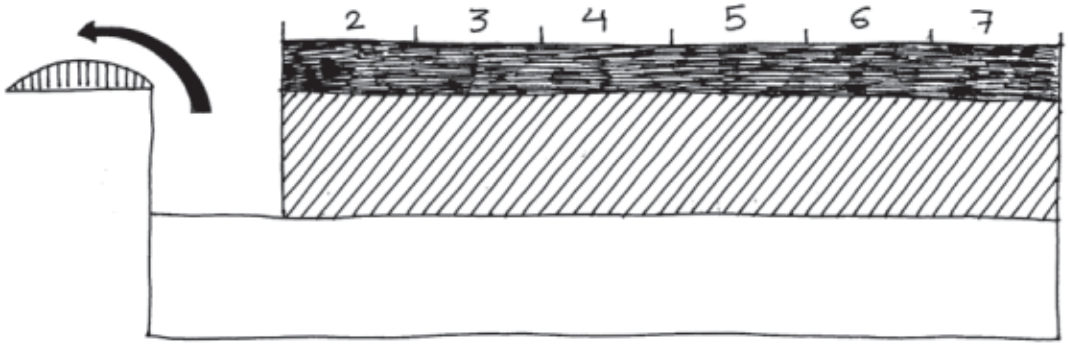


Fig 16.4: Remove the Soil

6 Use a hoe, digging stick or crow bar to loosen the subsoil in Strip 1 down another 30 cm. Do not remove this soil.

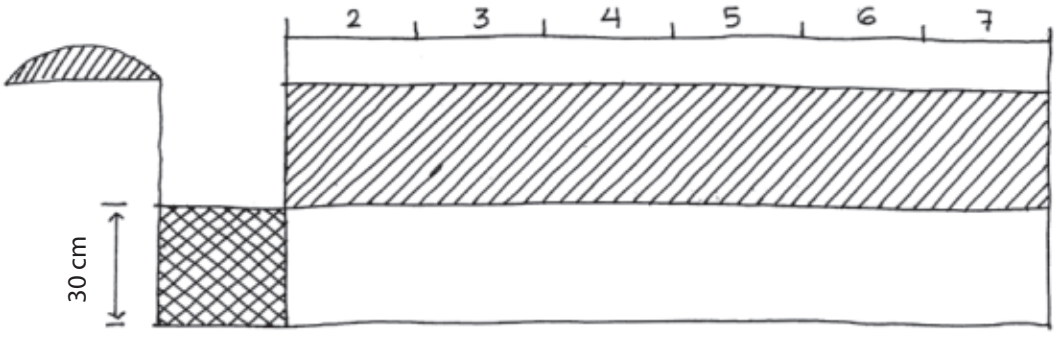


Fig 16.5: Loosen the Subsoil

7 Remove the top 30 cm of soil in Strip 2. Put this soil on top of the subsoil of Strip 1.

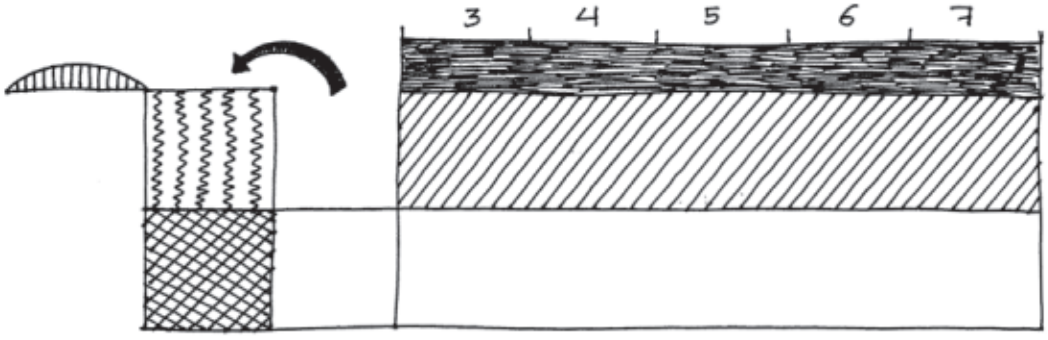


Fig 16.6: Move the Soil

8 Repeat Step 6 above. Use a hoe, digging stick or crow bar to loosen the sub soil in Strip 2 down another 30 cm. Do not remove this soil.

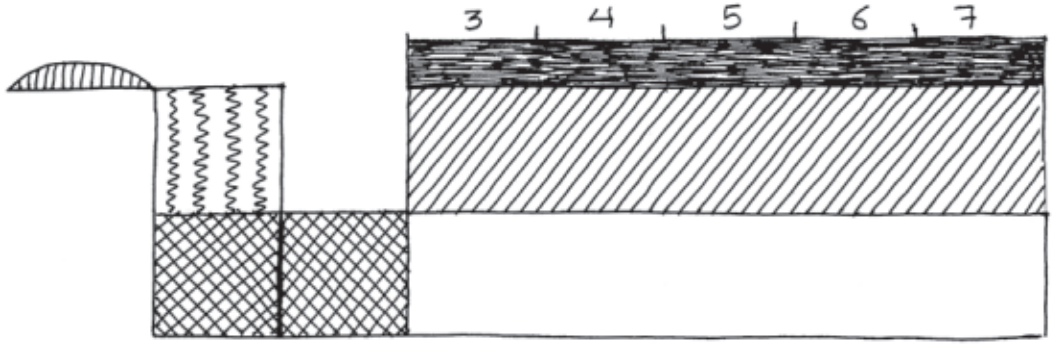


Fig 16.7: Repeat Step 6

9 Repeat Step 7. Remove the top 30 cm of soil in Strip 3. Put this soil on top of the subsoil of Strip 2. Continue this process until you reach the last Strip in the garden bed.

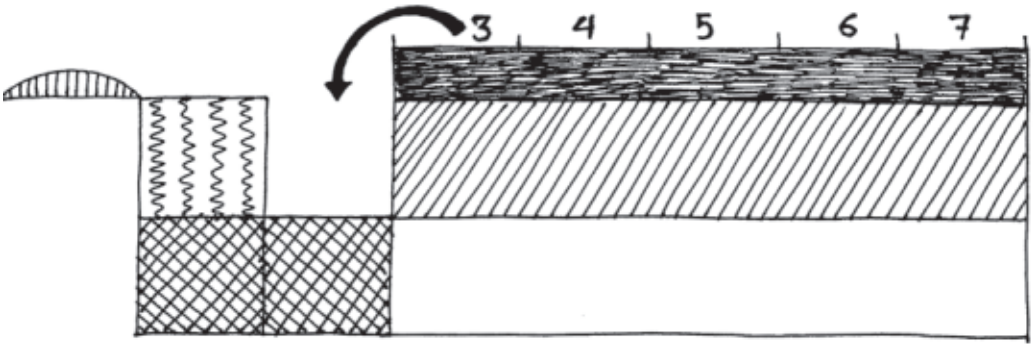


Fig 16.8: Repeat Step 7

10 In the last Strip, dig and loosen the subsoil the same way as in every other Strip. Take the topsoil from Strip 1 that you put at the side of the bed and put it on top of the subsoil in the last Strip.

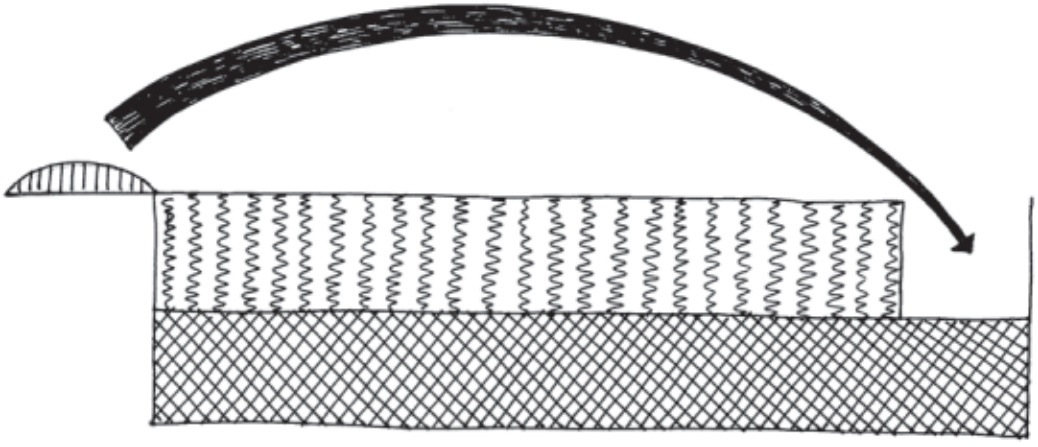


Fig 16.9: Last Strip

11 The double digging is now finished. Level the surface with a rake or the side of your hoe. Be careful not to step on the bed.

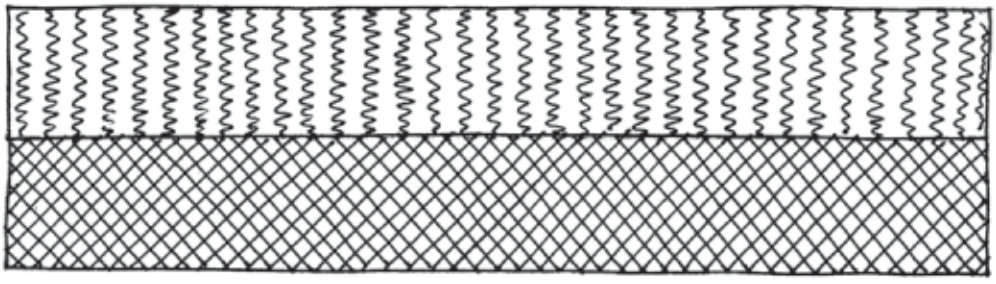


Fig 16.10: Level the Surface

12 Fertiliser can be added to the bed in two ways. The first way is to mix the fertiliser with the topsoil every time you put it into a new section. This is the best way because the nutrients will be deeper in the soil and will last longer. The second way is easier because you simply add fertiliser to the top of the finished bed and then dig it in. It's up to you which way you choose. For a 10 m^2 bed, a good fertiliser mixture is listed below:

10 kg	Compost or decomposed manure.
1 kg	Wood ash.
1 kg	Bone meal or bat manure.
1 kg	Crushed eggshells or mussel shells, snail shells, etc.
1.5 kg	Fishmeal, *leucaena* or other legume leaves.

Put the fertiliser on top of the bed. Then use a hoe to dig the fertiliser down 15 cm. Water the bed well and wait for at least 24 hours before planting. Always add a good layer of mulch on top of the bed to keep in the moisture and nutrients.

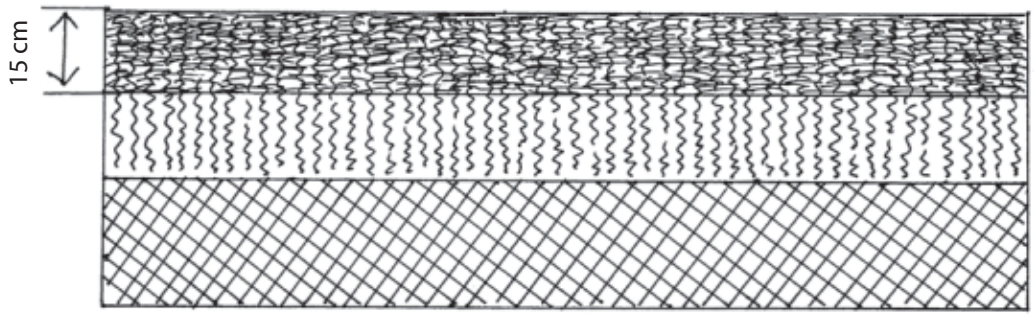


Fig 16.11: Add Fertiliser

NOTES

Overview

Compost basket beds are normal raised beds with containers placed directly into the soil. These containers are filled with kitchen scraps, garden waste and leaves from leguminous and other plants. Crops are grown around the containers. The material in the containers decomposes and steadily releases nutrients into the soil for the surrounding plants. The longer we use compost baskets beds the more fertile they become. Many crops can be grown but the most successful are long beans, chilli, eggplant, okra, corn, lima beans, soy beans, and pumpkin.

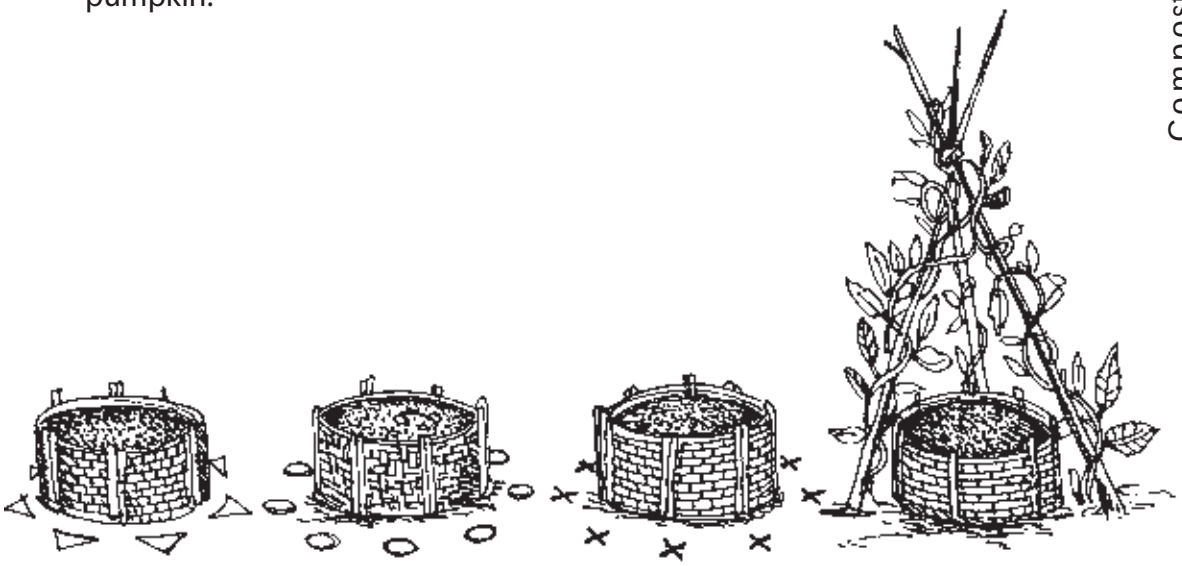


Fig 17: Compost Basket Beds

Materials:

- Bamboo or cane baskets at least 30 cm diameter and 30 cm high. Old or damaged baskets or containers can also be used.
- Any organic matter such as kitchen leftovers, weeds, grass, cuttings, manure, etc. can be used. Most of these things can be collected when working in the garden. Leaves from leguminous plants such as *Leucaena* and *Gliricidia* are a good source of nitrogen.

Procedure:

We can use an old raised bed or make a new one for compost baskets.

1 Clean the site and save any organic matter for later. Collect any baskets that you will need.
2 Dig holes into the raised beds large enough for your baskets. The holes should be spaced at least 1 m apart and 15 cm deep.

3 Put the baskets into the holes so that they are half in and half out (i.e. 15 cm deep).
4 Put the manure and decomposed organic matter into the baskets first. Soil organisms will soon start to work.
5 Put the fresher and less decomposed materials in next. Fill the baskets to the top and try and keep them as full as possible by always adding more organic matter. We do not need to turn the material in the baskets like we do for other ways of composting.
   - If you were able to find and use manure and decomposed organic matter, you can immediately plant your seeds or seedlings. If you only use fresh materials such as green leaves and grasses, then you will need to wait at least a week before the material begins to decay.
6 Plant seeds or seedlings around the baskets, 5 - 10 cm away from the edge. We can not plant inside the baskets.
7 A few weeks after planting, start watering the baskets instead of the plants. This will help the decay process and encourage the plant roots to spread towards the basket.
8 After harvesting your crops, remove the organic matter from the baskets and dig it into the surrounding soil. This will help the next generation of seeds and seedlings. Prepare the baskets again in the same way.

NOTES

Overview

Circle beds are very similar to compost basket beds. They concentrate nutrients and water and are an efficient way to grow many types of plants in difficult conditions and with little space. They are useful for children or the very old because they are easy to make and maintain.

- Circle beds can be made in nearly any area because they do not need much space.
- Circle beds do not need compost because we can use organic matter straight from our kitchens, gardens and forest. As the organic matter decomposes over time, the soil bed becomes more fertile.
- Circle beds can be used in the dry season because we do not need to use a lot of water. We can use waste water from our kitchens and bathrooms, and the organic matter helps prevent evaporation.
- Circle beds can be made small for short-life crops, or large for plants that can be grown for many years.
- Circle beds become more fertile the longer they are used.

Fig 18.1: Circle Bed

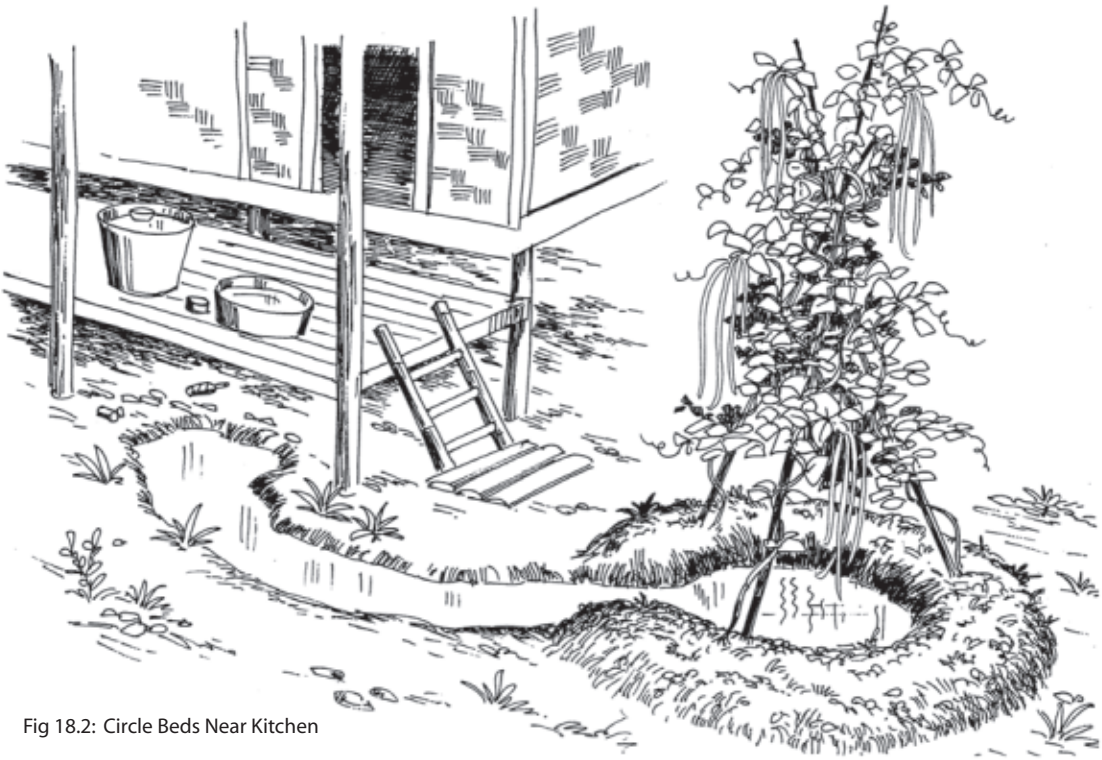


Fig 18.2: Circle Beds Near Kitchen

Small Circle Bed

Procedure:

1 Select a site for the circle bed. Tap stands, kitchens, toilets, etc., are all good places because the circle beds can use the waste water.

2 Dig a hole at least 1 m in diameter and 30 cm deep. Separate the topsoil from the subsoil. Shape the inside like a bowl. (Figure 19.1)

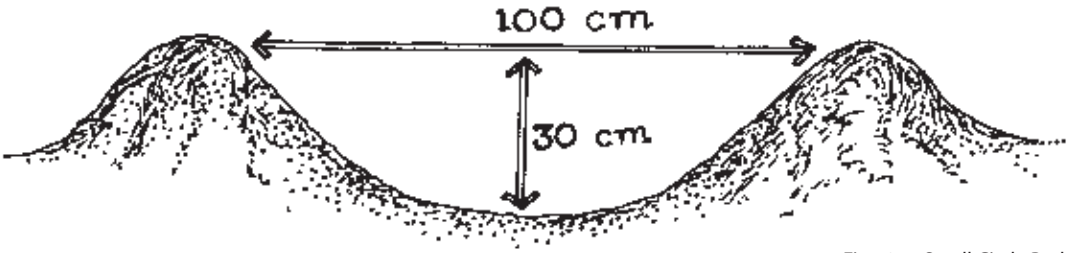


Fig 19.1: Small Circle Bed

3 Put the subsoil taken from the hole around the edge of the circle. Put the topsoil on top of this.

4 Fill the hole with organic matter such as: green leaves, dry leaves/grass, old rice straw, animal manure, etc. This organic matter will soon decay and become compost.

5 Plant vegetable seeds / seedlings around the edge of the circle. For the first month nutrients from the decaying organic matter will not be available. So it is a good idea to first plant legume crops such as mung bean to quickly improve soil fertility. (Figure 19.2)

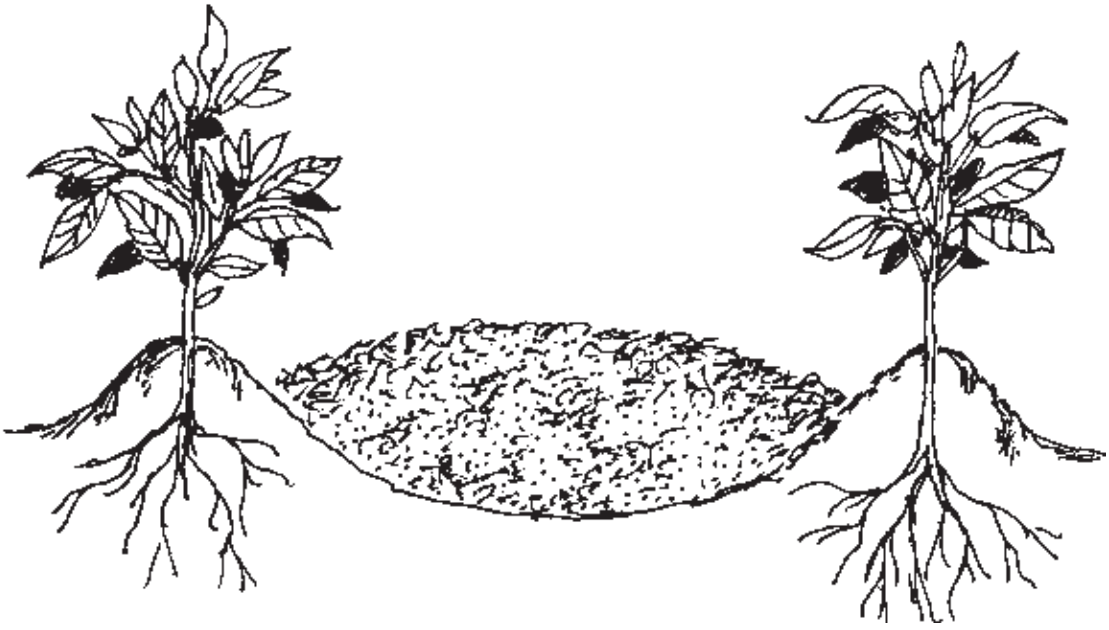


Fig 19.2: Plant Small Circle Bed

Large Circle Bed

A large circle bed is made the same way as a small circle bed, except that it is twice as big and we can use different plants. A good size for a large circle bed is 2 m in diameter and 1 m deep. (Figure 20.1)

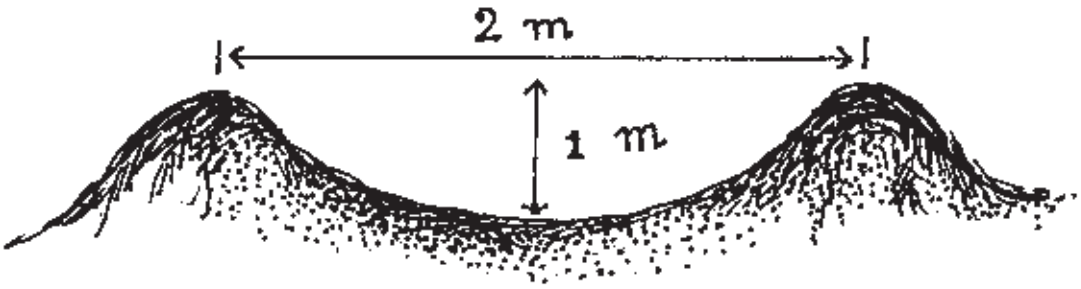


Fig 20.1: Large Circle Bed

Along with planting short-lived species around the circle bed, we also plant a mix of papaya and bananas. Under these species and on the rim of the hole we plant taro and sweet potato that like to grow in shade. (Figure 20.2)

Fig 20.2: Plant Large Circle Bed

Overview

Growing plants in containers is the most efficient way of growing vegetables in limited space and with limited water. Soil, nutrients and water are all concentrated in one place and easily available for plant roots.

Almost any vegetable can be grown in a container, but containers are best suited to fruiting crops that can take advantage of the concentrated nutrients. Examples of this include: tomato, pumpkin, bitter gourd, chillies, and rozelle.

Containers can be put anywhere there is enough sunlight. They can be placed together and protected by a small fence, or kept on high ground away from animals and children. See the table on page 50 for a guide to planting in containers.

Containers

Nearly anything can be used for a container as long as it is strong enough to hold soil and can last for at least one growing season (four to ten months). Bamboo baskets are very good if you have enough bamboo. Sacks and bags used for rice, beans and charcoal make very good planting containers. Old plastic buckets and tubs are also good, but holes should be drilled near the bottom to let water drain out. Metal containers such as oil tins can also be used, but the metal can heat up quickly in the sun and plant roots can be damaged. All recycled containers should be cleaned thoroughly before planting to remove any old material that could be poisonous. Metal containers should be lined with plastic to prevent contamination.

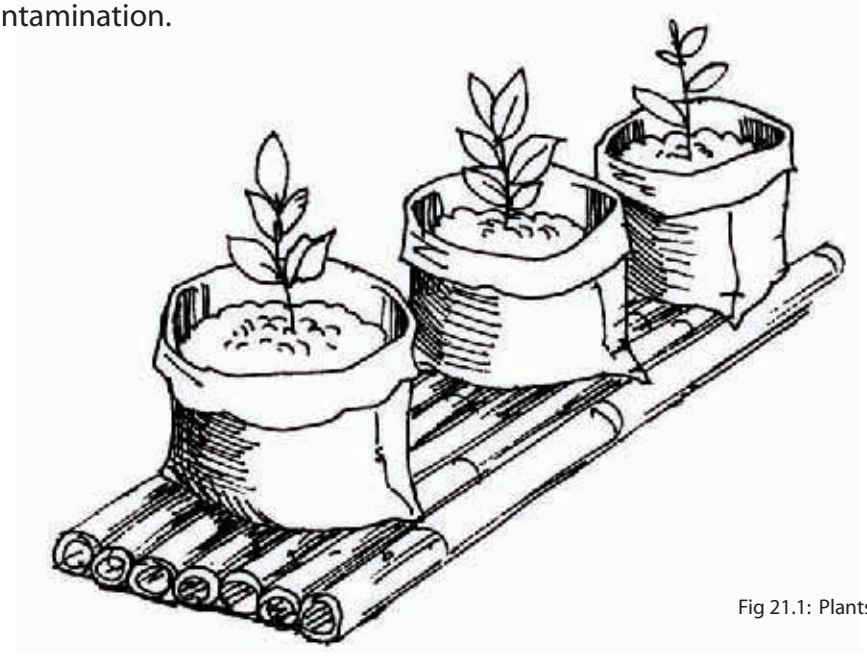


Fig 21.1: Plants in Old Rice Sacks

Basic Crop Container

These are the simplest types of containers to use for growing plants in limited spaces. Nearly any type of material can be used: bamboo, rice sacks, old buckets etc. Bamboo and rice sacks will normally only last one season so it is best to use these materials to grow annual plants that take at most twelve months to mature.

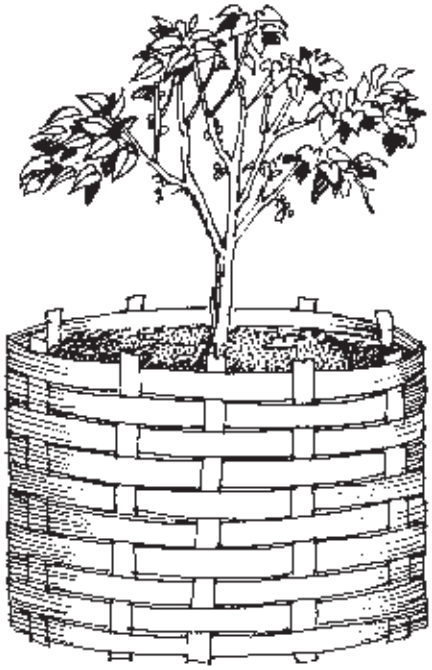


Fig 21.2: Basic Crop Container

Crop Container with Extra Basket

These containers are larger than the Basic type, above, so more plants can be grown in them. A special container is put in the middle to add manure, compost or other fertilizer to improve plant growth.

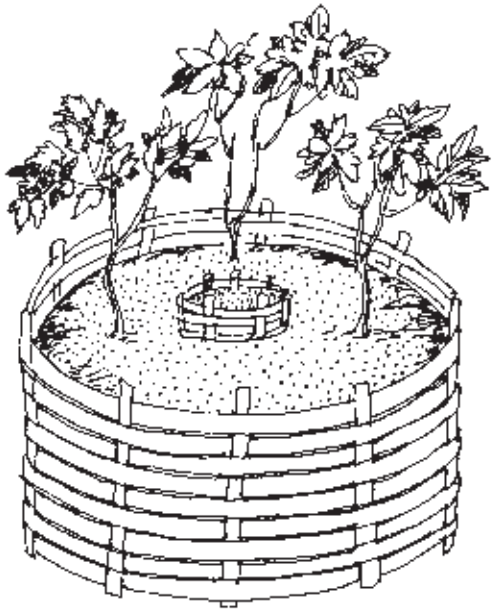


Fig 21.3: Crop Container with Extra Basket

Crop Container with Trellis

These are containers that are surrounded by a bamboo or wire trellis so that climbing plants can be grown. They are easy to manage, make good use of sunlight, and are perfect for crops like beans, cucumbers, and snake and bitter gourds. The bamboo and wire can be expensive or difficult to find in camps, and is sometimes not strong enough for growing pumpkins.

Fig 21.4: Crop Container with Trellis

Multiple Crop Containers with Trellis

These containers use the same idea as the single container trellis above, but can be grown in narrow spaces along the side of a house or fence if there is enough sunlight. They also make better use of the trellis by allowing more plants to be grown at different stages so there is a continuous yield.

Fig 21.5: Multiple Crop Containers with Trellis

Crop Container and House Trellis

This method is good because it saves space and provides lots of sunlight, but if the roof is made of thatch or grass then it will rot after about one year as the plants trap moisture. If the roof is made of zinc, then it can become too hot in full sunlight and will damage leaves and reduce yields.

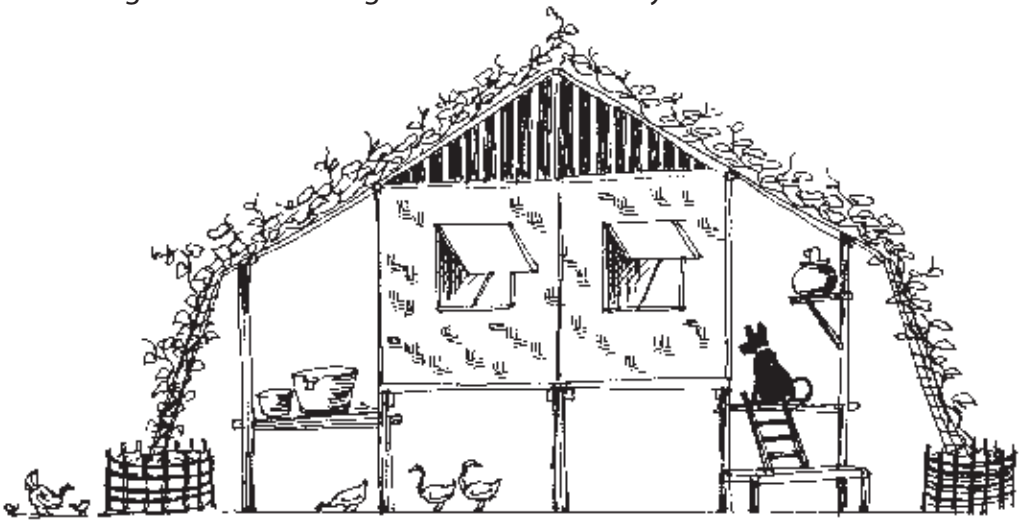


Fig 21.6: Crop Containers with House Trellis

Crop Containers Around Kitchens and Washing Areas

These spaces are often not used for anything else, so hanging containers around kitchen or washing areas make good use of waste water. Sometimes, kitchen scraps can attract animals like dogs, chickens and pigs, which can damage the containers and plants if they are not properly protected. Also make sure that the container plants are not given too much water as yields will be reduced.

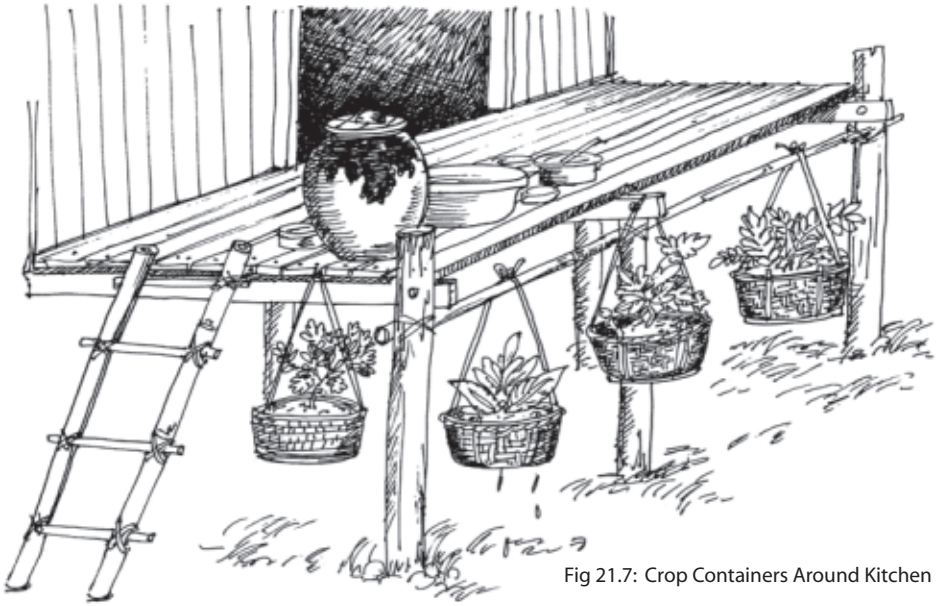


Fig 21.7: Crop Containers Around Kitchen

Crop Containers on Steps / Terrace

Space underneath can be used for storage or growing shade tolerant plants. In camps, it may be difficult or expensive to find enough bamboo or wood to make raised gardens like these. Think about other high areas around the house where container plants can be placed.

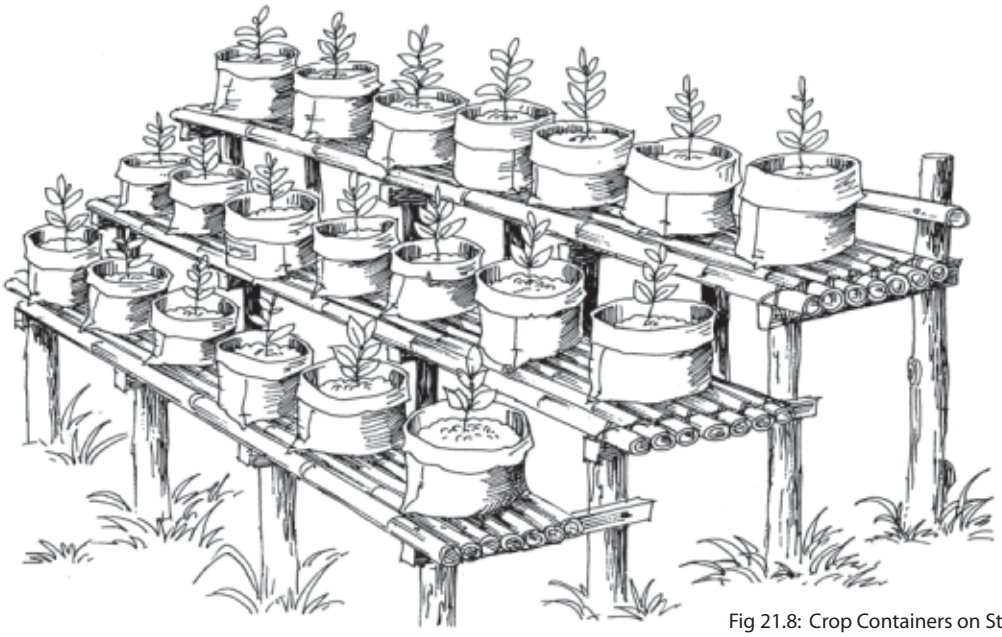


Fig 21.8: Crop Containers on Steps

Crop Containers in Trees

This method lets the crops use the tree as a living trellis and helps protect them from pests and other animals. The topsoil around the tree is very good for use in the containers.

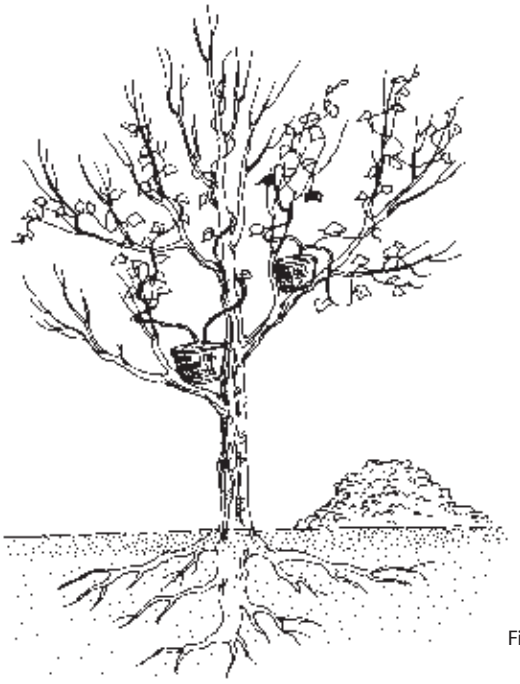


Fig 21.9: Crop Containers in Trees

Soil for Crop Containers

Here are three types of soil mix that can be used for planting different crops in containers:

1 Container Soil - Simple:

a Collect fallen leaves from the forest floor or dry leaves from legumes such as *Leucaena, Gliricidia, Cajanus,* bean crops etc. Green leaves can also be used but we must wait at least two weeks before planting anything in the containers.
b Fill the bottom half of the container with the leaves (about 30 cm deep is best).
c Fill the rest of the container with good topsoil or compost (at least 15 cm).
d Plant the seeds or seedlings and then water thoroughly.

2 Container Soil – Fruit Production:

This mix contains a good amount of phosphorous for the development of flowers and fruits.

a Collect fallen leaves from the forest floor or dry leaves from legumes such as *Leucaena, Gliricidia, Cajanus*, bean crops etc. Green leaves can also be used but we must wait at least two weeks before planting anything in the containers.
b Thoroughly mix **good topsoil** or **garden soil** (2 parts), with **compost** (1 part). While mixing add a small amount of **bat manure** with **wood ash** (one handful is enough).
c Fill the bottom half of the container with the leaves (about 30 cm deep is best).
d Fill the rest of the container with soil mix, plant the seeds or seedlings and then water.

3 Container Soil – Leaf Production:

This mix contains a good amount of nitrogen for leaf development.

a Collect fallen leaves from the forest floor or dry leaves from legumes such as *Leucaena, Gliricidia, Cajanus,* bean crops, etc. Green leaves can also be used but we must wait at least two weeks before planting anything in the containers.
b Fill the bottom half of the container with the leaves (about 30 cm deep is best).
c Thoroughly mix **good topsoil** or **garden soil** (2 parts), with **compost** (1 part). While mixing add ½ part of **fresh pig manure**.
d Fill the rest of the container with the mix, plant the seeds or seedlings and then water.

Watering

Plants grown in containers need to be watered more frequently than plants grown in beds and fields. This is because there is only a small volume of soil in a container to hold moisture. The benefit is that most of the water is taken up by plant roots and very little is wasted as runoff. To check the moisture level, push your finger 5 cm down into the soil. If it is dry, water the container until water starts to run out of the bottom of the container.

Fertilising

The small volume of soil in a container also means that plants need frequent fertilising. Depending on the species of plant and its growth stage, fertiliser should be added about every two weeks. The best way to do this is by using a liquid fertiliser (See Section 5: Fertilisers and Pest Control). This will replace nutrients and maintain good levels of micro-organisms within the soil. The liquid fertiliser should be well diluted so that it is not so strong that it burns or kills the plant.

Vegetable	Min Container Size	Number of Plants
Bean - Pole	10 L	6 plants / 5 cm - 8 cm apart
Bean - Bush	20 L	6 plants
Cucumber	25 L	2 plants / train vertically
Tomato	25 L	1 plant
Eggplant	25 L	1 plant
Chilli	10 L	1 plant
Pumpkin	25 L	1 plant
Corn	50 L	4 plants / 10 cm apart
Mustard Green	2.5 L	1 plant
Onion	2.5 L	16 green onions / 3 cm - 5 cm apart
Lettuce	2.5 L	1 plant
Carrot	5 L	3 - 4 plants / 3 cm - 5 cm apart
Radish	5 L	4 - 5 plants / 3 cm apart
Spinach	2.5 L	1 plant
Cabbage	2.5 L	1 plant
Chinese Cabbage	2.5 L	1 plant
Kale	25 L	3 - 4 plants / 15 cm apart
Broccoli	25 L	1 plant

Overview

Compost pit beds are similar to circle beds where plants are grown around decaying organic matter. However, compost pit beds have a lid that covers the organic matter to reduce smell and keep out pests. Compost pits have similar benefits to other types of compost beds:

- Organic matter can be used directly without making compost first. This reduces labour and time.
- Homes and gardens are cleaner because kitchen, garden and farm waste can be collected and disposed of in the compost pits.
- The trellis around the pit saves space and is designed for growing climb ing plants such as bitter gourds, pumpkins, beans, and cucumbers.
- The soil surrounding the pits becomes more fertile the longer it is used. Eventually, perennial crops such as bananas and taro can be grown along with vegetables.

Materials:

- Wood or bamboo poles; 1.5 m–2 m long.
- Old tyres, wood or bamboo slats; 60 - 70 cm diameter.
- Bamboo matting, old tin or anything else that can cover the pit.

Procedure:

1 Clean an area for the bed. Save any grasses or weeds for composting material. Make sure that the top soil is kept separate to the subsoil that is dug out of the pit.
2 Dig a pit approximately 40 cm diameter and 90 cm deep.
3 Put the old tyre / wood / bamboo around the top of the hole to make the cover plate. Secure it by placing some of the subsoil around the edges.
4 Put the weeds / grasses and other organic matter into the pit and water until moist. Cover the pit with the bamboo matting or lid.
5 Use the topsoil to build up a bed around the compost pit. Seeds or seedlings can be planted now.
6 Keep adding organic matter and watering the pit. The surrounding soil will become more fertile the longer the pit is used.
(Figure 22, Pg. 52)

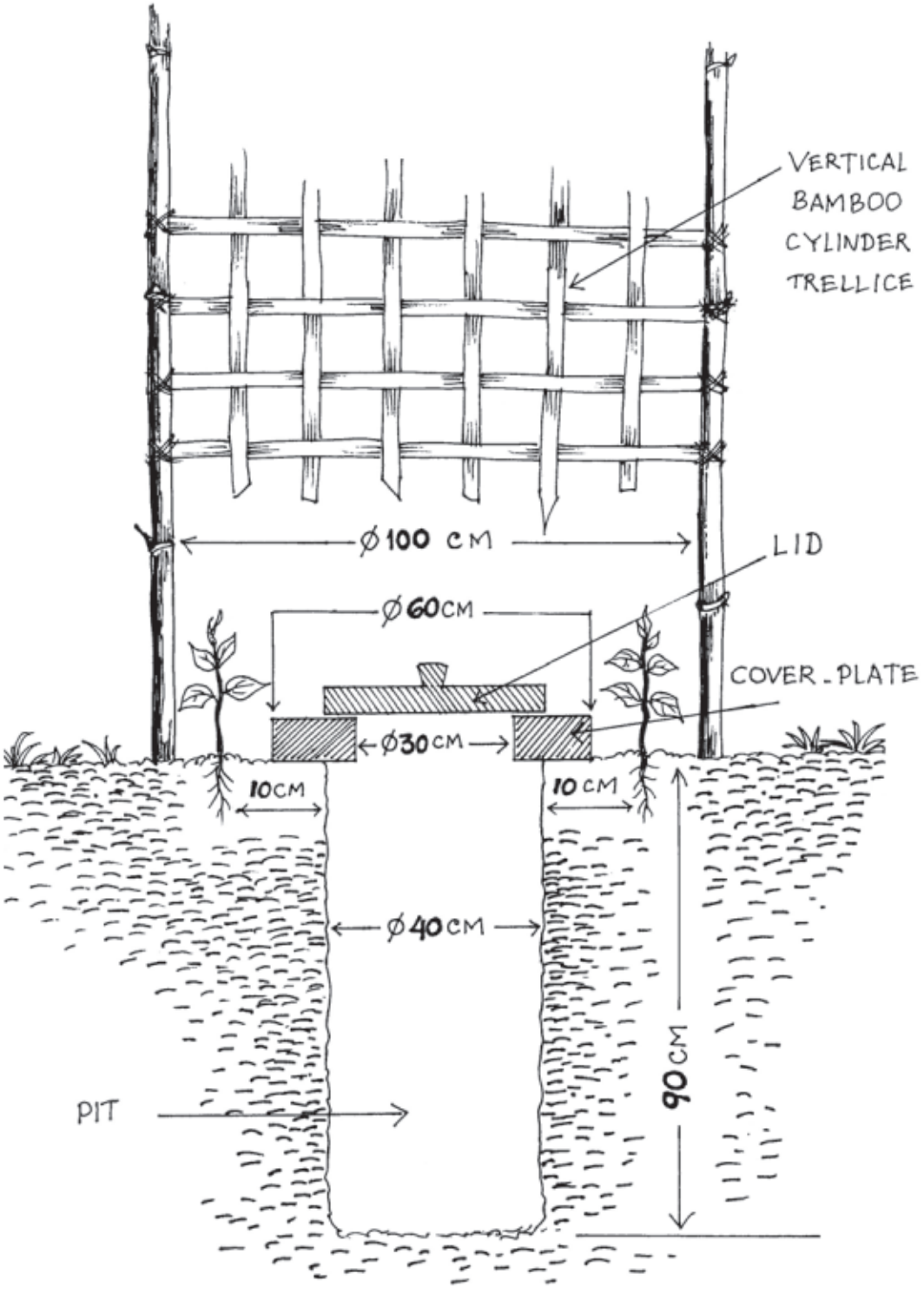


Fig 22: Compost Pit Bed

Overview

Agro-forestry means combining agriculture and forestry so that trees are grown to benefit crops that are grown together on the same land. Agro-forestry is normally practised in larger gardens and on farms, but can also be used in small household gardens. It is very useful where the soil has poor fertility and natural fertilisers are difficult to find. Agro-forestry uses multi-purpose species (See Section 6: Plants) as a source of nitrogen and organic matter for the soil, and provides food, fodder, medicine, fuel wood, and building material. Some of the many uses of agro-forestry are shown below:

Green Manure

Fresh leaves of most multi-purpose trees contain good amounts of nutrients, especially Nitrogen (N). These leaves can be dug into the soil to improve fertility.

Fig 23: Green Manure

Mulch

We can use the leaves and branches from multi-purpose trees to cover the soil, keep it moist, add organic matter, and help control weeds.

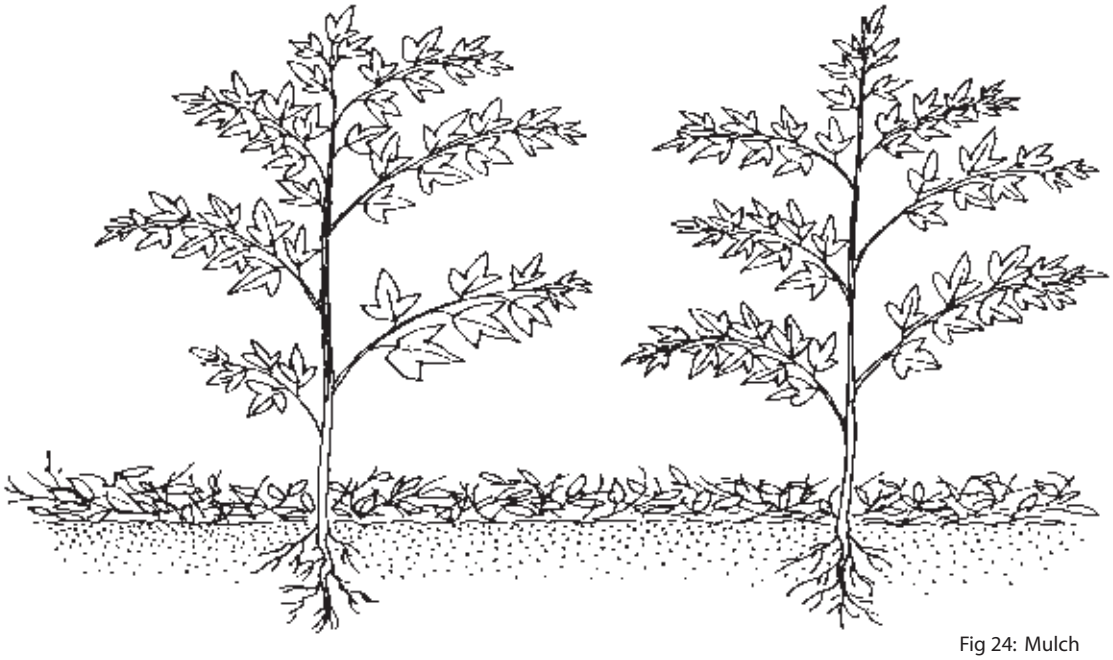


Fig 24: Mulch

Fodder

Fresh leaves from most multi-purpose tree species are a good source of fodder for cows, pigs, chickens, and other animals. Many tree species provide fodder that is rich in protein, energy, and micro-nutrients, which can help with weight gain and keep animals healthy. Humans are also able to eat some parts of many multi-purpose trees. For example, young *Leucaena* leaves and pods are a good source of iron, protein, and vitamin C. Food provided by multi-purpose trees is very useful during the wet season when heavy rainfall sometimes makes it difficult to grow vegetable crops.

Fig 25: Fodder

Fuel Wood and Building Materials

Most multi-purpose tree species grow very quickly. This means that after two or three years they can be cut back (coppiced) to provide fuel wood for cooking and heating. Older trees of most species are also a good source of building materials, providing poles for fencing, housing, and stakes for climbing crops, etc.

Fig 26: Fuel Wood and Building Materials

NOTES

Choosing Good Multi-purpose Trees

A list of multi-purpose trees for agro-forestry is included in Section 6: Plants. Below is a summary of points to think about when choosing trees for your garden or farm:

1 Easy to Establish

Choose trees that grow easily from seeds or cuttings. The quicker these trees become established the quicker they can provide useful materials for the farm or garden. Trees that are easily established usually have good resistance to disease and pests, and this will make them easier to care for later on.

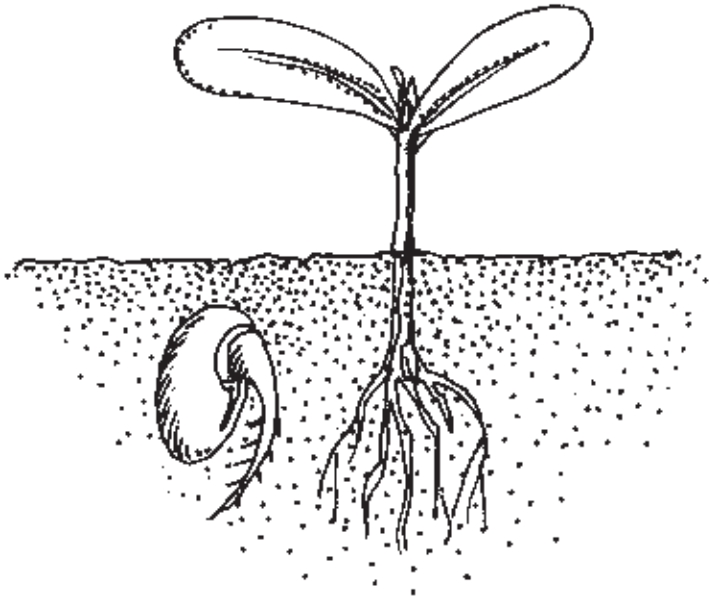


Fig 27.1: Seedlings

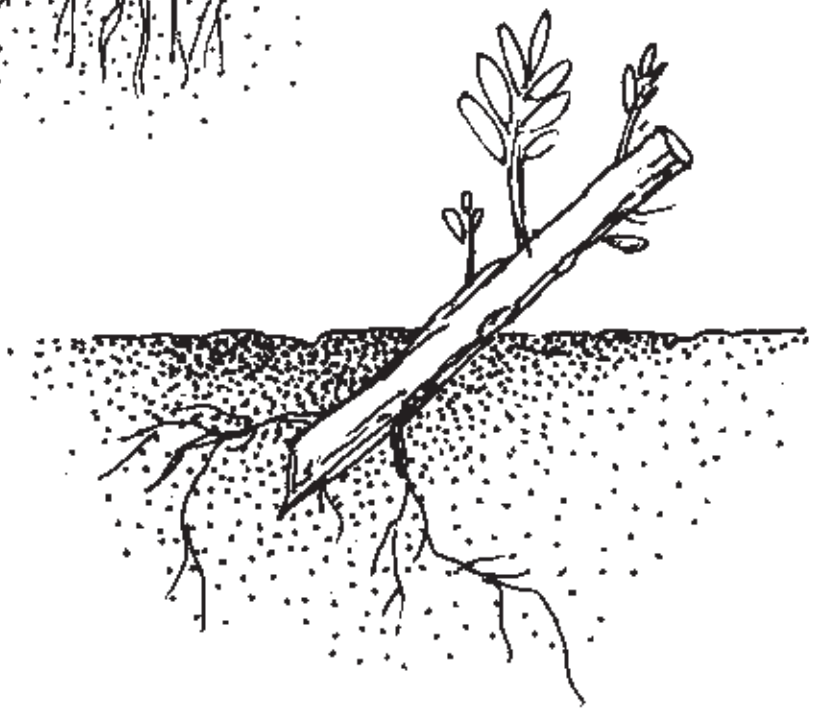


Fig 27.2: Cuttings

2 Increase Soil Nitrogen

Legume species use bacteria growing near their roots to collect nitrogen from the air (Nitrogen-Fixing). This nitrogen is used by the plants and is returned to the soil as organic matter where it can be used by other plants. The leaves of legume species provide good amounts of nitrogen when used as green manure or mulch, or added to compost.

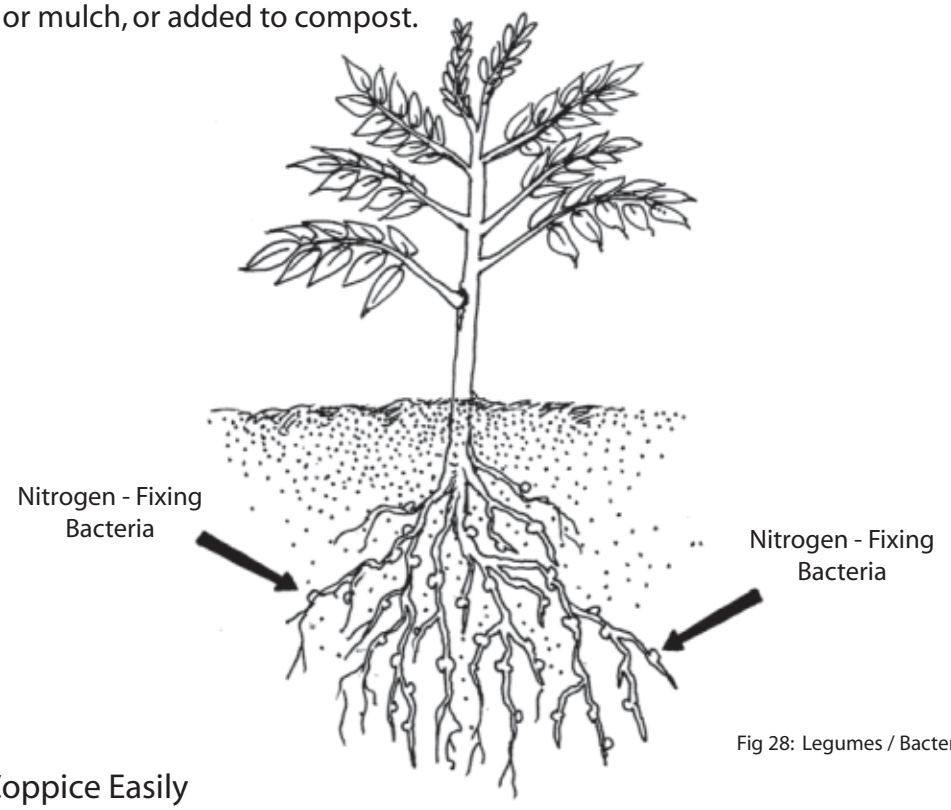


Fig 28: Legumes / Bacteria

3 Coppice Easily

To coppice means to cut back the branches and leaves of a tree. Most multipurpose trees can be coppiced easily and the leaves can be used as mulch or in compost, and the branches for firewood or building materials. New branches and leaves will grow back quickly on established trees and no damage will be done to the plant. It is best to coppice trees during the wet season so that they have enough water to grow back.

Fig 29: Coppice

4 Provide a Lot of Organic Matter

Most multi-purpose tree species grow quickly and provide a large amount of organic matter such as leaves and branches. This organic matter can be harvested regularly to provide nutrients for crops as well as firewood, fodder, and building materials.

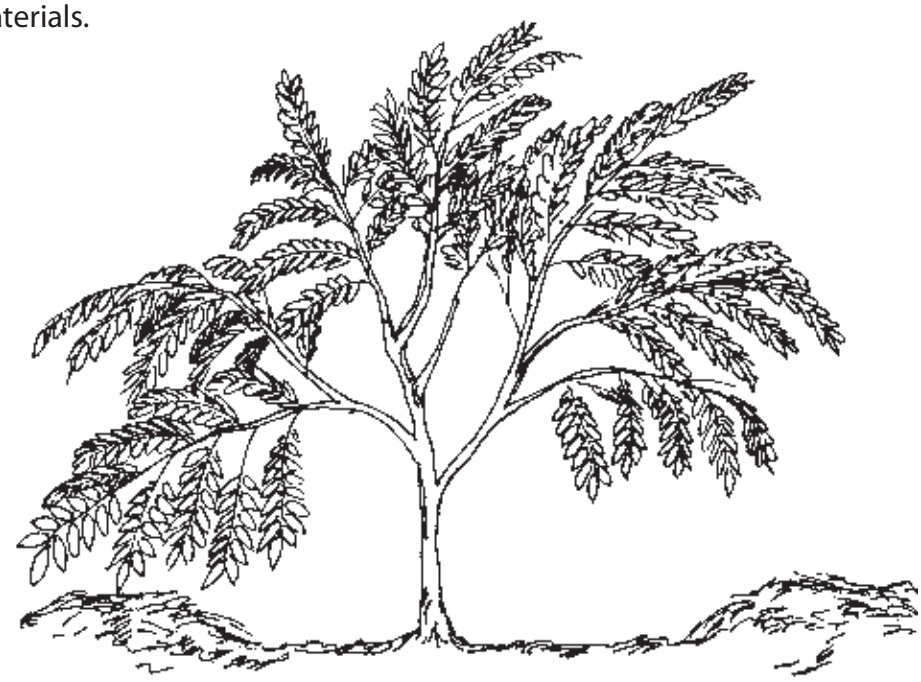


Fig 30: Organic Matter

5 Deep Rooted

Trees with deep roots will not compete with shallow rooted vegetable crops for moisture or nutrients. They will also bring up nutrients from deeper in the soil, and make them available to crops when their leaves are used as green manure or mulch. Trees with deep roots are also able to help control erosion when used in contour planting.

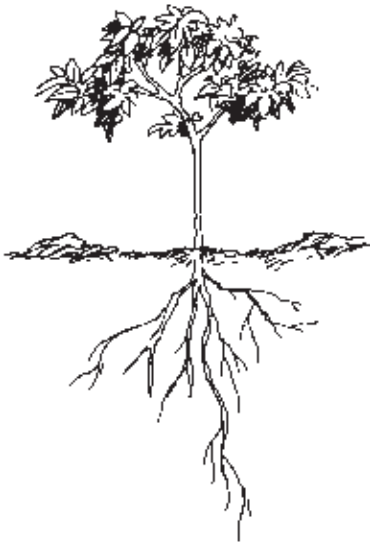


Fig 31: Deep Rooted Plant

Alley Cropping

The easiest and most efficient system of agro-forestry is called Alley Cropping. This is where crops are grown between rows of multi-purpose trees. The trees provide fertilizer for the crops and help protect them from the weather. A brief description for using an alley crop system is provided below:

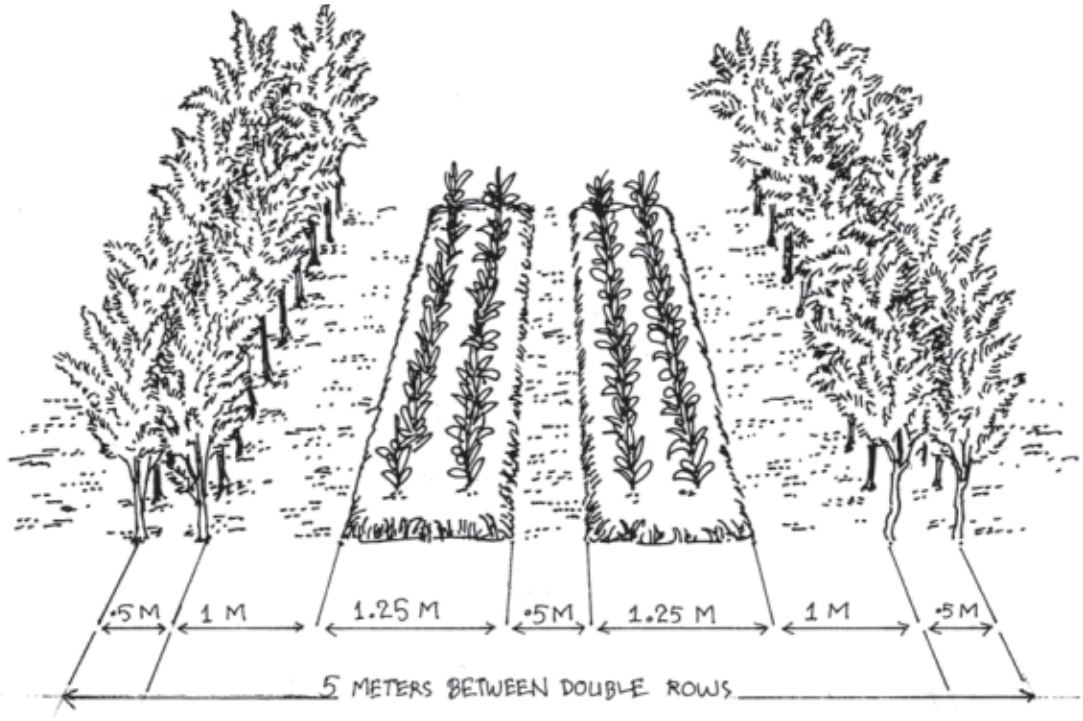


Fig 32.1: Plan for Alley Cropping

Procedure:

1 Choose a site in the garden or farm. It is best if the land is level, but a small slope is alright.
2 Make a plan of where the crop beds will be made (Figure 32.1). If the beds are made straight between north and south, then the crops will receive a lot of sunlight, which is good for growing in the wet season.
3 Make No-Dig Beds or Double-Dig beds. The rows can be as long as you like, depending on how large your site is.
4 When the beds are finished, start preparing the rows (alleys) for the trees. It is good to raise the soil a little bit by adding compost and other organic matter to make sure the trees have good drainage and enough nutrients. Trees can be planted directly by seed, but they will take a long time to become established. It is best to prepare seedlings in pots first and then transplant them to the site, or to use cuttings of mature trees if possible.

5 The crop beds can be planted as normal. In the first season the trees may not grow very quickly, but by the end of the second season, many species may have grown nearly two metres tall and their trunks may have a diameter of about 2-4 cm. If at this stage the trees are too tall and are shading the crops, they can be cut back (coppiced) and used as mulch, green manure, or compost. (Figure 32.2)

6 By the third season, the alley-cropping system should be well established. If managed carefully, the trees will continue to grow and provide an excellent source of nutrients for the crop beds and other uses.

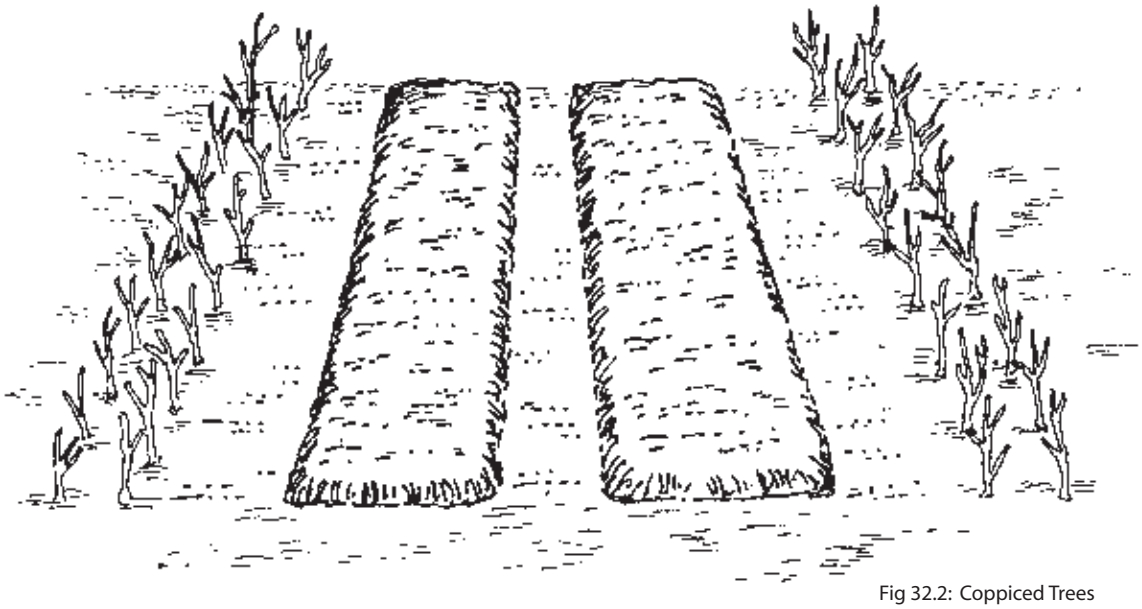


Fig 32.2: Coppiced Trees

NOTES

Overview

Contour planting is a way of farming on hills and slopes that reduces erosion and improves soil fertility. It uses both agro-forestry methods and multi-purpose tree species, and is a sustainable alternative to shifting rotation where there is little land available. An important tool in establishing a contour farming system is called the A-Frame.

The A-Frame

A contour line is a measurement of how high the land is across a slope. When contour lines are close together, the slope is very steep. When contour lines are far apart, the slope is not steep. An A-Frame is a tool to measure contour lines across slopes. (Figure 33)

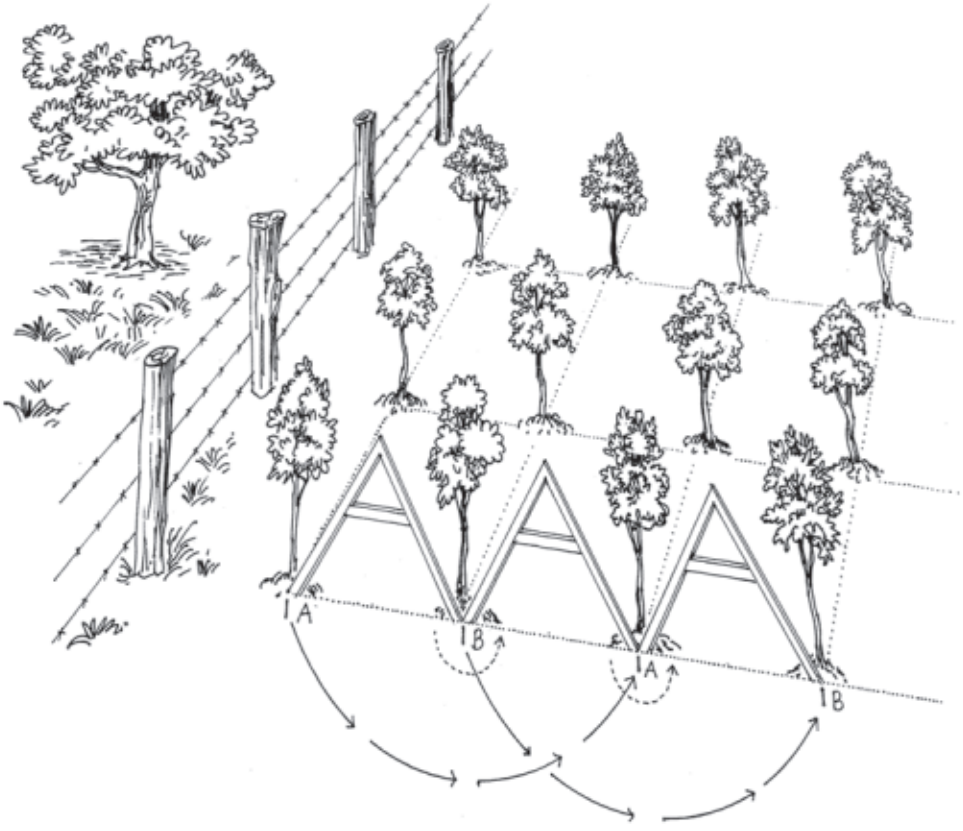


Fig 33: A-Frame Measurement

Making an A-Frame

1 Collect two straight wooden or bamboo poles and cut the length to 2 m. Collect another pole and cut the length to about 1 m.
2 With rope or vine, tie the two 2 m poles together at the top so that they make a triangle. Then tie the 1 m pole across the middle of the 2 m poles so that it makes the letter 'A'. (Figure 34)
3 Find a heavy stone about the size of your fist. Tie it to the top of the A-Frame so that it hangs down about 10 cm below the middle pole.
4 On a flat area of ground (e.g. on cement around a well, the floor of a house), hold the A-Frame up and let the rock swing freely until it stops. Once the rock has stopped moving, use a knife to mark the place where the rope or vine crosses the centre pole. This is called the centre line, and when the rope is over this line it shows that the A-Frame is sitting on flat level land.

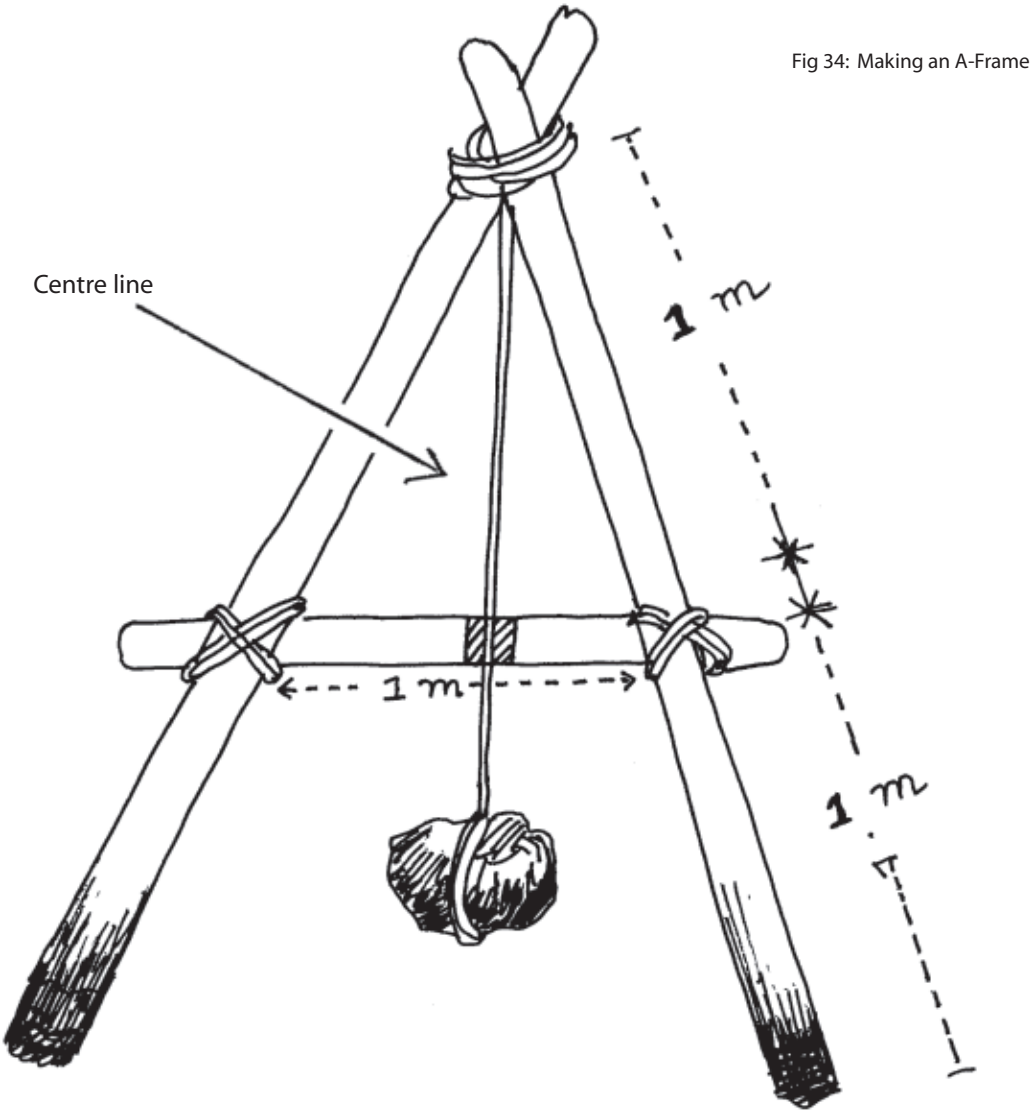


Fig 34: Making an A-Frame

Using an A-Frame

1 It is best to use an A-Frame with two or three people.
2 Collect a good supply of stakes; the best are sharpened sticks or pieces of bamboo about 30 cm long.
3 Start at one side of the top of the hill or slope you have chosen for contour planting.
4 Place the A-Frame on the ground and rotate it until the rope is on the centre line.
5 Put stakes into the ground at each leg of the A-Frame. (Figure 35). This is the beginning of the contour line.
6 Keeping one leg of the A-Frame in the ground, carefully rotate the other leg around until the rope is again on the centre line. Put in a new stake where the A-Frame leg touches the ground. (As we repeat these steps we become quicker and more accurate).
7 Keep repeating this process until you reach the end of the slope you want to farm. At the end you should have a line of stakes that mark an equal height across the slope.
8 After the first line is complete, move down the slope until the first line is at the level of your straight, outstretched hand. If the slope is very steep, this may only be a few metres away. On smaller slopes it could be up to 10 metres away. This is the place to start the second contour line, which is made exactly the same way as the first line.
9 Keep repeating the whole process until you come to the bottom of the slope or hill. This area of land is now ready to begin contour planting.

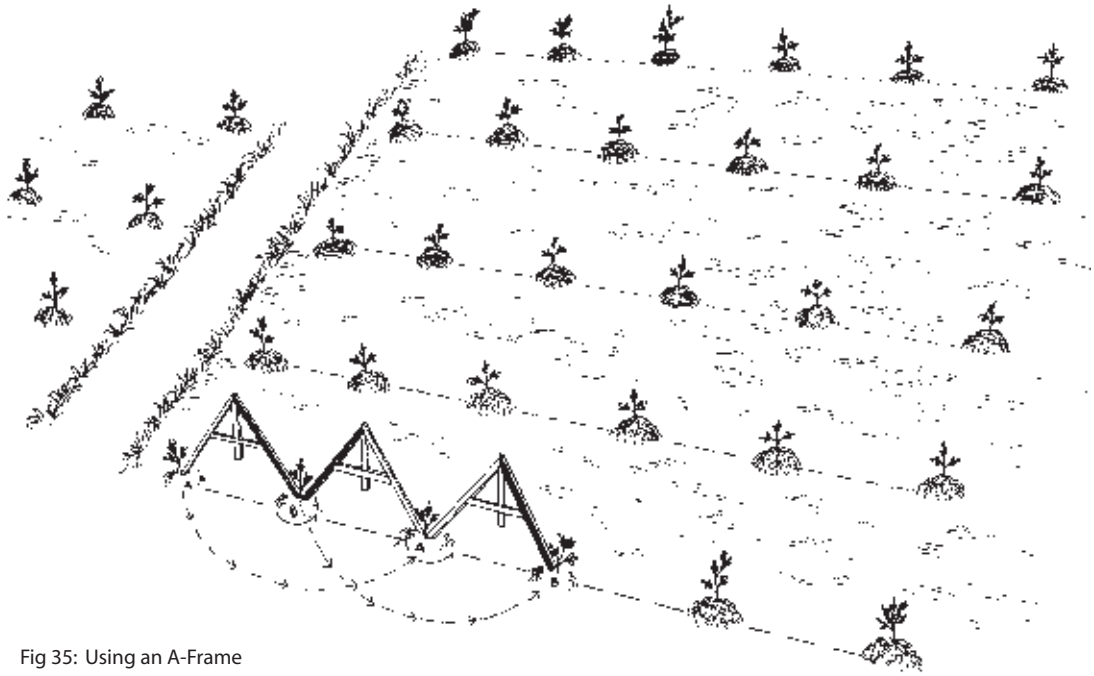


Fig 35: Using an A-Frame

Digging Contour Line Trenches

Once the contour lines have been marked it is time to start digging the drainage trenches. These are lines cut into the slope along the contours that help absorb water and reduce erosion. This is where we will plant multi-purpose trees.

1 Beginning at the first contour line at the top of the slope, use a hoe to collect the topsoil and put it a little way down the slope away from the stakes. Do this for the whole length of the contour line.

2 Next, start digging the trench parallel to the stakes. The trench should be about 50 cm wide and about 30 cm deep. Put the soil you dig up down the slope from the trench (Remove the stakes as you work along the contour line). (Figure 36.1). Sometimes we may find large rocks in the ground. If these are very big they can be left in the soil, but if small it is good to remove them with a pick axe or crow bar if one is available. Use these rocks to make the walls of the trenches stronger.

3 After the trench has been dug, put the topsoil collected at the beginning on top of the subsoil dug from the trench. This topsoil will be useful when it is time to start planting trees along the contour line.

4 When the first contour line trench is finished, repeat the process for the rest of the contour lines along the slope.

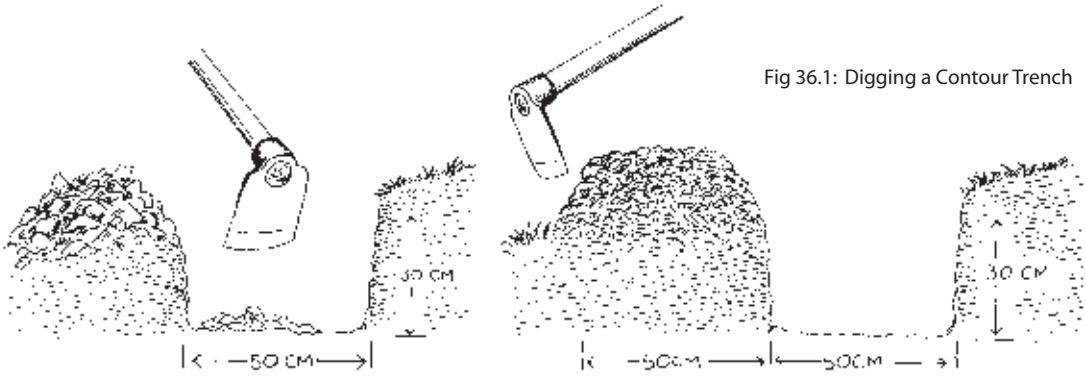


Fig 36.1: Digging a Contour Trench

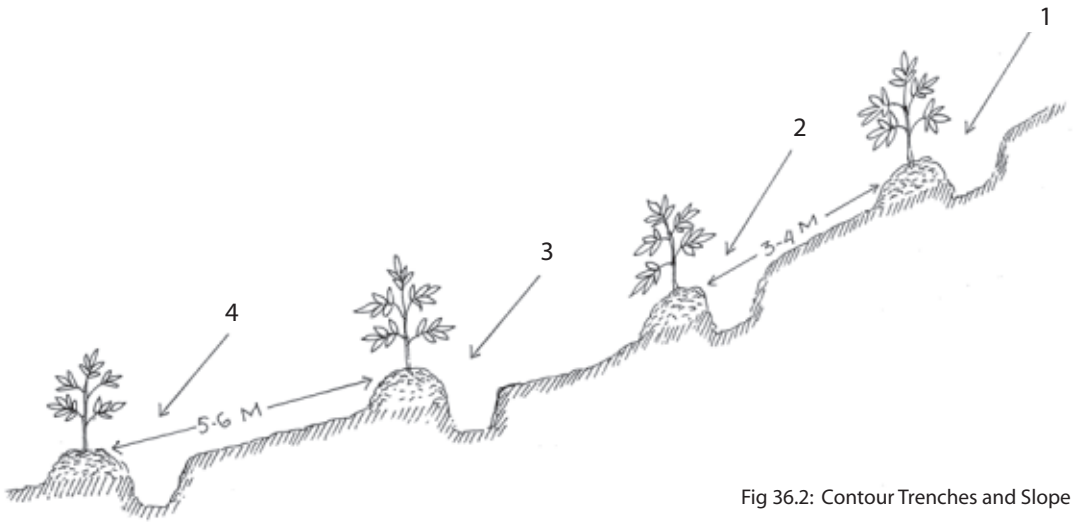


Fig 36.2: Contour Trenches and Slope

Planting Contour Lines

The best time to plant trees along the contour lines is at the beginning of the wet season. Trees can be planted directly from seed, but it is easier and quicker to transplant seedlings or cuttings. It is best if most of the trees to be planted are multi-purpose species (See Section 6: Plants). There are many different species we could choose. Use Figure 37 to plan your own contour farm:

1 Starting with Line 1 at the top of the slope, we could plant first *Sesbania* and then *Leuceana* every 50 cm. These are legume trees that will grow quickly and improve soil fertility. Planting them mixed together means they can offer different benefits and help reduce pest damage.
2 Line 2 should be planted with different species. The space between Line 1 and 2 is not very far apart because the slope is steep; it might be a good idea to plant *Cycopogon* (Lemon Grass). This species grows very quickly, has thick roots that hold the soil, and repels many types of pests. Because it does not grow very tall, it will not overshadow the crops grown next to it.
3 Line 3 could be planted with a fodder species (*Flemingia*) and a legume (*Tamarindus*). These two species grown together would provide animal feed, green manure, soil nitrogen, fire wood and medicine.
4 Line 4 could be planted with a fruit species (*Psidium*) and a legume (*Acacia pennata*). These two species would provide fruit, leaves and pods to eat or to sell, firewood, green manure, soil nitrogen and medicine.

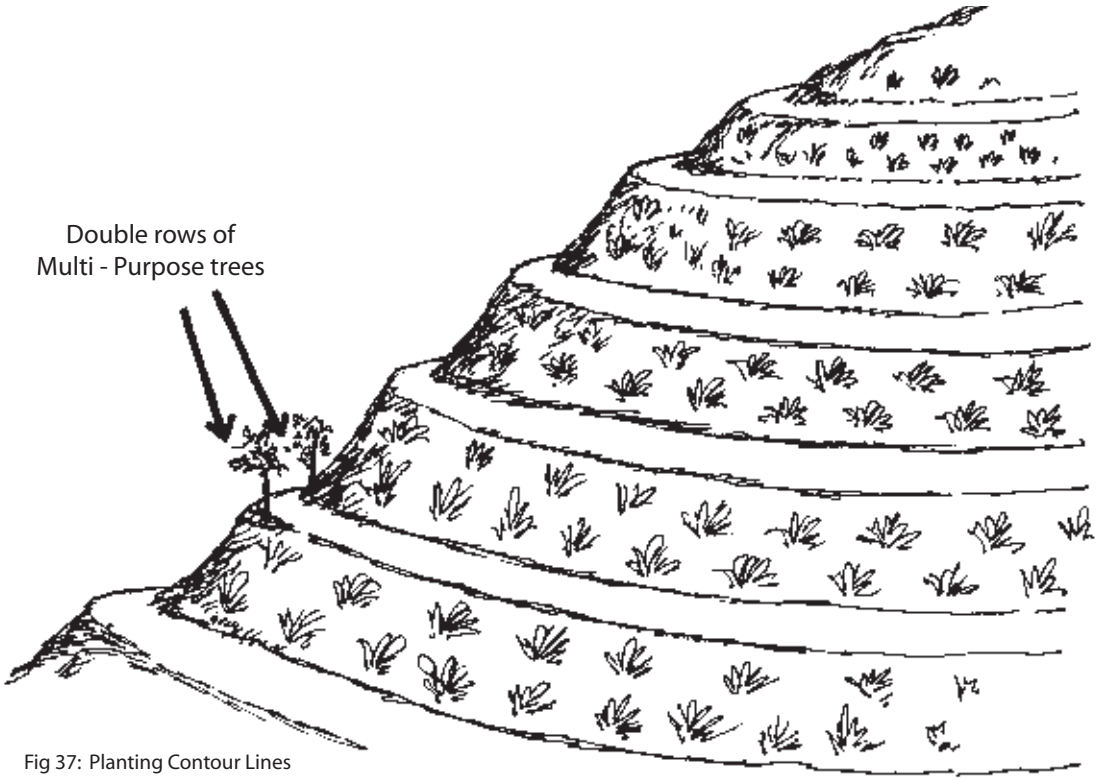


Fig 37: Planting Contour Lines

Growing Crops Between Contour Lines

The land areas between the contour lines are called strips and this is where crops are grown (Figure 38). All types of crops can be grown in these strips, both annual and perennial. Some examples of crops include:

- Vegetable crops: Mustard, cow pea, tomato, lettuce, pumpkin, rozelle, etc.
- Tuber crops: Taro, sweet potato, potato, radish, etc.
- Fruit crops: Guava, coffee, banana, etc.
- Grain crops: Rice, maize, buckwheat, etc.

As we will learn in Section 4: Growing Crops, it is best if different crop species are grown together and rotated between different strips between seasons. This will improve soil fertility and reduce damage by pests and diseases. Normal fertilising and pest control methods can also be used as described in Section 5: Fertilisers and Pest Control.

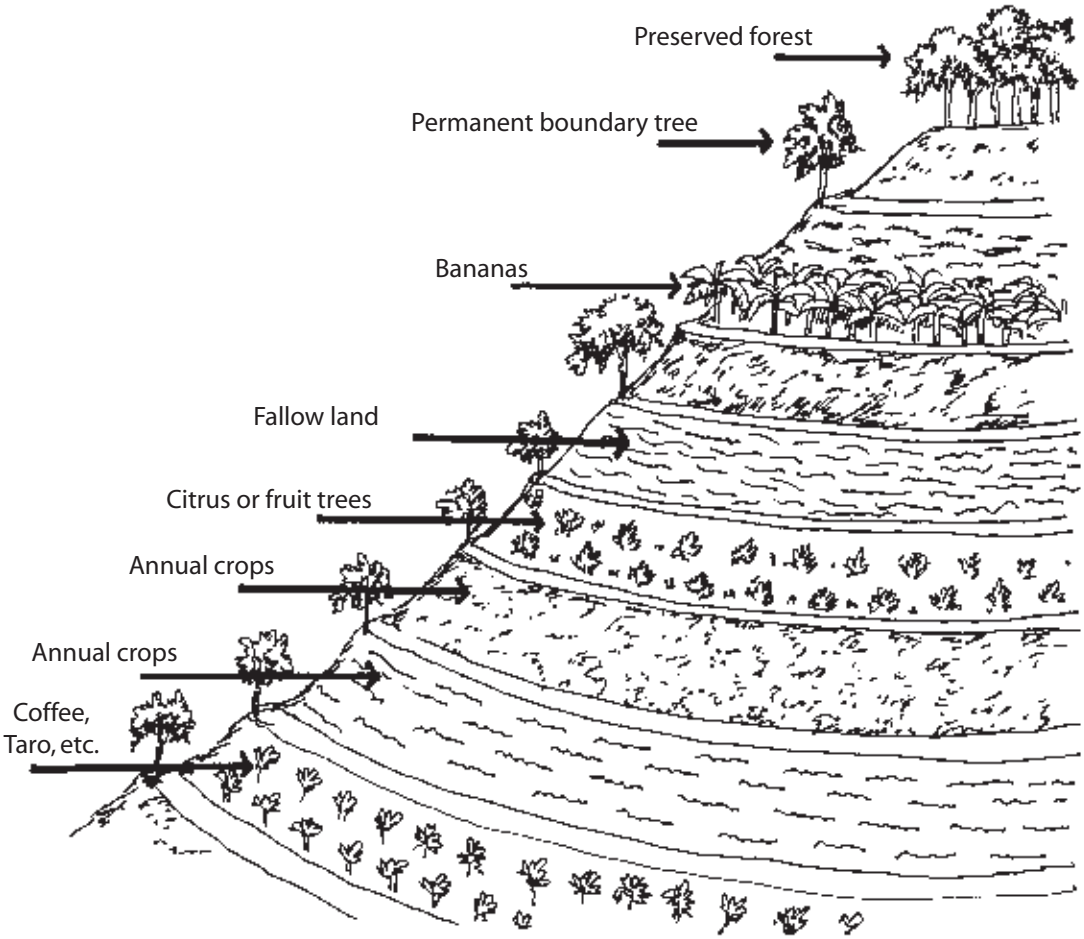


Fig 38: Growing Crops Between Contours

An extra benefit of contour farming is that as the multi-purpose trees grow, they will provide more and more resources. Many of the species will improve soil fertility through added nitrogen and large amounts of green manure as they are coppiced and used for mulch or dug into the soil. Trees will also provide a good source of food, fodder, firewood and building materials as they get older.

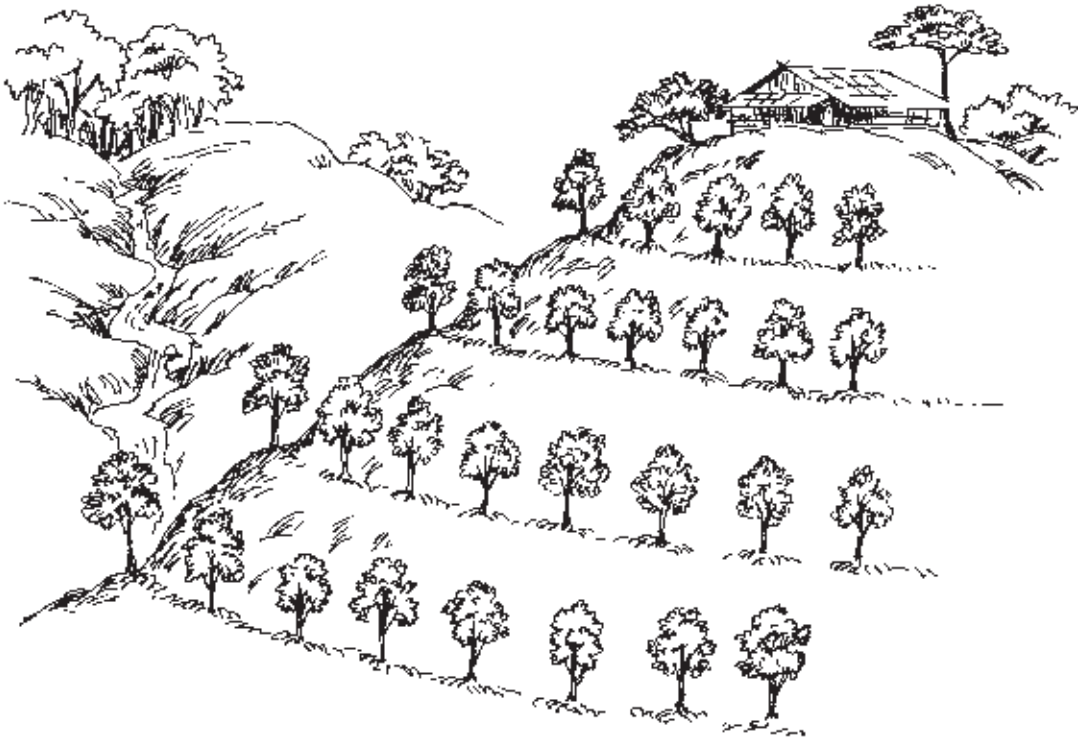


Fig 39: Established Contour Farm

NOTES

Overview

Integrated farming means raising different types of animals and plants together so that they can benefit from each other. Integrated farming is very efficient because it recycles resources between the different types of animals and plants. Inputs like land, fodder, and fertiliser are all reduced and production made more sustainable.

A good example of integrated farming in small spaces is the Pig / Poultry / Fish / Plant model (Figure 40). In this method, a pig or chicken pen is placed directly over a fishpond. The size of the pond and the number of animals must be in balance or there will be too much or too little manure and the recycling system will not work. A good ratio is one pig or 10 chickens to 3 m^3 of water depending upon the maturity of the animals.

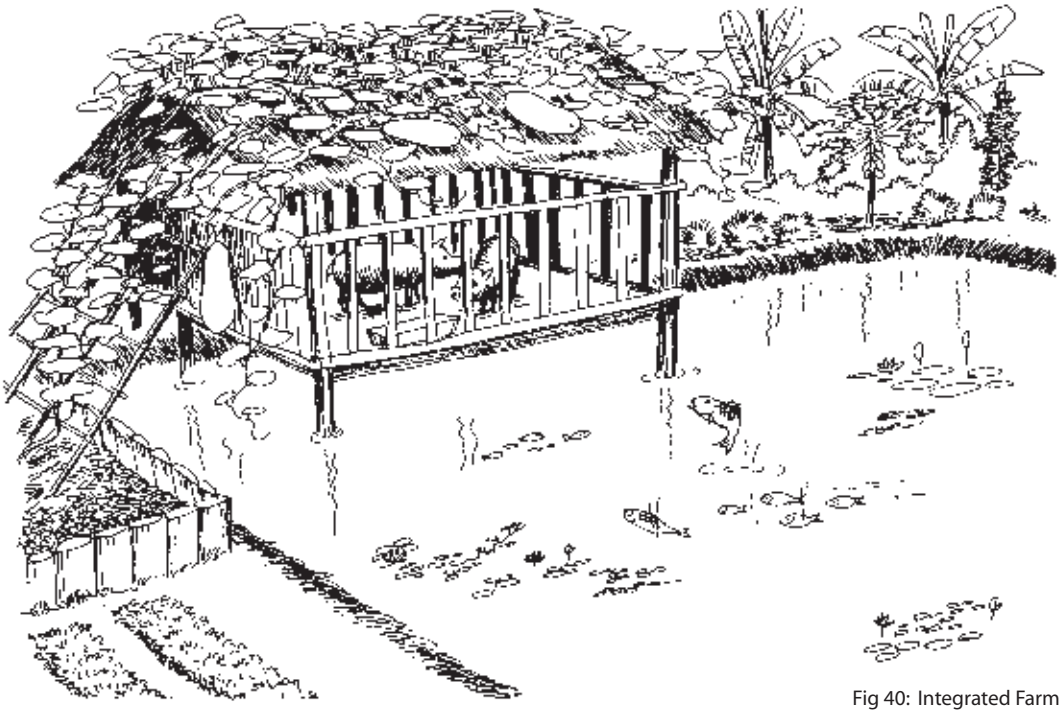


Fig 40: Integrated Farm

The pigs or chickens in the pen are fed normal food, such as kitchen scraps, rice / banana / gruel, etc., as well as plants that grow on the water or at the edge of the pond. The manure from the pigs or chickens falls into the water. The fish eat some parts of the manure (especially pig manure), while the remaining manure adds nutrients to the pond, helping plants like algae and azola grow. Fish in turn can eat these plants as well as other organisms attracted to the pond, such as insects.

NOTES

NOTES

CAN 4

Section 4: Growing Crops

Transplanting
Inter-Cropping
Crop Rotation
Mulch
Watering

Overview

Transplanting means moving a plant from one place to another. This usually means moving seedlings from a container or seed bed to garden beds and fields (See Section 2: Seeds). During transplanting it is very important to keep seedlings strong and healthy. Cloudy days with no wind are the best days for transplanting. Late afternoons and evenings are the best times of day to transplant. Careful transplanting will give better yields.

Before Transplanting

It is important to prepare garden beds and fields before transplanting seedlings. First, the soil should be tilled and fertilised. Second, a basic plan must be made for spacing the plants in the bed. Correct spacing can increase yields by helping to evenly share soil nutrients amongst plants.

Fig 41: Crop Spacing

As you can see in Figure 41, diagonal rows make better use of bed space by allowing more plants to be planted in the same area. This method also gives a better total plant cover for the bed and provides living mulch.

Transplanting

Young seedlings can be easily damaged when they are removed from the soil and planted in a new place. This is called *transplant shock*. Before transplanting, seedlings should be slowly exposed to more sunlight and watered with diluted liquid manure. During transplanting, seedlings must be handled very carefully to prevent damage to the roots, stems and leaves. Less damage will mean better growth after transplanting. It is best to transplant in the evening so that seedlings will not be burnt by strong sun.

Procedure:

1 Before removing seedlings from beds or containers, the soil should be thoroughly watered. This will help keep more soil around the roots and reduce root damage. Be sure that the soil is not too wet or it will fall away as the seedlings are lifted out.

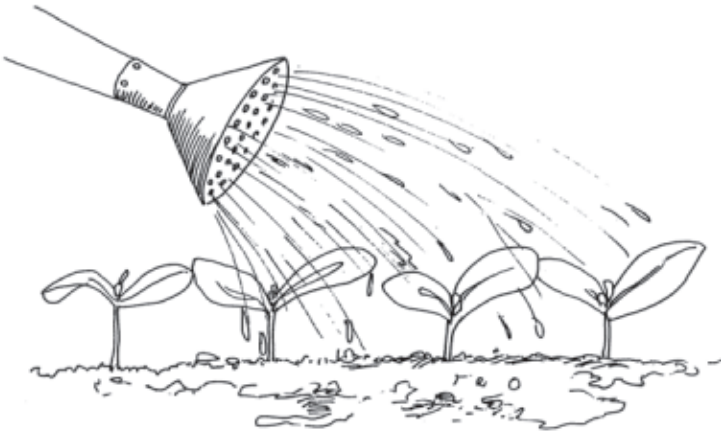


Fig 42.1: Water Seedlings

2 Use your hand or a fork to gently lift the soil under and around the seedling's roots. Try to keep as much soil around the roots as possible. Place the seedlings on the ground in a safe place.

Fig 42.2: Remove Seedlings

3 Carefully separate seedlings one at a time from each other. Try not to handle them too much. The seedlings should be only held by the tips of their leaves or by the soil around their roots.

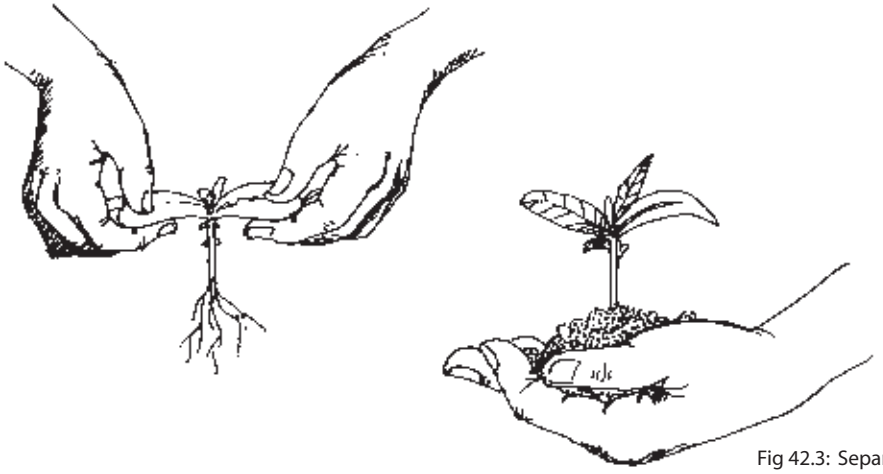


Fig 42.3: Separate Seedlings

4 If a seedling is in a pot, carefully turn it upside down, hold the plant between the 2nd and 3rd fingers, and tap the pot with your other hand.

5 When planting seedlings, make the holes in the bed a little wider and a little deeper than the seedlings roots. This will help give the roots room to grow. Add a small amount of compost or well-rotted manure to the bottom of the hole before putting the plant inside.

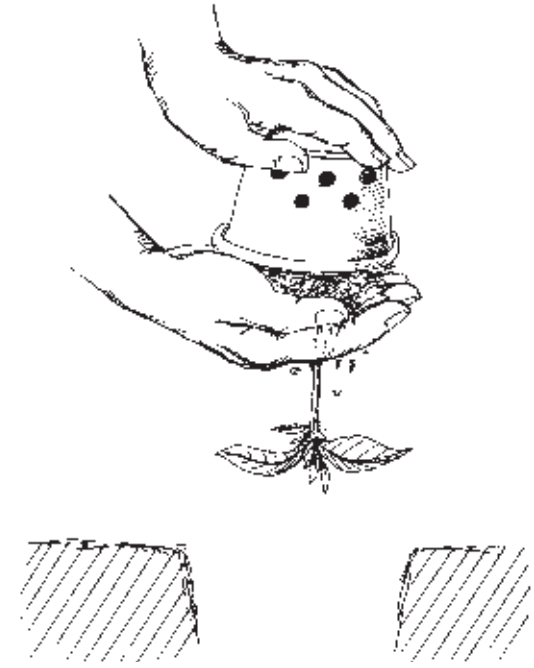


Fig 42.4: Remove Seedling from Pot

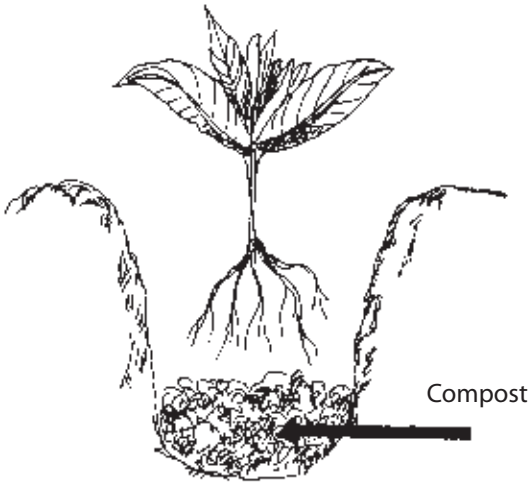


Fig 42.5: Add Compost

6 Seedlings should be planted up to their first two leaves. This will make sure the upper roots do not become exposed and loose moisture. It will also stop them from bending over. Plants that bend over develop tough stems which reduce the size and quality of yield.

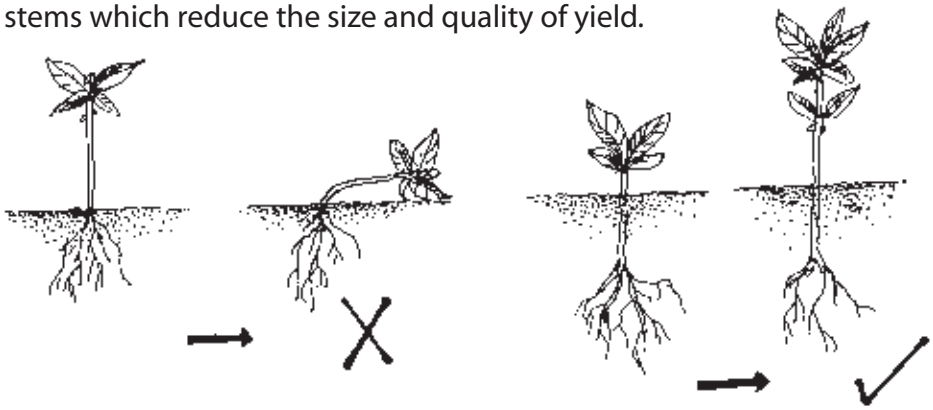


Fig 42.6: Plant Seedlings

7 The soil should be pressed firmly around the plant, but not too tight. Soil packed too tightly can damage the plant and also prevent water, air and nutrients from reaching the roots. Soil that is too loose around the roots will allow too much air and water to gather, causing root burn and decay. Firm contact of the roots with the soil will help the plant roots absorb nutrients and water.

8 Seedlings should be watered very soon after they are transplanted. Very weak diluted liquid manure or liquid compost can be used. This gives plants nutrients that help to overcome the shock of transplanting. It can also help to remove air pockets from around the roots and stabilize the plant in the soil.

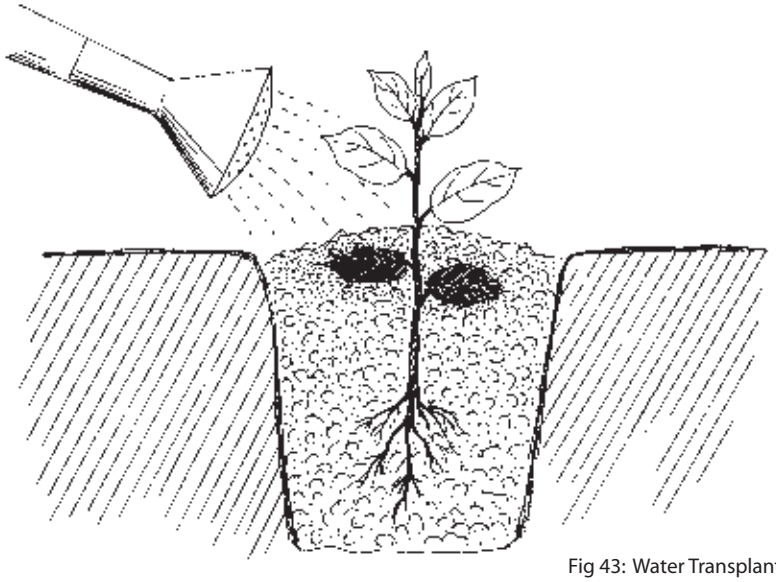


Fig 43: Water Transplanted Seedlings

Overview

Inter-cropping means growing several species of plant on the same piece of land. Inter-cropping is good for the soil because different species have different growing conditions and different nutrient needs. Also, some species release chemicals that can prevent insects attacking them and the other plants growing nearby.

Example:

1 A species with shallow roots may grow well with a species with deep roots because the two species will take nutrients from different parts of the soil. For example, lettuce with shallow roots can be planted next to tomatoes with deep roots.

Fig 44.1: Deep and Shallow Roots

2 A species that needs certain types of nutrients may grow well with species that needs different types of nutrients,. For example, a leaf crop such as lettuce needs nitrogen for good yields. It will grow well with a fruit crop such as pumpkin, which needs more potassium. Growing these together with a legume species will help to improve yields in general.

Fig 44.2: Different Nutrient Needs

3 A species that needs a lot of sun may grow well with a species that prefers shade. For example, corn grows tall and prefers good sunlight, while cucumbers and pumpkins spread along the ground and can grow well in partial shade.

Fig 44.3: Sun and Shade

4 Some plants such as sweet potatoes are best grown in raised beds for good drainage. Growing legumes together in these beds will increase leaf yields. Growing plants like corn between the beds will save space and provide some shade.

Fig 44.4: Using Space

Species that are Friends or Enemies

As we have seen, it is a good idea to grow some species of crops together as it increases both health and yield. These species are called *Companions* (Friends). Similarly, some species of plants do not grow well together because of competition for nutrients or sunlight, or because of reactions to certain plant chemicals. These species are called *Antagonists* (Enemies). Ask farmers in your local area about any companion and antagonist crops they may know. For a short list of these types of plants, see the table below.

Plant	Companions	Antagonists
Bean	Potatoes, Carrots, Cucumbers, Cauliflower, Cabbage, Corn.	Onions, Garlic,
Cabbage, Broccoli Cauliflower, Kale	Potatoes, Onions, Garlic, Beetroot, Celery.	Pole beans, Tomatoes, Strawberries.
Carrot	Tomatoes, Beans, Cauliflower, Cabbage.	Dill.
Corn	Potatoes, Beans, Cucumbers, Pumpkins, Squash.	Sunflowers.*
Cucumber	Beans.	Potatoes.
Eggplant	Beans.	Potatoes, Tomatoes.
Lettuce	Carrots, Radishes.	-
Onion	Tomatoes, Lettuce, Beetroot.	Sunflowers.*
Potato	Beans, Corn, Cabbage.	Pumpkins, Cucumbers, Sunflowers,* Tomatoes.
Pumpkin	Corn.	Potatoes.
Tomato	Onions, Parsley, Carrots.	Cabbage, Potatoes.
Soya Bean	Helps everything grow better.	-

Note:
* Sunflowers have 24 substances which slow down the growth of any plants growing near them.

NOTES

Overview

Crop rotation is the practice of growing a different crop during different seasons on the same land. Crop rotation breaks many pest and disease life cycles, increases available nutrients, and helps build healthy soil.

Pests and Diseases

Different plant species are at risk from different types of pests and diseases. When one type of crop is grown in the same place season after season, the number of pests and diseases specific to the crop will increase. By rotating different crops, the life cycle of pests and diseases is broken and damage can be reduced.

Nutrients

Different plant species need different types and amounts of soil nutrients. If the same crop is planted every year, then the nutrients the plant needs are quickly lost. A good example of this is corn, which needs a lot of nutrients. After corn is harvested, the nutrient levels in the soil are low. For the following season it is good to grow a legume crop such as cow pea, to help increase the levels of soil nitrogen.

Crop rotation is commonly practised by many farmers every two seasons, using the same two crops (e.g. rice and soy bean), but it can be more effective to extend crop rotation up to four seasons to better manage nutrients, soil texture, and pests and diseases.

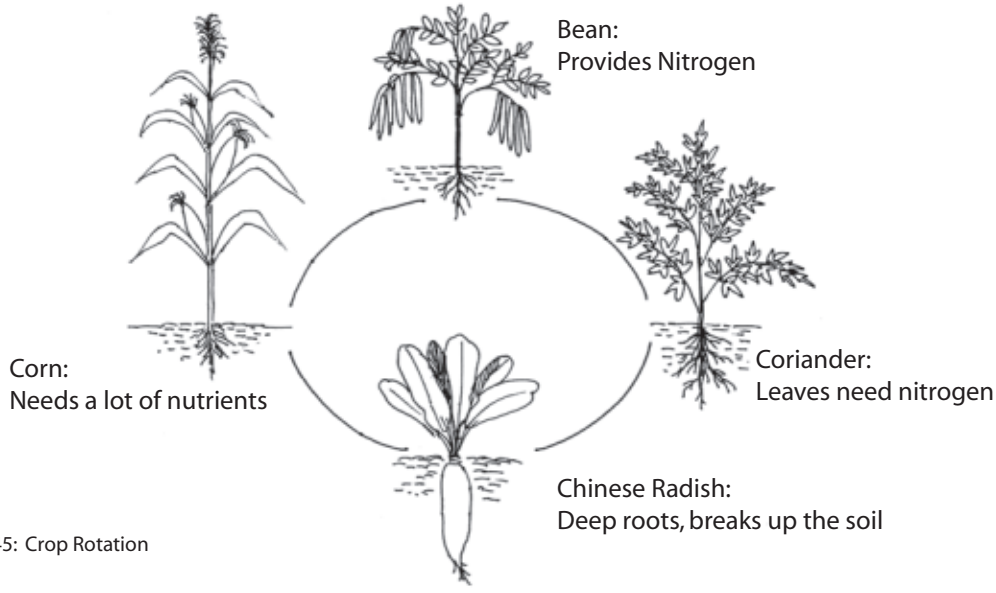


Fig 45: Crop Rotation

Crop Rotation Groups

1 *Legumes:* Take in nitrogen from the air and release it into the soil; examples include all types of beans and some agro-forestry species such as *Sesbania* and *Leuceana*.
2 *Leaf Crops:* Need nitrogen; examples include lettuce, kang-kong, spinach, broccoli, amaranth, cabbage, kale, coriander and mustard.
3 *Fruit Crops:* Need phosphorus and potassium; examples include gourds, cucumber, pumpkin, tomato, chilli and eggplant.
4 *Root Crops:* Need phosphorus and potassium; examples include onion, shallot, garlic, carrot, taro, and radish.

Heavy Feeders	Light Feeders	Heavy Givers
(Need Lots of Nutrients)	(Need Fewer Nutrients)	(Add Nutrients to the Soil)
Tomato	Most Root Crops	All Legumes
Eggplant	Carrot	Cow Pea
Pepper	Sweet Potato	Snake Bean
Cabbage	Radish	Soy Bean
Broccoli		Red Bean
Cauliflower		Mung Bean
Corn		
Melon		
Pumpkin		
Cucumber		

NOTES

Overview

Mulch is a layer of organic material that is put on top of the soil. It acts the same way as litter on the forest floor, helping to conserve moisture and improve soil quality. Mulch is one of the best and easiest ways to care for soil and grow healthy crops. Mulch can be made of straw, rice husks, cut grass, leaves, compost, and many other types of organic matter.

Benefits of Mulching

1 Conserves Water

When soil is exposed to hot sun and winds, water in the upper layers evaporates and the soil becomes dry. Mulch absorbs a large amount of water and releases it slowly. It also helps to keep soil cool and reduce evaporation. This means that moisture is kept in the soil for a longer time and the need for watering is reduced. A thick layer of good mulch can keep soil moist for several days.

Fig 46: Reducing Evaporation

2 Reduces Soil Erosion

Erosion is caused when water falls on the soil faster than the soil can absorb it. The extra water washes away nutrients and destroys the structure of the soil. Mulch acts like a cushion and protects the surface of the soil from heavy rain or watering and absorbs the extra water. (Figure 47)

3 Controls Weeds

Mulch stops sunlight from reaching the surface of the soil. Without sunlight, the seeds of weed species can not germinate easily. Any weeds that do germinate can be easily removed because decaying mulch gives the soil a loose, friable texture.

4 Improves Soil Structure

Soil that is protected by mulch is shaded from the sun and kept at a constant temperature. This makes it a perfect home for many organisms that help improve the quality of the soil. Earthworms and many types of insects tunnel through the soil, breaking down organic matter and letting in more air and water.

5 Increases Soil Fertility

A thick layer of mulch adds a large amount of organic matter to the soil. The weather and soil organisms break down this organic matter and turn it into nutrients that are available for plant roots. Different types of mulch will breakdown and provide different types and amounts of nutrients. For example, mulch that is made up of old manure and leaves of legume plants will provide a good amount of nitrogen to the soil. Mulch that is made up of rice husks or straw will add very little nitrogen, but is a good source of carbon that many micro-organisms need.

6 Helps Reduce Disease

Mulch that is light, clean and quick to dry helps prevent the spread of fungal disease among plants. Mulch also helps to reduce the number of fungi spores carried by splashing water.

7 Recycles Organic Matter

Many organic things found around our homes, gardens or farms can be used for mulch. If this organic matter is not used for compost or mulch, then its nutrients are being wasted.

8 Saves Time and Labour

Mulch keeps the soil moist, so this reduces the amount of watering we need to do. Mulch prevents the growth of weeds, so this reduces the amount of time we spend weeding. Mulch improves soil structure and fertility, so this reduces the time we spend cultivating and fertilising.

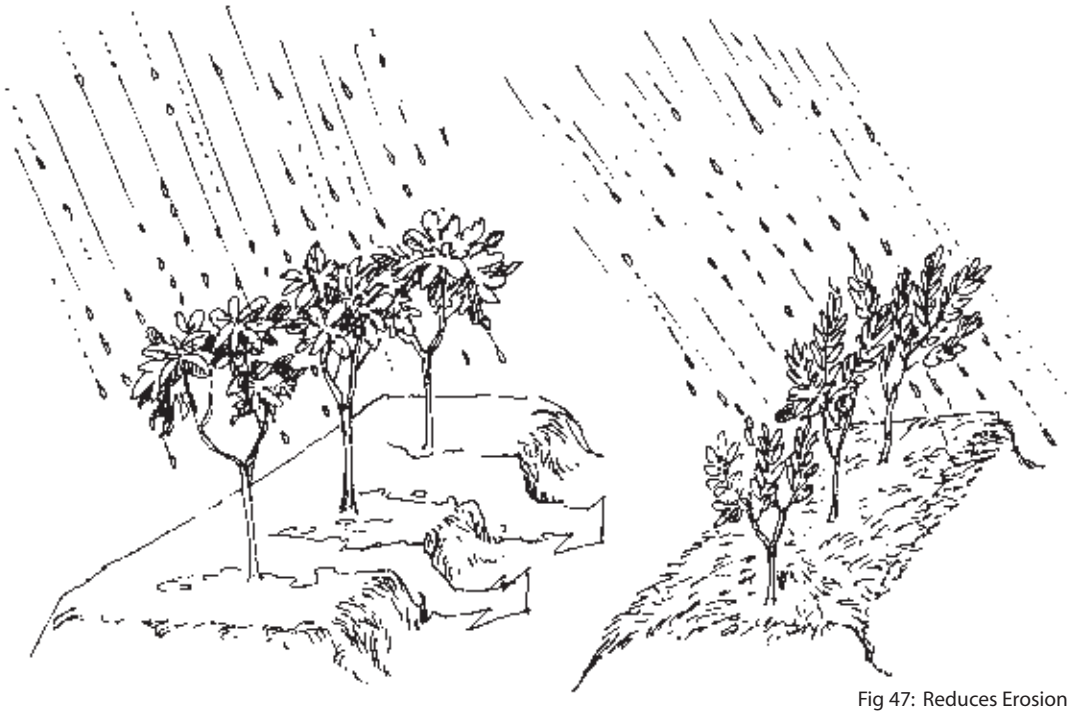


Fig 47: Reduces Erosion

Mulch for Seeds and Seedlings

Putting mulch on crop beds for seeds and seedlings will conserve moisture and keep the soil cool. Germination of seeds will be faster and seedlings will grow stronger, especially when the weather is hot and dry. Soil that has been planted with seeds can be covered in a thin layer of mulch. If the mulch is too thick no sunlight will reach the seeds, and it will be difficult for them to germinate. It is a good idea to look under the mulch each day to see whether the seeds have germinated. After the seeds have germinated pull the mulch away from the new shoots. This will stop the seedlings from becoming caught in the mulch, and the seedlings will get enough sunlight and space to grow.

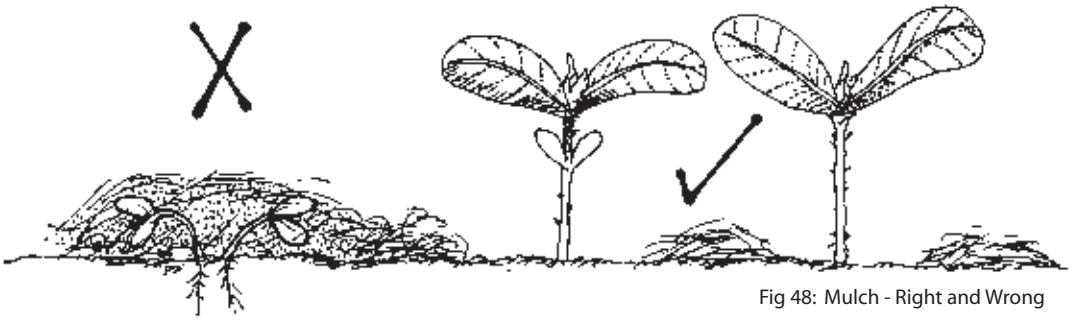


Fig 48: Mulch - Right and Wrong

Mulch for Plants and Trees

If mulch touches the stem of a plant or the trunk of a tree it will hold moisture and reduce the flow of air. This is a good environment for fungus, which can cause the stem or trunk to rot. It is very important to leave a space around stems and trunks.

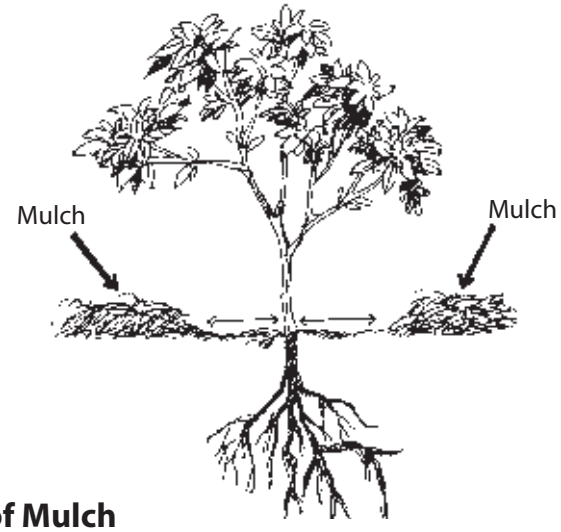


Fig 49: Mulch Around a Tree

Special Types of Mulch

Pests such as slugs and snails, can not move over mulch that is made of sawdust or crushed eggshells. This can help stop our plants from being eaten by these pests.

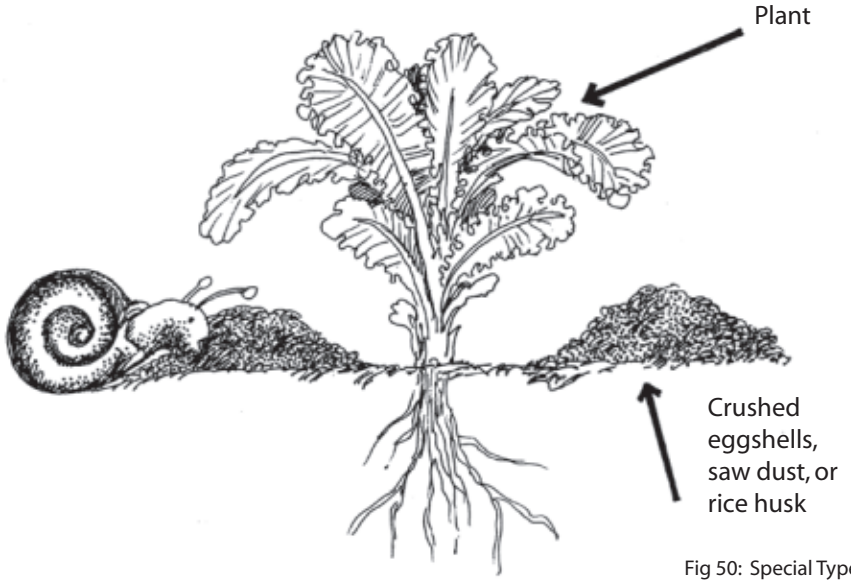


Fig 50: Special Types of Mulch

Mulch for Fruit Trees

The ground area around the edge of the canopy of a tree is called the drip line. As rain falls off the leaves of the tree, this area becomes a good source of moisture for the tree roots. If we put a thick layer of mulch around the drip line, the extra moisture will help break down the organic matter and provide a good source of nutrients for the roots of the tree that are growing underneath.

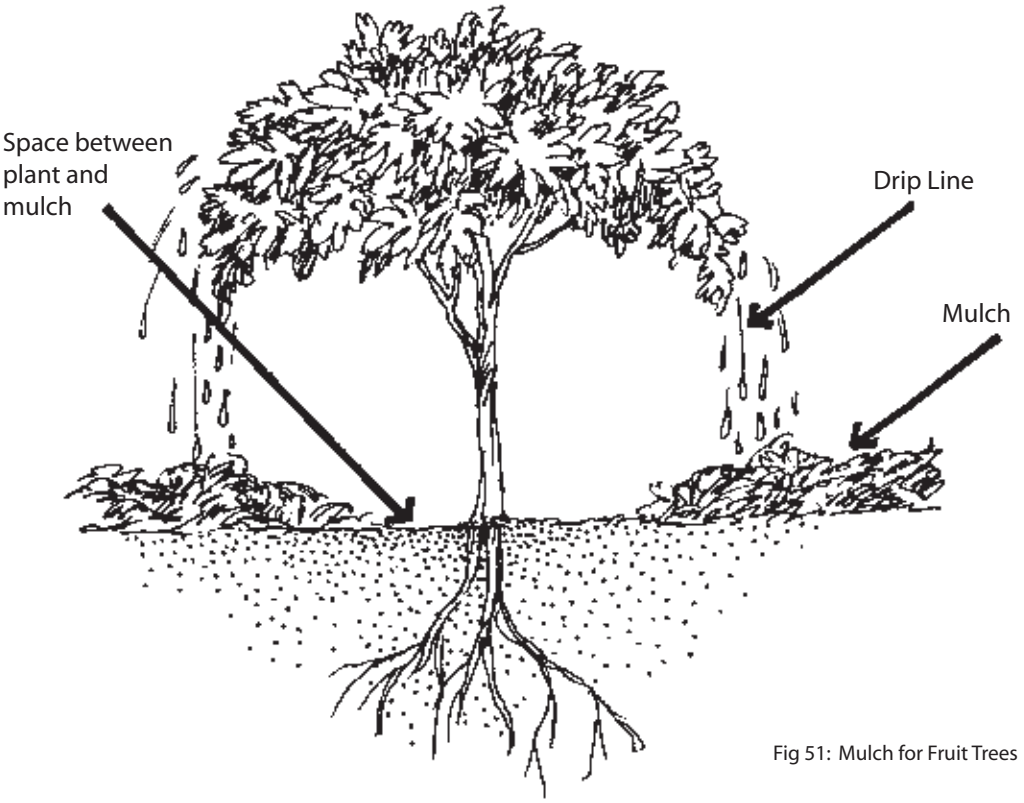


Fig 51: Mulch for Fruit Trees

NOTES

Overview

All living organisms need water to survive. We need to manage water carefully to be sure that we have a reliable supply for our crops. In this topic we will look at how to conserve and use water more efficiently.

Too Much Water

Plants will die if there is not enough water. But if there is too much water, plants can also die. If a soil does not drain well and absorbs too much water, it becomes waterlogged. Waterlogged soils have very little space for air and plant roots have difficulty breathing. Plants can often drown. Other effects of too much water include:

- If there is too much rain or watering, water will move through the soil very quickly and take away nutrients. This is called leaching. Soils that are leached of nutrients have very little food available for plant roots. Plants can often starve.
- Similarly, if there is too much rain or watering, topsoil can be washed away. This is called erosion. Erosion takes away valuable nutrients and destroys soil structure, making it difficult for plants to survive.

Water Needs

Different plant species need different amounts of water. For example, sweet potato can survive with less water than cucumber, and mustard needs more water than eggplant.

Plants also need different amounts of water at different stages of their life. For example, young seedlings or transplants are very sensitive to dry soil and need to be watered regularly. All plants need more water when they are flowering and producing fruits.

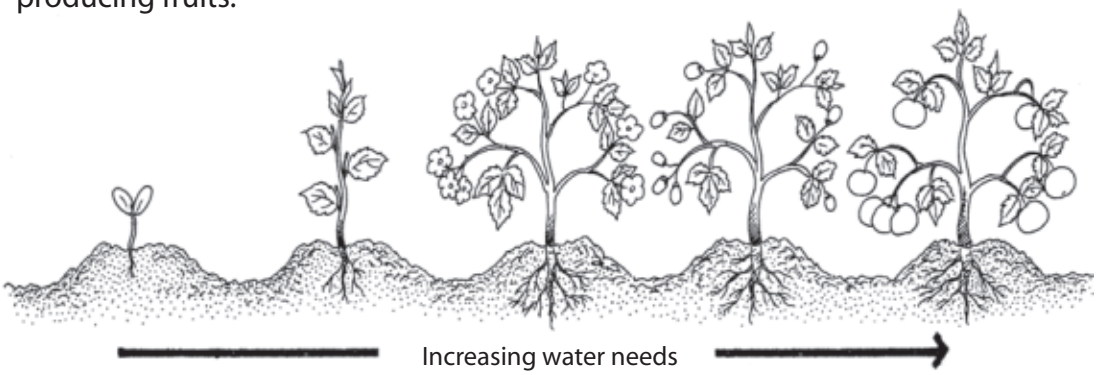


Fig 52: Water Needs of Plants

Saving Water

Soil that is rich in organic matter, and protected by mulch, will be able to conserve moisture over a long time. This is because organic matter is very good at trapping and holding moisture.

In hot, dry weather, a lot of moisture evaporates from the top layers of soil. Deep in the soil there is less evaporation, and the soil can hold water for a long time. Plants with deep root systems can use this water even when soil at the surface has dried out. When watering in the cold and hot seasons, we should make sure that water saturates the soil and not just wets the surface. If water can flow deeper than 10–15 cm, then plants with deep roots only need to be watered 2 to 3 times each week. If we only water the surface of the soil, plants will develop shallow root systems as they try to reach the surface water before it evaporates. Shallow roots dry out quickly and can be easily damaged.

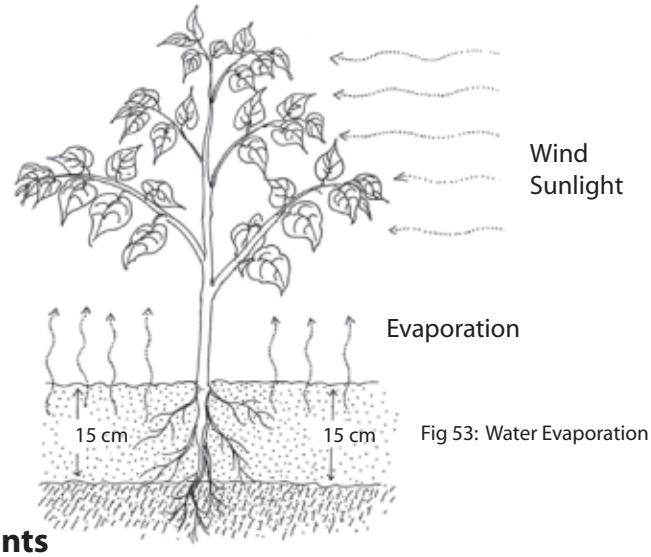


Fig 53: Water Evaporation

Watering the Roots of Plants

The roots of most vegetables grow in the top 20–30 cm of soil, but some plants, like tomatoes, can grow as deep as 1.5 m in good soil. We can save water by watering plant roots directly. There are two ways we can do this: containers and trench watering.

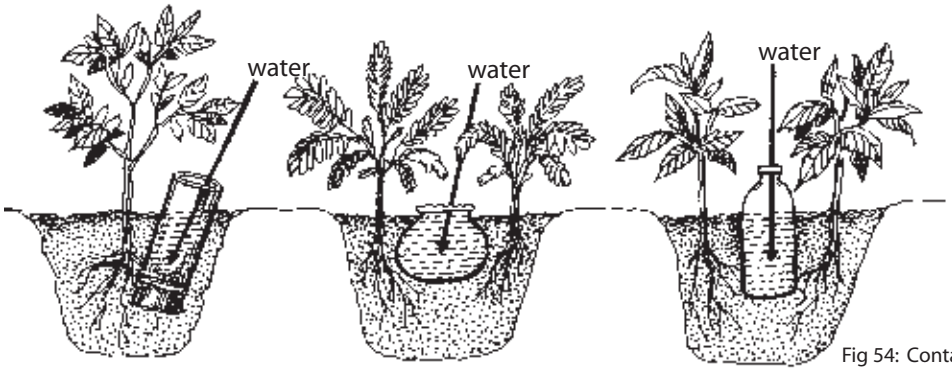


Fig 54: Container Watering

1 Containers

When preparing a crop bed, put an unglazed or cracked pot, bamboo pipe, or plastic drink bottle into the soil so that the top is just above the soil surface. The bamboo and bottles need to have small holes pushed through them first. Plant seeds or seedlings into moist soil about 10 cm from the centre of the container. Water as normal for two to three weeks. After the plants have become established, we only need to pour water into the pot 2 or 3 times each week. The water will slowly soak down into the root zone.

2 Trench Watering

Connecting trenches for watering are very similar to traditional irrigation ditches. Trenches are dug around individual or groups of plants. The trenches are sloped to let the water flow slowly down the whole length of the trench. They confine water to root zones and also collect rainfall.

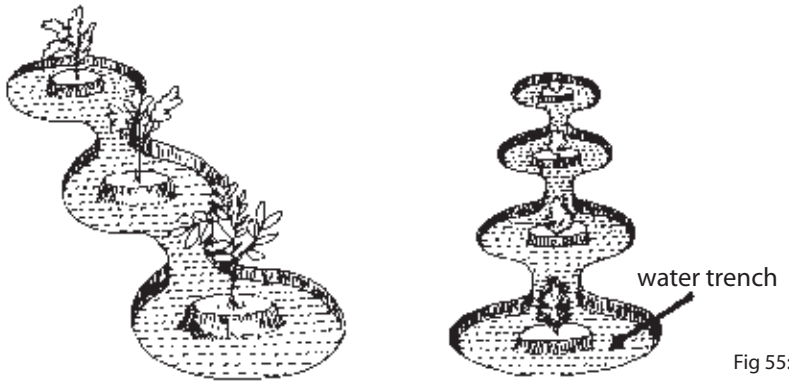


Fig 55: Trench Watering

Drip Irrigation

When we water with a watering can, a hose or an overhead sprinkler, some water is immediately lost because of evaporation, through surface run-off, or by falling in areas that don't need water, such as paths. A drip irrigation system is a good way to reduce the amount of water that is lost.

Drip irrigation releases water directly to the soil so there is very little evaporation. The water is also released slowly so that there is very little run-off. Water moves slowly down through the soil and is used efficiently by plant roots.

Fig 56: Drip Irrigation

The drip irrigation system in Figure 56 needs only a container to hold water, and a pipe or hose. The container is put on high ground so that gravity lets the water run out. The hose or pipe has very small holes so that water comes out one drop at a time. Plants are grown next to each hole. Make sure the hose is blocked at the end to stop water from running out.

Recycle Water

Water that is normally wasted around the house can be used again for growing plants. Water can be recycled from washing dishes and clothes, and from places where we bathe. One way is to channel waste water from the kitchen or bathroom into circle beds. Another way to recycle water is to grow plants that like wet conditions, such as taro or kang kong, near kitchens or washing areas.

The Time to Water

The best time of day to water plants is early in the morning when the soil is cool, or late in the afternoon. At these times the sun is low in the sky and there is usually less wind. This means that there is less evaporation of water from the top layer of the soil, so water has time to soak in and be absorbed by vegetable roots.

Fig 57: Watering Times

Catching Water

A lot of rain falls to the ground that we do not use. We can increase the amount of water available to us by trying to catch and store this extra water. A small roof with gutters and a few 200 litre drums can collect enough water for at least 3 or 4 small vegetable beds. In monsoon areas, this method of water collection is useful for establishing seedlings in the early stages of the cold season.

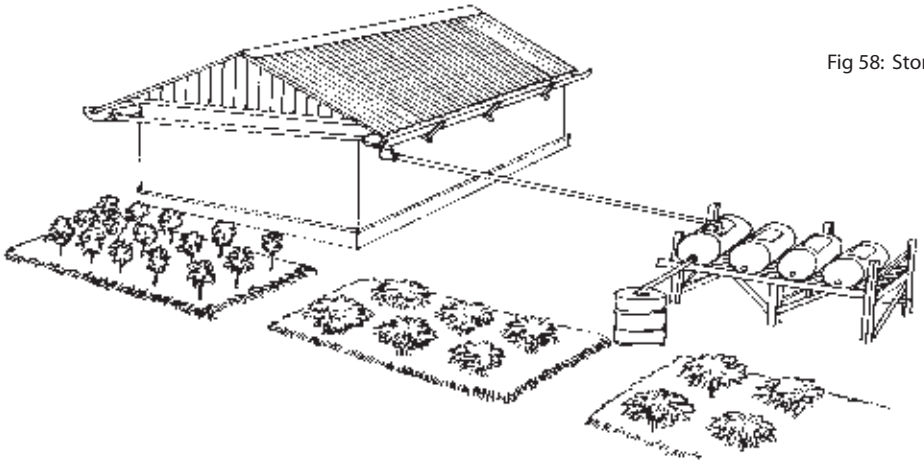


Fig 58: Storing Water

NOTES

CAN 5

Section 5: Fertilisers & Pest Control

Animal Manure
Green Manure
Liquid Fertiliser
Compost
Earthworms
Bio-Activators
Natural Pest Management

Overview

- Animal manure is made of organic matter and micro-organisms, and is a good source of nutrients. Different types of animal manure contain different quantities of nutrients (See Table: Animal Manure, below), but all types of manure can be used to improve the fertility of soils in gardens and farms.
- Animals that eat mostly vegetable matter make the best manure for improving soil fertility. This manure contains a lot of organic matter and beneficial bacteria. Manure from animals that eat mostly meat can have parasites and should not be used directly for growing food.
- Fresh manure from most types of animals is usually wet, not dry. Wet manure has a higher nutrient content than dry manure. However, the nutrient content of fresh manure can be too high and it can burn plants if applied directly. It is best to compost or dilute fresh manure before using it.
- Fresh manure usually contains high levels of soluble nitrates and phosphates that can pollute ground water, rivers and soil. It is best to keep animals, and to store or use manure at least 30 m away from a water source.

Animal Manure	N%	P%	K%	OM%	Moisture%
Cow / Buffalo	0.6	0.2	0.5	17	83
Pig	0.5	0.3	0.5	14	86
Chicken	1.1	0.8	0.5	25-45	55-75
Duck	0.6	1.4	0.5	25-45	55-75
Goat / Sheep	0.7	0.3	0.9	32-34	66-68
Rabbit	2.4	1.4	0.6	33	43
Bat*	10-15	5-10	1-5	-	-

* Dry

Using Animal Manure

- The best way to use animal manure is to make compost with it. The manure adds nutrients to compost and increases the number of micro-organisms that help decay organic matter.
- If manure is not composted immediately, it should be kept in a moist pile to stop the loss of nutrients. If manure is kept spread out and allowed to dry, a lot of nitrogen will be lost to the atmosphere.
- If fresh manure is added directly to the soil, it is best to wait at least one week before planting.

- Mixing manure from different types of animals can provide a good balance of different nutrients.
- An easy way to collect and use animal manure is to use bedding. Bedding is a material that is used to keep animals clean and dry because it absorbs liquid manure and urine.
  Examples of bedding include:
  - Rice straw used in chicken houses or cow pens.
  - Rice husks.
  - Saw dust.
  - Peanut shells.
  - Dry leaves.

  As well as being an easy way to recycle materials, bedding improves soil structure and adds carbon to balance the high nitrogen content of the manure. It is best to wait a week or two for decay before adding the mix ture of manure and bedding to the soil.
- If not composting, the best way to apply manure is to spread it thinly over the soil and then dig it in. Light rain or watering will help the soil to absorb more nutrients. A lot of manure put in one small area is not very useful and could even damage plants if it is too fresh.

Note:
See page 97 for information on using animal manure as a liquid fertiliser.

NOTES

Overview

Green manure is any type of plant that is grown to benefit the soil. Green manure is food for soil organisms, and can be food for animals or people. Green manure crops are very important in places where there is not enough compost or animal manure available.

Benefits of Green Manure

- Many different species of plant can be used as green manure and the seeds are usually easily available.
- When using green manure there is no need to use resources outside the farm or garden to improve soil fertility.
- All green manure species recycle nutrients and add organic matter to improve soil structure and fertility.
- Leguminous green manure crops specifically increase soil nitrogen.
- Green manure protects soil from exposure to sun, rain and wind, and so prevents erosion.
- Planting green manure between crops can help break the life cycle of some pests and weeds and reduce disease.

Using Green Manure

There are different ways and different types of green manure to use. The most common method is to grow green manure species on land that is being used for food crops. This helps to prevent erosion, replace nutrients, and repair soil structure. Green manure species can also be grown on land next to food crops, and harvested for use as mulch and fertilizer.

Rotation

In this system a green manure crop is grown during the time between harvesting one food crop and planting the next. This is very important for food crops that need a lot of nutrients, such as corn or mustard. The green manure is grown normally, but is dug back into the soil before it starts to flower and reproduce. This makes sure that when the plants decay the maximum amount of nutrients and organic matter are recycled back into the soil. Cow peas, mung beans and *Sesbania* are good green manure species to use, because they are legumes that do not need a lot of water.

Fig 59.1: Legume Crop under Maize

Living Mulch

Living mulch is a green manure that is grown under a food crop. Living mulches are nearly always legume species that can supply extra nitrogen to increase the yield of the food crop. A good example of a living mulch system is mung bean and maize. When the maize has become established after about four weeks, mung bean is sown in the same field. The maize is older and taller, so it does not need to compete with the mung bean for sunlight. The mung bean is a legume, so it adds nitrogen to the soil. The maize crop is harvested as normal, and the mung bean is dug back into the soil or harvested.

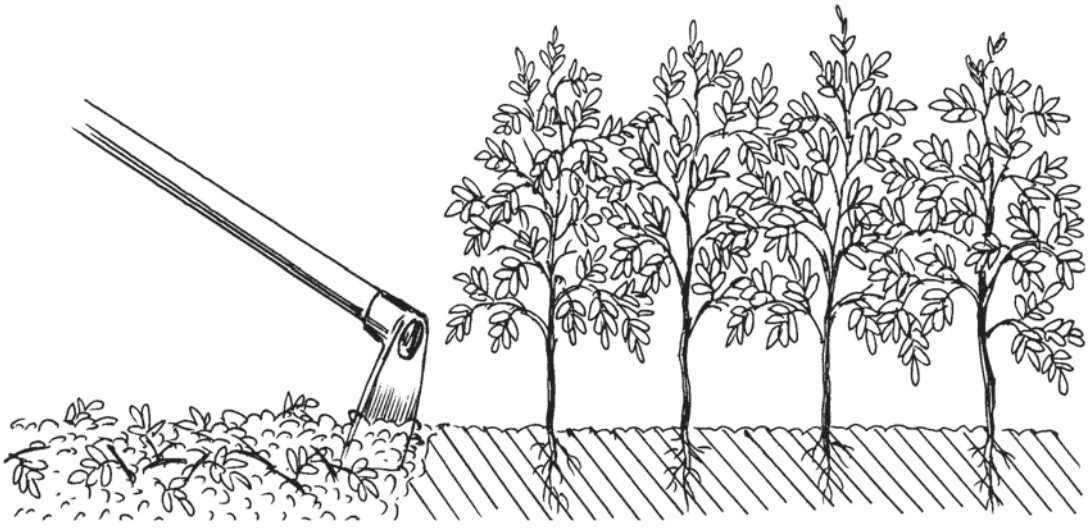


Fig 59.2: Digging in Leaves for Fertiliser

Green Manure from Agro-Forestry

Living fences, alley cropping, and contour planting are all examples of agro-forestry. In this system, trees and other perennial species are grown near or next to crop fields and beds to provide food, fodder, fuel wood and protection. The leaves and small stems of these plants can also be harvested and used as mulch or dug into the soil. Examples of good green manure trees include: *Moringa, Leucaena, Calliandra, Gliricidia, Azardirachta,* etc. See Section 6: Plants, for more information.

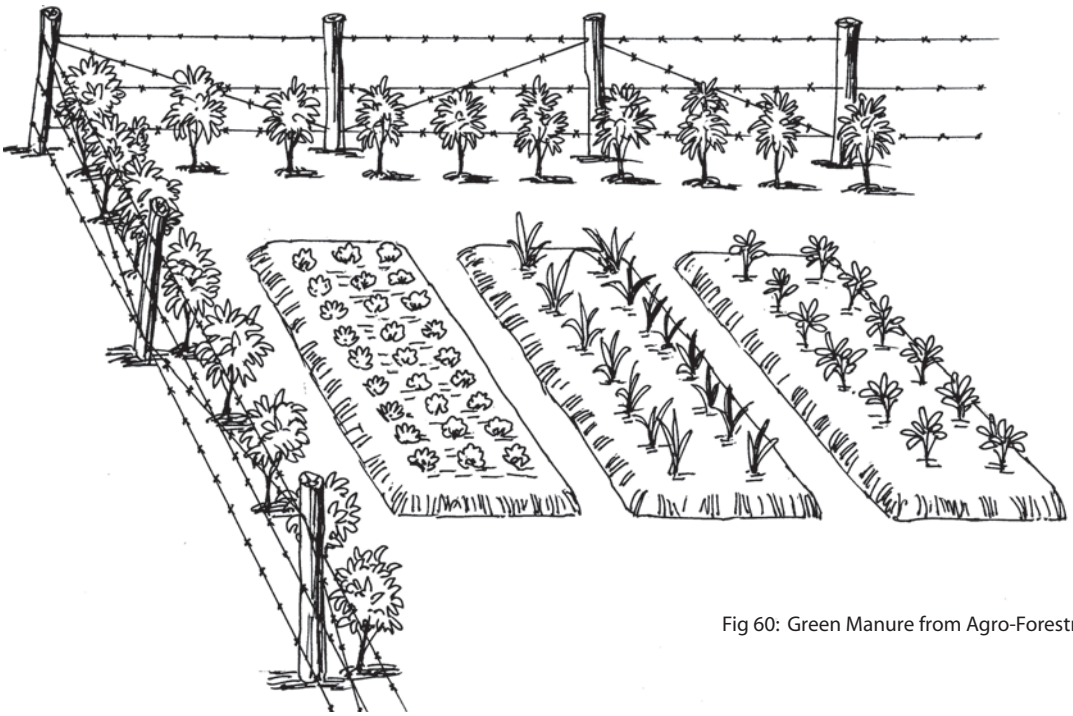


Fig 60: Green Manure from Agro-Forestry

NOTES

Overview

Liquid fertilisers are made from animal manure, green leaves or compost, which have been soaked and diluted in water. They contain many soluble nutrients and micro-organisms that can quickly and easily improve plant growth. Plants can absorb liquid fertiliser through their roots and the pores in their leaves. Liquid fertilisers are usually applied every two weeks, but can be used more frequently if plants have an increased need for nutrients, for example: after transplanting, during flowering and fruiting, or if stressed by disease or drought.

Liquid Animal Manure (Manure Tea)

Animal manure is rich in nutrients, micro-organisms and organic matter. The manure of most farm animals can be used for liquid fertiliser, but it needs to be applied in different ways depending on existing nutrient levels. See Table: Animal Manure on page 92 for more information about the nutrient levels of different animal manure.

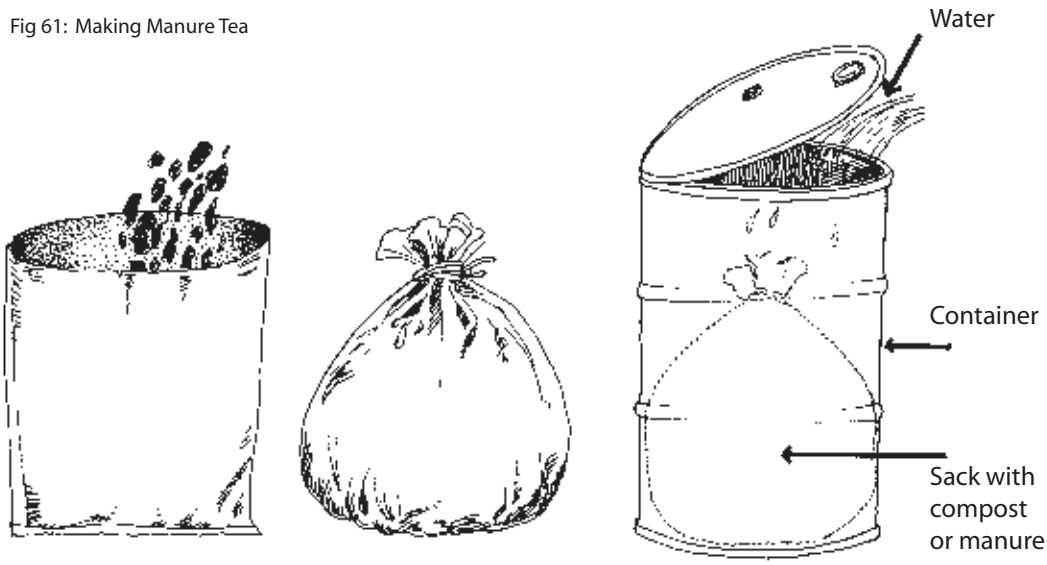
Materials:

- A rice or grain sack, or any type of cloth that will let water and air move through it.
- A large container for holding water. The bigger the container the more manure tea can be made. Make sure the container is clean.
- A lid or cover for the container.
- Animal manure; fresh is best.

Procedure:

1 Collect the manure and put it in the sack. Tie the sack closed.
2 Put the sack into the container.
3 Fill the container with water, but leave some space at the top.
4 Lift the sack up and down a few times to be sure that the manure be comes wet and gets mixed thoroughly. Do this two to three times every day.
5 Keep the lid or cover on the container to keep out pests and reduce smell.
6 Leave for two weeks.
7 Before using on crops, dilute one part of the finished liquid manure with twenty to thirty parts water (e.g.; 100 mL liquid manure with 2 L or 3 L water). Be careful – use only weak liquid manure solution on young plants. (Figure 61, Pg. 98)

Fig 61: Making Manure Tea



Using the Manure Tea

- After about two weeks the water in the container will have dissolved nutrients from the manure and it will look brown like tea.
- Take the sack out of the container and use the manure for making compost or preparing a new bed or field.
- The liquid left in the container is strong and will burn the leaves and roots of plants if it is applied directly. The liquid needs to be diluted with water before being used on crops. Manure teas made with concentrated manure from goats or chickens need to be diluted with more water than manure teas made with less concentrated manure from cows or pigs. On average, one part manure tea should be diluted with 20 parts water, but to be sure it is best to test a little liquid on a small area of weed or grass first. If after two or three days the area you have tested looks burnt or brown, the manure tea will need to be diluted with more water. With practice, experienced farmers will not need to test manure tea before using it.
- Liquid fertilizer is applied every two weeks, but can be applied twice a week if plants have an increased need for nutrients. They can be applied to both soil and leaves.
- The best times to use liquid fertiliser are early morning and early evening, when the liquid will be absorbed quickly and won't burn the leaves. If concentrating on the leaves, be sure to wet the underside of the leaves where the pores are. Water them until the liquid drips off the leaves.
- Surfactants can be used to improve the effectiveness of liquid fertilizers. Use coconut oil or a mild soap (one teaspoon per 5 L of spray) to make sure the leaves are completely covered.

Liquid Plant Manure (Plant Tea)

The leaves of all plants contain nutrients, and the leaves of legumes contain good amounts of nitrogen. Using the leaves of legumes to make plant tea is an effective way to increase nitrogen levels for crops.

Materials:

- A large container for holding water. The bigger the container the more plant tea can be made. Make sure the container is clean.
- A lid or cover for the container.
- A long stick or piece of bamboo.
- Scissors or a knife to cut up leaves.
- A good source of leguminous plant leaves (e.g. *Leucaena, Gliricidia, Tamarindus,* etc.)

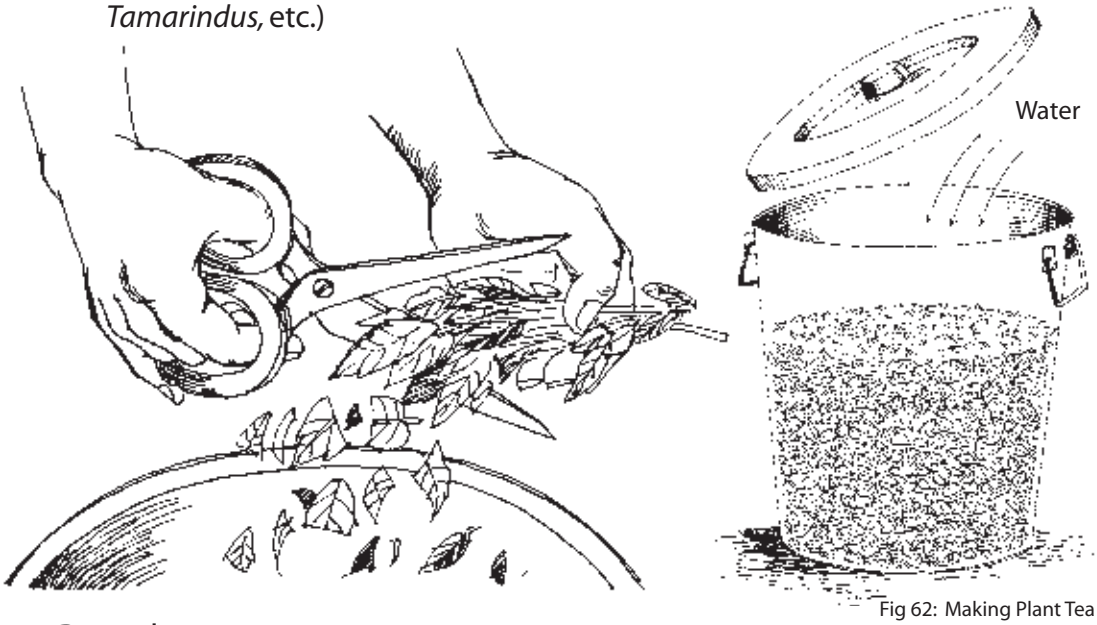


Fig 62: Making Plant Tea

Procedure:

1 Collect fresh leaves and cut them into small pieces.
2 Fill the container three quarters full with the leaves.
3 Fill the container with water, but leave some space at the top.
4 Stir the leaves and water with the stick. Do this two - three times every day.
5 Cover the container and wait for about 2 weeks.

Using the Plant Tea

As the leaves decompose and release nutrients, the water in the container will become darker, and after about two weeks it will be ready to use. Plant Tea is usually not as strong as manure tea, but it still must be diluted before using on crops. Test different strengths of plant tea before deciding on the best dilution (one part tea to 20 parts water is average). Apply plant teas the same way as manure teas.

Liquid Compost (Compost Tea)

Many of the nutrients in compost are easily dissolved in water, and compost tea is an effective way of delivering these nutrients to plants. The procedure for making compost tea is shorter and easier than for manure or plant tea, and the compost can provide a better balance of different nutrients.

Materials:

- Finished compost; remove any larger pieces.
- Watering can.
- Stick or bamboo for stirring.

Procedure:

1 Fill the watering can half with finished compost and half with water.
2 Stir gently until thoroughly mixed.
3 The compost tea can be used straight away and there is no need to dilute it.

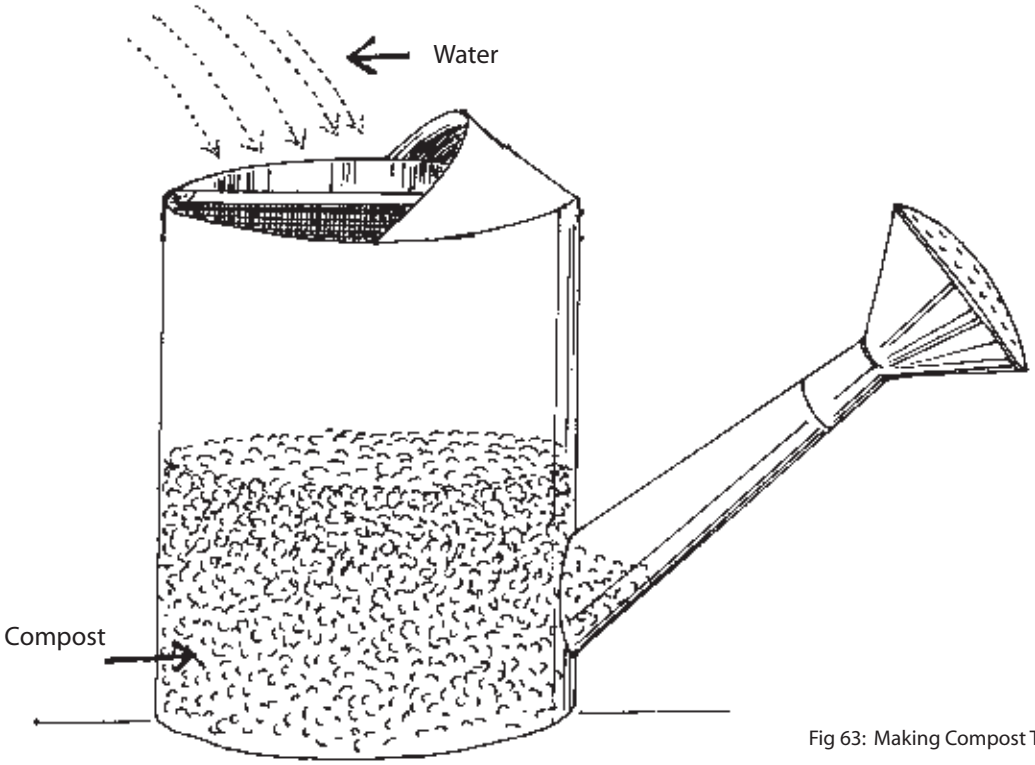


Fig 63: Making Compost Tea

Using the Compost Tea

The same compost can be used 3 to 5 times to make tea because the soluble nutrients dissolve slowly. The remaining compost is still very valuable and should be dug into the soil or used as mulch. Apply compost teas the same way as manure or plant teas.

The Forest Floor

In nature, all living things die, and their death allows life to be reborn. Animals and plants die and are decay through time, water, sun, air, and micro-organisms. In the forest, the roots of trees and plants gather nutrients from deep in the soil, and send them to the leaves of the trees and plants. When the leaves and branches die and fall to the ground, they decay. This process improves the structure and nutrient levels of soils. Farmers can copy the decay process to improve their soils by making compost.

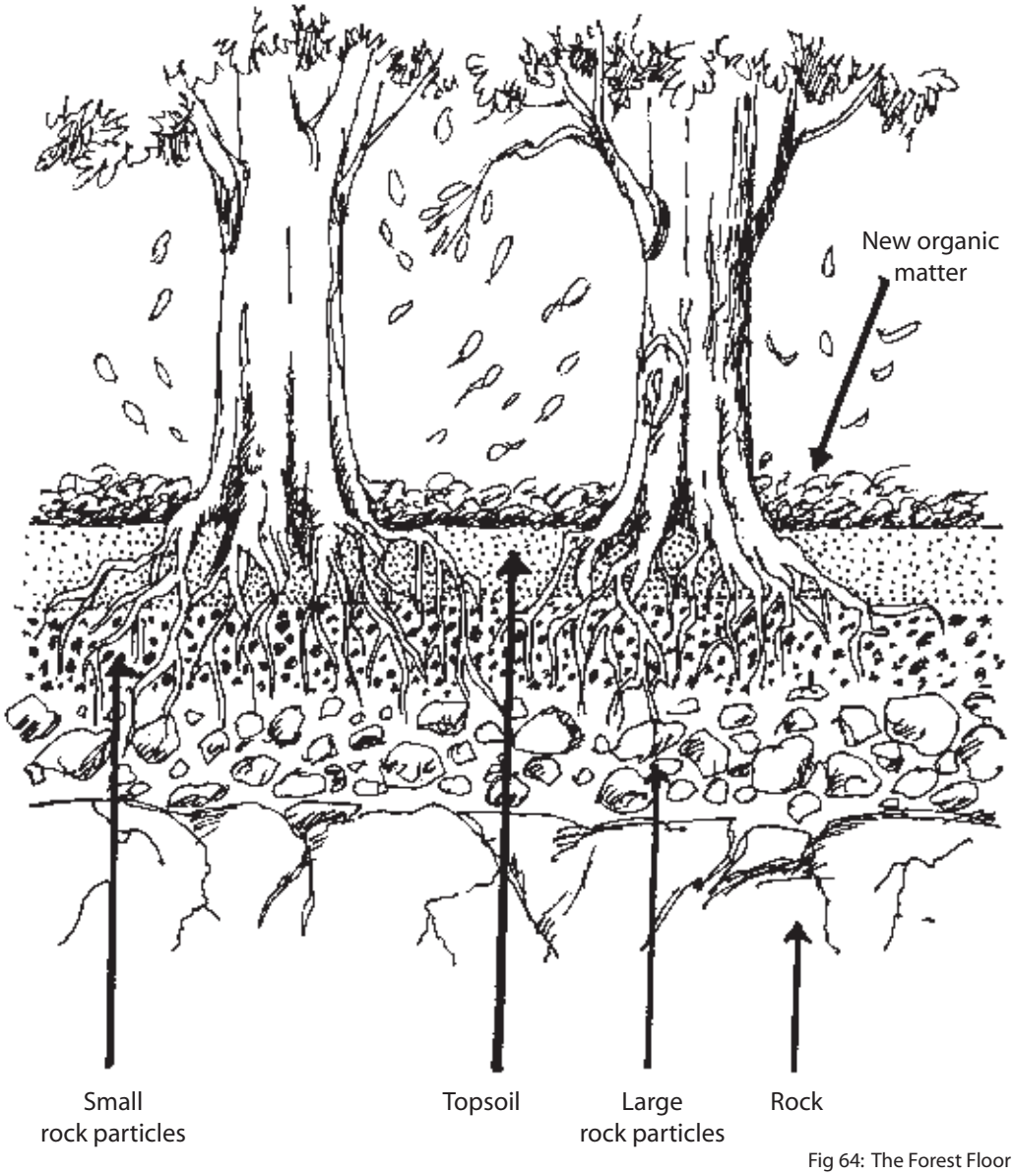


Fig 64: The Forest Floor

Composting

Composting is the process of controlling the decay of organic material to produce soil nutrients. Anything that will decay will provide nutrients for plant growth, but some organic materials provide more nutrients or are easier to compost than others. The most important point is that organic matter must be fully decayed before the nutrients are available for plants to use.

Just like decay on the forest floor, composting is a living process. It needs time, water, sun, air, and other organisms to succeed. By managing these things, farmers can produce good, nutrient rich compost all year round and have no need to use chemical fertilisers. The Table below gives detail of organic matter that can be composted and what type of nutrients it can provide. Compost can be made in a pit, in a mound, in baskets or it can be put straight onto the soil. In this topic we describe different ways to make compost near their home or on the farm.

Making Compost

A simple way to make compost is to think of three colours: Yellow, Green, and Black. Just as people need a balanced diet to be healthy, a good balance of materials produces healthy compost with more available nutrients:

- *Yellow:* Organic material rich in carbon; examples include dry leaves, thatch, rice straw, dried grass, etc.
- *Green:* Organic material rich in nitrogen; examples include green leaves, legume plants, kitchen scraps.
- *Black:* Organic material rich in micro-organisms and often nitrogen; examples include fresh animal manure, good topsoil and compost made recently.

Yellow - Carbon Rich Materials (C)	C/N
Coconut Husks	200 : 1
Sugar Cane Fibre	200 : 1
Paper	150-200 : 1
Rice Husks	120 : 1
Straw	120 : 1
Dry Grass	50 : 1
Dry Leaves	50 : 1
Tree / Bush Cuttings	50 : 1
Grass or Leaf Thatch from Old Roofs	50 : 1

Green - Nitrogen Rich Materials (N)	C/N
Vegetable Crops	12 : 1
Green Weeds	12 : 1
Vegetable and Fruit Waste	12 : 1
Soya Bean and Peanut Waste	15 : 1
Manure	15 - 20 : 1
Green Grass	20 : 1
Sugar Cane Cake	25 : 1

Black - Micro Organisms	
Fresh Animal Manure	Micro - Organisms/Nitrogen
Good Topsoil	Micro - Organisms/Nitrogen
Leaf Litter from Forest Floor	Micro - Organisms
Bio-Activators	Micro - Organisms
Fresh Compost	Micro - Organisms

Note:
The ratio of Yellow / Green / Black material should be 6:3:1
That is:

Yellow: 6 parts (example, 6 buckets of dried leaves)
Green: 3 parts (example, 3 buckets of fresh, green leaves)
Black: 1 part (example, 1 bucket of fresh animal manure)

We do not need to weigh or be exact for each part; with practice farmers can tell how much of each material there is just by looking at the amount.

Procedure:

1 Choose a place to make the compost, a space of 2^2 m is good. The area should be sheltered from too much wind or rain; under a tree is a very good place to make compost.
2 Collect the necessary Yellow / Green / Black materials from around your home, farm or forest. Break the material up into small pieces; the smaller the pieces the easier it will be for micro-organisms to break them down, just the same as we chew food. For example, if using rice straw for the Yellow material, chop it up into lengths 2-5 cm long before using them. Similarly, if the fresh manure is very wet, mix it with a little bit of water when adding it to the pile, or break dryer pieces up into small parts.
3 The compost can be made by putting the material together in layers or by mixing it all together before making it into a pile. Mixing the material all together means more work but produces faster compost.

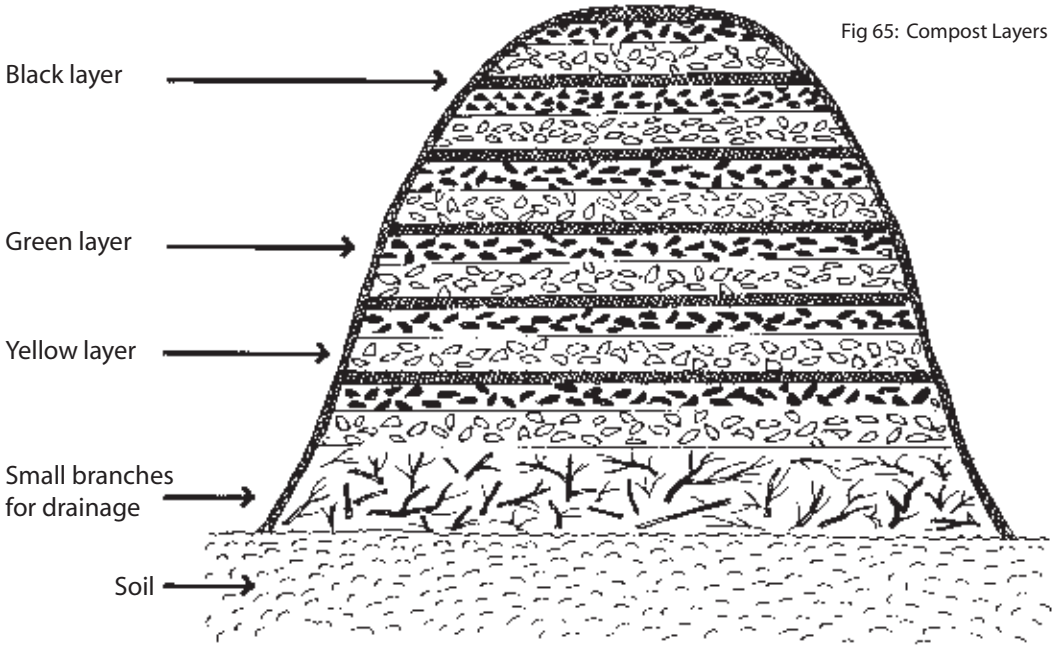


Fig 65: Compost Layers

4 The most important thing in making compost is making sure that there is enough air and water. To make sure that micro-organisms have air to breath, do not pack the materials too tightly. To make sure that micro-organisms have enough water to drink but not too much to drown, water the material lightly as you add it to the pile.

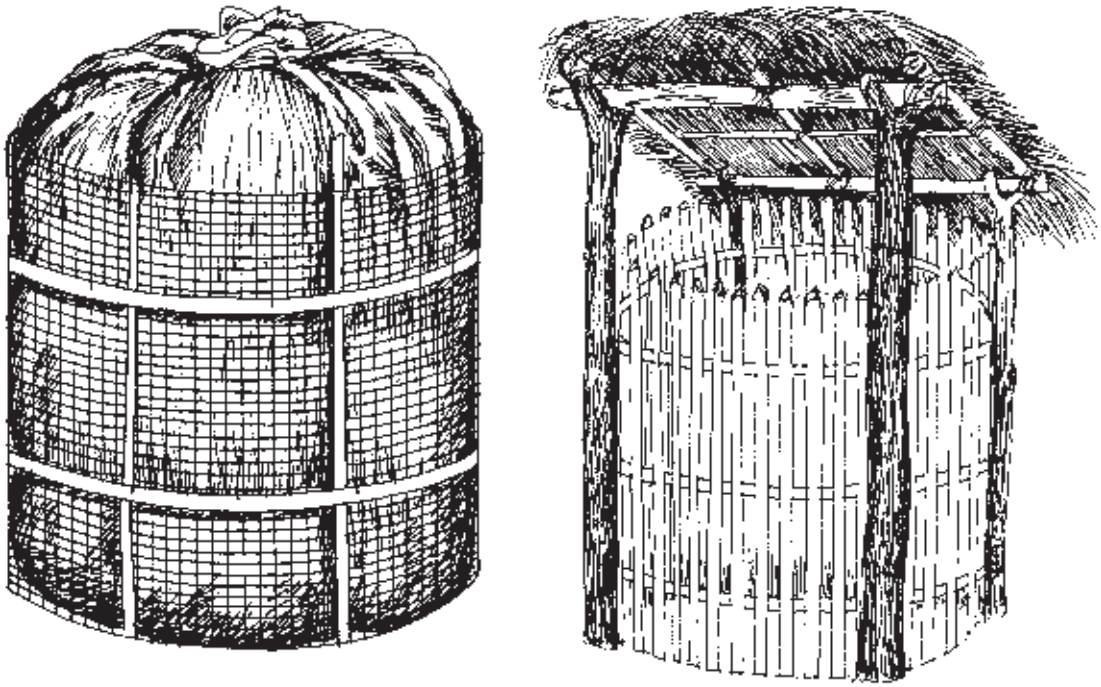


Fig 66: Compost Containers

5 Once all the material is all together in a pile, make sure that it is protected from heavy rain or animals. The simplest way to do this is to make a bamboo fence around the compost pile and use banana leaves or old plastic to cover the top. (Usually it is easier to make the fence first and put the compost materials into it).

6 Use a piece of bamboo or stick to make a hole through the centre of the compost from the top. After one or two days, the air inside this hole will get hotter and hotter as the micro-organisms start to decay the organic material in the pile. After a few more days it will cool down again as the micro-organisms start to use up the organic matter. Some farmers keep bamboo poles in their compost to let in more air.

7 To make sure that the micro-organisms are working effectively, it is important to mix the compost pile about every 7 days. Mixing the compost is simply done by removing the fence, and turning the bottom of the pile onto the top. When we do this we can observe if the compost is too wet and needs to be dried for a day, or if it is too dry and more water needs to be added. Once this is done the pile can be fenced again and then turned in another 7 days.

Depending on the weather, and the materials we use, compost made in this way is finished and ready to use in about 4 weeks. Finished compost has a good brown/black colour, smells like good topsoil, and has a good loose texture. It can be added straight away to garden beds, seed beds and container baskets, around trees, or used to make compost tea.

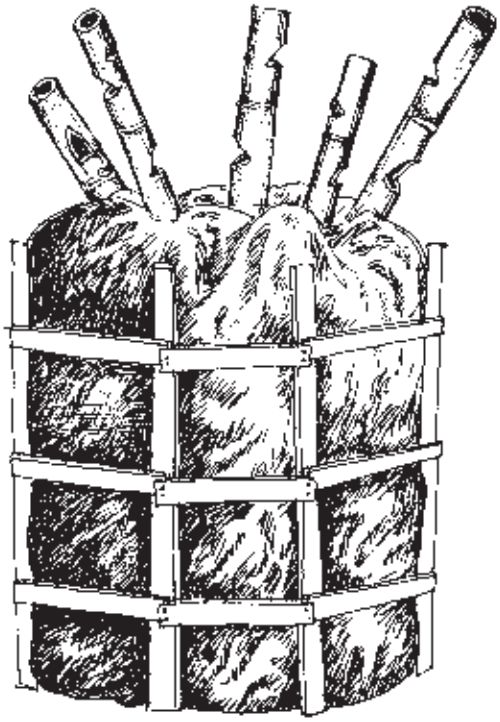


Fig 67: Aerating Compost

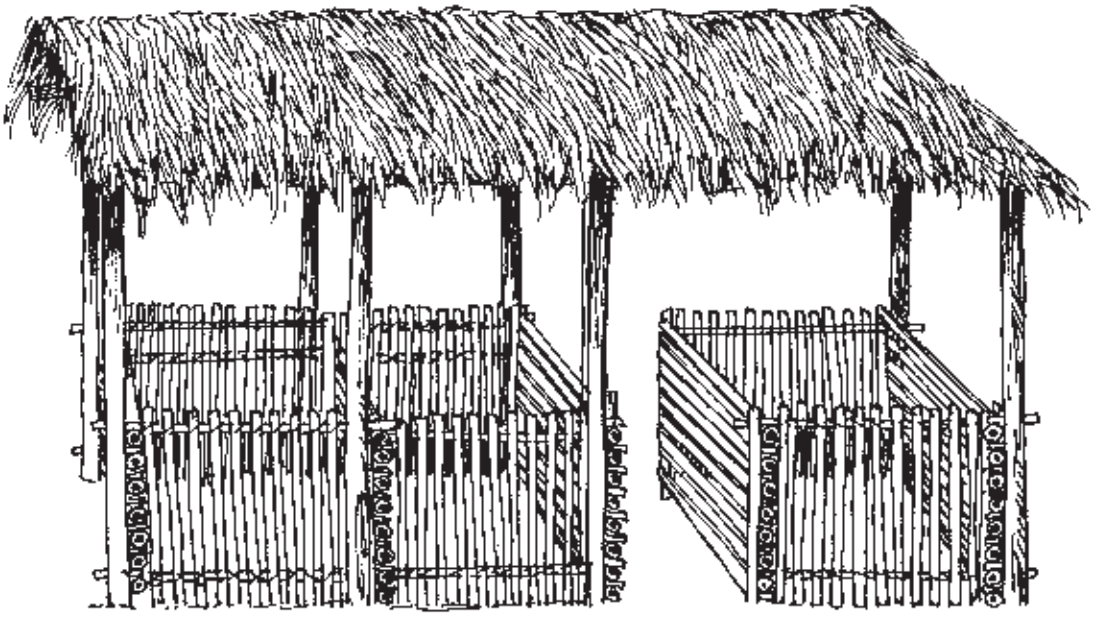


Fig 68: Rotating Compost

In Figure 68, continuous compost can be made by rotating a compost pile every 3 weeks in a sheltered area. Starting on the left, in pen number 1, make compost as normal. After 3 weeks dig it out and put it in pen number 2, and make new compost in pen 1. After another 3 weeks put compost 2 into pen number 3 and 1 into 2, and make new compost in pen 1. After another 3 weeks the compost in pen 3 is ready to use and the process can continue.

NOTES

Percentage Composition of Nutrients in Various Organic Materials				
No	Organic Materials	Nitrogen (N%)	Phosphorus (P%)	Potassium (K%)
1	Banana Skin (ash)	0	3.3	41.8
2	Banana Stalk (ash)	0	2.3	49.4
3	Coffee Grounds	2.1	0.3	0.3
4	Corn Cob (ground)	0	0	2.0
5	Corn Cob (ash)	0	0	50.0
6	Corn Stalk	0.8	0	0
7	Common Crab	2.0	3.6	0.2
8	Cowpea (green forage)	0.5	0.1	0.5
9	Cowpea (hay)	3.0	0	2.3
10	Cowpea (seed)	3.1	1.0	1.2
11	Cucumber Skin (ash)	0	11.3	27.2
12	Dried Jellyfish	5.0	0	0
13	Chicken Manure	1.1	0.8	0.5
14	Duck Manure (fresh)	1.1	1.4	0.5
15	Cow Manure	0.6	0.2	0.5
16	Pig Manure	0.5	0.3	0.5
17	Sheep Manure	0.7	0.3	0.9
18	Horse Manure	0.7	0.3	0.6
19	Rabbit Manure	2.4	1.4	0.6
20	Bat Manure	1 - 12	3 - 16	0
21	Egg Shell (burned)	0	0.4	0.3
22	Egg Shell	1.2	0.4	0.1
23	Feathers	15.3	0	0
24	Field Bean (seed)	4.0	1.2	1.3
25	Field Bean (shell)	1.7	0.3	0.4
26	Fish Scrap (fresh)	2 - 8	2 - 6	0
27	Fresh Water Mud	1.4	0.3	0.2
28	Garbage (rubbish)	3 - 4	0.1 - 4	2 - 4
29	Hair	12 - 16	0	0
30	Hoof Meal and Horn Dust	10 - 15	2	0
31	Leather (ground)	10 - 12	0	0
32	Orange Skin (ash)	0	3.0	-27.0
33	Peanut Shells	0.8	0.2	0.5
34	Pigeon Manure (fresh)	4.2	2.2	1.4
35	Pumpkin Seed	0.9	0.5	0.5

No	Organic Materials	Nitrogen (N%)	Phosphorus (P%)	Potassium (K%)
36	Residue from Raw Sugar	1.1	8.3	0
37	Tea Grounds	4.2	0.6	0.4
38	Tobacco Leaf	4.0	0.5	6.0
39	Tobacco Stalk	4.0	0.7	5.0
40	Bone Meal	1.1	11.0	0
41	Blood Meal	11.0	0	0
42	Cotton Seed	6.0	2.0	1.0
43	Soybean Meal	7.0	0.5	2.3
44	Saw Dust	0.2	0	0.2
45	Wheat Straw	0.7	0.2	1.2
46	Wood Ash	0	1.5	8.0
47	Worm Casting	0.5	0.5	0.3
48	Grass Clipping (green)	0.5	0.2	0.5
49	Compost (home made - 25% organic matter)	0.5 - 4	0.5 - 4	0.5 - 4
50	Leucaena Leaf	4.3	0 - 2	2.5
51	Gliricidia Leaf	4.2	0.3	3.4

NOTES

Earthworms

The farmers best friend is the earthworm. Earthworms constantly improve soil fertility by recycling organic matter and providing nutrients to new generations of plants. As earthworms move through the soil in search of food, they also create tunnels that improve the flow of air and water to plant roots. The more earthworms in the soil, the better the fertility of the soil and the healthier crops will grow.

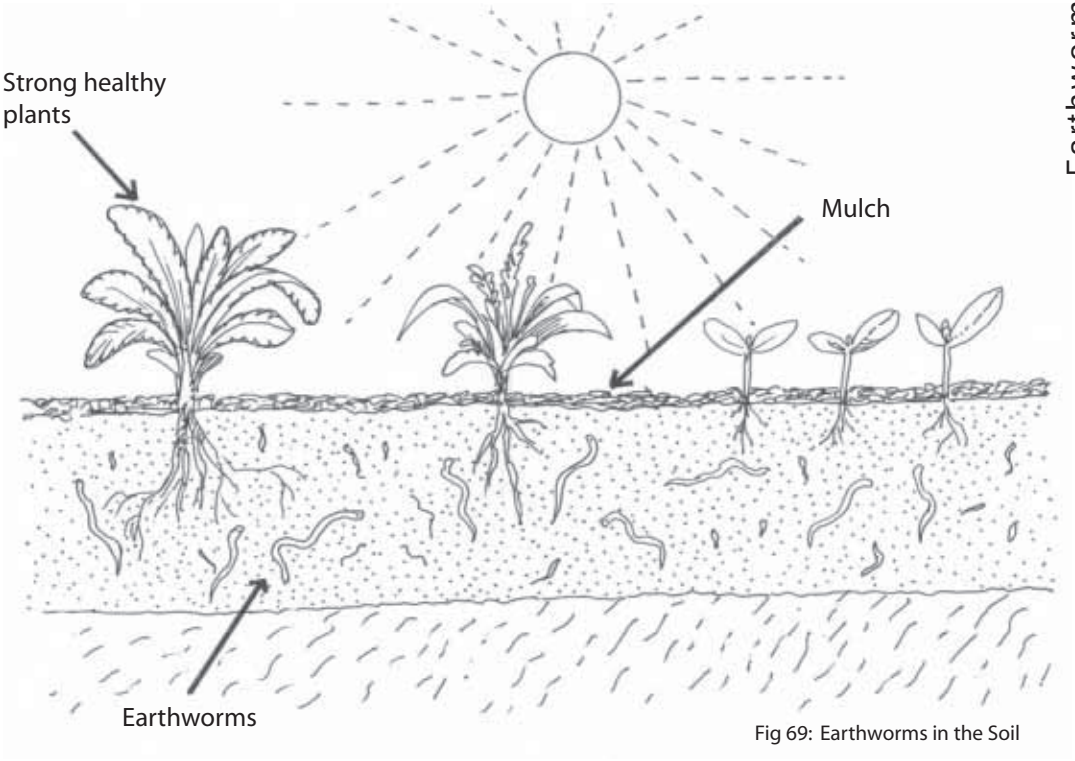


Fig 69: Earthworms in the Soil

Earthworms can be divided into three groups, and every group helps to improve soil fertility:

1 Surface Earthworms (*Epigeic*): These worms live at the surface of the soil, under mulch on garden beds and the forest floor. They are very important for the decay of fresh organic matter.
2 Soil Earthworms (*Endogeic*): These worms live within the soil and "eat" the soil to get nutrition from decayed organic matter.
3 Deep Earthworms (*Anecic*): These worms live deeper in the soil, but move to the surface at night to eat fresh and decaying organic matter. They are very important for creating tunnels in the soil for air and water, and for bringing nutrients up to plant roots.

When preparing and managing crop beds, we normally find both surface and soil earthworms. If we do not find any, then the soil is not very fertile and a lot of work will be needed to improve it. The best ways to encourage and increase the number of earthworms is to continually add compost, mulch and green manure to the soil. Heat, light, too much digging, and the use chemicals are all harmful to earthworms.

Raising Earthworms for Making Fertiliser

In the restricted spaces of refugee camps, many houses do not have enough land for compost piles or garden beds. However, many houses can use container planting if they have enough sunlight, and one of the best fertilisers for these containers is earthworm manure (called *Vermicast*). Vermicast is very rich in nitrogen, phosphorous, potassium and other nutrients such as calcium. It is easily produced in a small place, and it can help to recycle some types of organic material that would otherwise be wasted. Below is one method of making an earthworm farm to produce vermicast.

Materials:

- A clean container with a lid and holes in the bottom for good drainage. (We can use old washing basins, or oil tins cut in half sideways, or make our own container from bamboo, if available).
- Fresh or dry manure; pig, goat, cow or buffalo, manure is one good source of nitrogen and bacteria.
- Saw dust, rice husks, straw, old paper, or old thatch broken into small pieces (i.e. carbon).
- Worms collected from good topsoil, compost piles, or under mulch in crop beds or the forest.
- Water.

Procedure:

1 Choose a cool place for the container, protected from rain and away from direct sunlight. Try to keep the container up high, away from chickens, dogs and curious children.
2 Mix the manure (2 parts) and the paper or straw, etc. (3 parts), and put in the container. On the top, add a thick layer of mulch, paper, or broken thatch (up to 5 cm).
3 Add water until you start to see drops from the bottom of the container. Wait for 3 - 5 days for bacteria and fungus to start to grow. Make sure to keep the mixture moist but not too wet.

4 After 3-5 days, collect and add worms to the container. How many worms you add depends on how much food you can provide the worms, but add at least 2-3 handfuls. On the top, add another thick layer of mulch, paper, or broken thatch mixed with manure (up to 5 cm). Keep the mixture moist but not too wet.

5 After two or three days check to see if the earthworms are beginning to break down the top layer. If successful, keep adding more mulch to the top layer. It's best to keep adding the same type of material. Earthworms in small containers do not like meat, oil or the skins of citrus fruits. Remember to keep the mixture moist.

6 After a week we will start to see small, black round particles in the container. This is earthworm manure; vermicast. Collect the vermicast about once every month and use it directly on containers or make liquid manure.

NOTES

Overview

A bio-activator is a natural substance that has an effect on living things. In agriculture, a bio-activator is something that increases the biological activity of compost, manure, or soil and helps to make more nutrients available to crops.

In this section we will talk about three very useful types of bio-activators:

IMO Indigenous Micro-organisms.
FPJ Fermented Plant Juice.
FFJ Fermented Fruit Juice.

These three types of bio-activators use beneficial bacteria and other micro-organisms to quicken decay to make nutrients available. They are easy and cheap to make, and are especially useful for container planting and animal raising in small spaces.

IMO Indigenous Micro-organisms (Type One)

Materials:

- Rice (500 g).
- Raw sugar or molasses (150 g - 250 g). The weight of the sugar should be about one-third the weight of the rice before it is cooked.
- Plain paper (not newspaper).
- String.
- Plastic sheet or bag.
- Container big enough to hold the cooked rice.
- Hoe or shovel.
- Containers or bottles with lids to store the finished IMO mixture.

Procedure:

1 Cook the rice as normal.
2 Put the cooked rice into the container to a depth of about 3 cm.
3 Cover the container with the piece of paper and tie with string.
4 Dig a hole in forest litter or good soil and put in the container. Surround the container with leaf litter and soil and then cover it with the plastic sheet or bag to stop any water from getting in.
5 Check the place where the container is buried in the morning and evening to make sure no animals have disturbed it, but do not take off the plastic.
6 After 3 to 5 days, depending on the weather and the soil, remove the container. If the rice is wet, has fungus (a green / yellow colour), and smells a little sour, then micro-organisms have started to grow .

7 Put the sugar or molasses in the container and mix well with the rice.
8 Cover and tie the container with paper again and put back into the same hole. Surround with leaf litter/soil, and cover with the plastic sheet.
9 After 6 to 7 days, take out the container and check inside. The rice should have become a thick, strong smelling liquid. This liquid is full of living micro-organisms.
10 Using a cup, spoon or funnel take the finished IMO liquid out of the container and pour into the storage containers or bottles. Add a little extra water and then put the lids on and store in a cool place away from sunlight. The IMO is now ready to use.

Making Compost with IMO (Type One)

IMO should be mixed with rice bran to the proportion of 1:500 (Example: 1 g of IMO for 500 g of rice bran). In the following example we will use 5 g of IMO for 2.5 kg of rice bran:

1 Take 2.5 kg of rice bran and add water to it until you can form a ball with it in your hand that does not break or loose its shape.
2 Add the 5 g of IMO and mix well.
3 Keep the mixture in a container in a cool, dry place.
4 After 2 to 3 days, the mixture will have started fermenting and will be warm/hot to touch.
5 Take the fermented rice bran and mix it with 75 kg to 125 kg of fresh animal manure (i.e., 30 to 50 times the weight of the rice bran).
6 Mix in 15 kg to 25 kg of good soil (i.e. 20% of the weight of the manure).
7 When the rice bran, animal manure and soil have been mixed together, cover the pile with rice straw or dry leaves. Protect the pile from rain by covering it with a plastic sheet.
8 In 2 to 3 days, the pile will heat to 40-50 degrees Celsius and then start to cool. The complete decay process will take about three weeks.

The finished IMO compost can be used the same way as other types of compost. It can be applied to fields and beds at the rate of 10 tonnes per hectare.

IMO Indigenous Micro-organisms (Type Two)

Materials:

- 1 kg Rice bran.
- 1 kg Topsoil.
- 1 kg Sugar.
- 20 L Water.
- Cloth.
- Container with lid, big enough to hold about 25 L.
- Containers or bottles with lids to store the finished IMO mixture.

Procedure:

1 Mix the rice bran and the topsoil together thoroughly.
2 Mix 2 teaspoons of sugar with 2 cups of water until it dissolves.
3 Mix the rice bran-topsoil with the sugar-water.
4 Wrap the mixture in the cloth and tie it closed. Put this cloth in a sheltered, shady place and keep it there for 2 days.
5 After two days, in another container mix the rest of the sugar with the 20 L of water until it dissolves.
6 Take the cloth and put it into the sugar-water. Put a rock on top of the cloth to make sure it stays under the water.
7 After 3 days the liquid in the container will be full of micro-organisms. The left-over soil inside the cloth can be added to compost.
8 Using a cup, spoon or funnel take the finished IMO liquid out of the container and pour into the storage containers or bottles. Put the lids on and store in a cool place away from sunlight. The IMO is now ready to use.

Uses of IMO (Type One and Two)

- Mix one teaspoon (5 mL) IMO with one litre of water. The diluted IMO mixture can be sprayed onto plants to increase their resistance to disease and as a leaf fertiliser.
- Use diluted IMO on animal bedding to reduce smell and to make a valuable compost source.
- Directly spray diluted IMO onto garden beds, mulch, container plants and in fields around plants to increase microbiological activity and soil fertility.

FPJ Fermented Plant Juice (Type One)

Materials:

- 3 kg Fresh stems and leaves of plants such as bananas, beans, cabbage, cucumber, drumstick, grasses, *Leuceana spp*, melons, morning glory, mustard, sweet potato, tamarind, etc. Other types of plants can be used if these are not available, but the material should be fresh and easy to cut up.
- 1 kg Sugar or molasses.
- Container big enough to hold the plant material and sugar.
- Containers or bottles with lids to store the finished FPJ mixture.
- Plastic bag strong enough to hold about 2 L of water.
- Plain paper (not newspaper).
- String.

Procedure:

1 Collect the stems and leaves before dawn or very early in the morning. Do not wash them.
2 Cut the plants into small pieces; the smaller the better.
3 Mix the plant material with the sugar very thoroughly. It is better to do this with hands so that everything mixes in well.
4 Put the mixture into the container. Put the plastic bag filled with water on top of the mixture. This compresses the material and forces the air out. It will also help avoid contamination.
5 Cover the container with the paper and tie with string. Keep in a cool, dark place overnight.
6 The next morning, remove the plastic bag filled with water. Keep the container in the same place for another 5 to 7 days. As the FPJ mixture ferments, the plant material will change from green to yellow to brown, and the liquid will begin to smell sweet and a little bit like alcohol.
7 Pour the liquid into the storage containers using a bamboo or plastic strainer, or a piece of cloth. Do not squeeze the plant residue, but remove it and use as mulch or in compost.

Uses of FPJ (Type One)

- The best dilution of FPJ Type One is 1/2 teaspoon FPJ to 1 L water. This can be applied to all parts of plants and to the topsoil around them. FPJ is usually applied once a week, but can be applied more frequently if pests or diseases are attacking crops, before crops begin important growth stages, or if there has been heavy rain.
- Using the same dilution, FPJ can be added to animal bedding to reduce smell and make valuable compost. It can also be fed to sick animals to increase the effectiveness of digestion. (Some farmers drink a solution of 1 part FPJ to 4 parts water for the same reason).

FPJ Fermented Plant Juice (Type Two)

Materials:

- 2 kg Kang kong (*Convolvulus spp*) leaves and stems.
- 2 kg Bamboo shoots or green leaves.
- 2 kg Banana stem.
- 3 kg Sugar or molasses.
- Container with lid, big enough to hold the plant material and sugar.
- Containers or bottles with lids to store the finished FPJ mixture.

Procedure:

1 Collect the plants before dawn or very early in the morning. Do not wash them. Cut all the plant material into pieces approximately 3 cm long.
2 Put the cut plant material into the container and gently mix in 2 kg of the sugar. Stir in one direction only (e.g. left to right) so that the plant material is not crushed or damaged.
3 Evenly spread the remaining 1 kg of sugar over the top of the mixture. Do not stir it.
4 Cover the container and put it in a cool, sheltered place. Do not open the lid for ten days.
5 After ten days, open the lid and smell the mixture. If there is only a weak smell, put the lid back on and leave the container for a few more days. If the mixture smells bad as if it is rotting, add one or two handfuls of sugar.
6 After another 5 to 15 days, depending on the weather, the mixture will smell a little bit like alcohol and be ready to use.
7 Using bamboo or plastic strainer, or a piece of cloth, pour the mixture into a storage container. Do not squeeze the plant residue, but remove it and use it as mulch or in compost.

Uses of FPJ (Type Two)

- Mix 2 tablespoons of FPJ with 10 L of water. This can be sprayed on the soil around plants or directly onto the plant. FPJ Type Two is very good for leaf crops such as mustard, kang kong and kale, etc.

Note:

The most effective FPJ for plants are those made from the same type of plant. For example, FPJ made from the buds or young fruits of cucumber can help fruit setting and development in maturing cucumbers, while also helping to prevent disease and insect attack.

FFJ Fermented Fruit Juice (Type One)

Materials:

- Sweet, ripe fruit such as banana, fig, mango, papaya, etc. Citrus fruits such as lime or orange are not very useful.
- An equal weight of sugar or molasses to the fruit.
- Container with lid, big enough to hold the plant material and sugar.
- Containers or bottles with lids to store the finished FFJ mixture.

Procedure:

FFJs are prepared the same way as FPJs.

See Fermented Plant Juice (Type One) on page 115, and follow steps 1 to 7 in the Procedure section.

Uses of FFJ (Type One)

- A dilution of 1 teaspoon FFJ to 1 L water can be sprayed on beds and fields to increase nutrient availability.
- This dilution can also be used on animal bedding to reduce smell and levels of harmful bacteria.
- Many farmers believe that 2 - 3 tablespoons of FFJ added to a glass of water is a healthy drink.

Note:

- FFJ made of only ripe pumpkin, papaya, banana and sugar/molasses is very effective for fruit and flower crops.
- FPJ and FFJ can be mixed and used together and diluted as normal for different crops. Some good mixes are listed below:

For leaf crops	10 FPJ : 1 FFJ
For flower crops	5 FPJ : 5 FFJ
For fruit and root crops	1 FPJ : 10 FFJ

Overview

Pests are organisms that damage our crops. Caterpillars that eat leaves, worms that eat roots, fungi and bacteria that feed on seeds, etc., are all examples of pests. But pests are part of our environment and occur everywhere in nature. Pests are not a problem if we can maintain a balanced ecosystem in our farms and gardens. If we loose this balance, however, and have more bad insects than good insects, or if a fungus or disease spreads to many plants, we need to control these pests so that they do not destroy our crops.

The best way to control pests is to copy nature and maintain a balanced ecosystem. We should try to use only local seed stock, mix and rotate our crops, and encourage natural enemies of pests such as frogs, birds, wasps and spiders, etc., to live in our gardens and farms. We should avoid mono-cropping, chemicals, and destruction of the soil.

In certain conditions, pests can still be a problem. If pests are damaging a large part of our crops and are threatening our harvest, then we have the choice of using natural pesticides. In this topic we will describe how to make and use several types of natural pesticides. Most natural pesticides are generally safer than artificial chemical pesticides that we can buy at the market, but we should remember that all pesticides can be poisonous to humans and should be used carefully.

There are five rules we must follow:

1 We should not use pesticides unless we have to.
2 We should not make or use pesticides near children.
3 We should try not to get pesticides on our clothes or skin.
4 We should clean all of our equipment and clothes after we have made or used natural pesticides. We should not use the same equipment to prepare food.
5 We should always wash and clean any fruit or vegetables before we eat them.

Soap Solution

Target Organisms:
- Aphids and thrips.

Ingredients:
- 20 grams Soap Flakes.
- 5 litres Water.

Procedure:
- Mix the soap and water together thoroughly.

Application:
- Flick or spray onto infested areas in the early morning or evening.

Note:
- This soap solution is used in many types of natural pesticides. It is a good idea to make this solution before trying any of the other solutions included in this topic.
- Test this solution on a small part of a plant first to be sure that it is not too strong.

Soap and Kerosene

Target Organisms:
- Aphids, some beetles, leaf miners, mites and some sucking insects.

Ingredients:
- 500 grams Soap.
- 8 litres Kerosene.
- 4 litres Water.

Procedure:
1. Mix the soap and water together thoroughly.
2. Mix in kerosene and stir for 5 minutes until the solution is a smooth white colour without any oil on the surface.
3. Cover and leave the solution to cool. It should become thick like honey.
4. Before use, dilute the solution with 10 - 15 parts water.

Application:
- Once diluted, this solution can be flicked or sprayed onto plants in the early morning or evening.

Wood Ash

Target Organisms:
- Leaf miner (*Liriomyza huidobrensis*).

Ingredients:
- Ash from cooking fires, burnt straw or maize cobs.

Procedure:
- Use the ash as a powder or mix with water.

Application:
- Flick or spray onto infested areas in the early morning or evening.

Note:
- Ash will need to be applied again if there has been rain or heavy watering.
- Do not use ash made from the shells or husks of coconuts, because this ash can be harmful to leaves.

Wood Ash and Lime ($CaCO_3$)

Target Organisms:
- Pests of cucumbers and gourds such as maggots and cucumber beetle.

Ingredients:
- 1 cup Wood ash.
- 1 cup Lime ($CaCO_3$).
- 4 litres Water.

Procedure:
1 Mix all ingredients together thoroughly.
2 Leave covered for one hour.
3 Filter through a cloth into a storage or spray container.

Application:
- Flick or spray onto infested areas in the early morning or evening.

Note:
- The mixture will need to be applied again if there has been rain or heavy watering.
- Do not use ash made from the shells or husks of coconuts, because this ash can be harmful to leaves.

Wood Ash and Kerosene

Target Organisms:
- Sucking insects such as aphids, green flies, and rice ear bugs, etc.
- This method is preventative only. It will not be effective if plants are already heavily infested.

Ingredients:
- 1 kilogram Wood Ash.
- 6 teaspoons Kerosene.

Procedure:
1 Mix all ingredients together thoroughly.
2 Leave covered for one hour.

Application:
- Dust plants early in the morning twice a week.

Note:
- Do not use ash made from the shells or husks of coconuts, because this ash can be harmful to leaves.

Wood Ash and Sour Milk

Target Organisms:
- Fungus diseases such as mildew and rust.

Ingredients:
- 1 tablespoon of Wood Ash.
- 1 cup Sour Milk.
- 1 litre Water.

Procedure:
1 Mix the wood ash and water together thoroughly.
2 Leave covered for twelve hours.
3 Filter into a separate container.
4 Mix in the sour milk.
5 Before using, dilute the solution with 3 litres of water.

Application:
- Flick or spray onto infested areas in the early morning or evening.

Note:
- This solution can damage plant leaves if made too strong. Always test on a small section first and check after 24 hours. If the plant appears wilted or burnt, dilute the solution with more water.

Chilli (*Capsicum annum*)

Target Organisms:
- Ants, aphids, caterpillars, cabbage worms, rice weevils, cucumber mosaic virus, tobacco mosaic virus, some types of beetle and warehouse pests.

Ingredients:
- 100 grams Dried Chillies (about 12 chillies).
- 1 litre Water.

Procedure:
1 Grind chillies.
2 Mix the ground chillies with water thoroughly.
3 Leave covered for 24 hours.
4 Filter into a separate container.

Application:
- Flick or spray onto infested areas in the early morning or evening.

Note:
- This solution can be very painful if it enters the eye. Be careful when mixing and applying to crops. Always wash hands after use.
- This solution can damage plant leaves if made too strong. Always test on a small section first and check after 24 hours. If the plant appears wilted or burnt, dilute the solution with more water.

Chilli and Soap

Target Organisms:
- Ants, aphids, caterpillars, cabbage worms, rice weevils, cucumber mosaic virus, tobacco mosaic virus, some types of beetle and warehouse pests.

Ingredients:
- 100 grams Dried Chillies (about 12 chillies).
- 1 litre Water.
- 5 litres Soapy Water.

Procedure:
1 Grind chillies finely.
2 Mix the ground chillies with water thoroughly.
3 Leave covered for 24 hours.
4 Filter into a separate container.
5 Mix with 5 litres of soapy water.

Application:
- Flick or spray onto infested areas in the early morning or evening.

Note:
- This solution can be very painful if it enters the eye. Be careful when mixing and applying to crops. Always wash hands after use.
- This solution can damage plant leaves if made too strong. Always test on a small section first and check after 24 hours. If the plant appears wilted or burnt, dilute the solution with more water.

Chilli and Garlic (*C. annum & Allium sativum*)

Target Organisms:
- Many types of leaf eating insects.

Ingredients:
- 50 grams Dried Chillies (about 6 chillies).
- 50 grams Garlic (about 1 handful).
- 1 litre Water.

Procedure:
1 Finely chop or pound the chillies and garlic.
2 Mix all ingredients together thoroughly.
3 Leave covered for 24 hours.
4 Filter into a storage or spray container.

Application:
- Flick or spray onto infested areas in the early morning or evening.

Note:
- This solution can be very painful if it enters the eye. Be careful when mixing and applying to crops. Always wash hands after use.
- This solution can damage plant leaves if made too strong. Always test on a small section first and check after 24 hours. If the plant appears wilted or burnt, dilute the solution with more water.

Chilli and Garlic and Onion (*C. annum + A. sativum + Allium copa*)

Target Organisms:
- Aphids and some types of leaf eating insects.

Ingredients:
- 50 grams Dried Chillies (about 6 chillies).
- 50 grams Garlic (about half a handful).
- 50 grams Onion (red or white).
- 1 litre Soap Water.

Procedure:
1 Finely chop or pound the chillies, garlic and onion.
2 Mix chillies, garlic and onion with the water thoroughly.
3 Leave covered for 24 hours.
4 Filter into a storage or spray container.

Application:
- Flick or spray onto infested areas in the early morning or evening.

Note:
- This solution can be very painful if it enters the eye. Be careful when mixing and applying to crops. Always wash hands after use.

Garlic and Soap and Mineral Oil

Target Organisms:
- Aphids, army worms, some beetles, coddling moths, Mexican bean beetles, cabbage worms, wire worms.

Ingredients:
- 100 grams Garlic (about 1 handful).
- 10 grams Soap.
- 0.5 litres Water.
- 2 teaspoons Mineral Oil.

Procedure:
1 Finely chop or pound the garlic.
2 Leave the garlic in the mineral oil for 24 hours.
3 Dissolve the soap in the water.
4 Use a stick to mix the garlic and mineral oil with the soapy water.
5 Filter the solution into another container.
6 Before use, dilute this solution with 20 parts water.

Application:
- Flick or spray onto infested areas in the early morning or evening.

Note:
- This solution is effective against many common pests, but different strengths should be experimented with against specific insects.

Garlic and Soap and Kerosene

Target Organisms:
- Many types of insects.

Ingredients:
- 50 grams Garlic.
- 30 grams Soap Flakes.
- 10 litres Water.
- 6 teaspoons Kerosene.

Procedure:
1 Finely chop or pound the garlic.
2 Put the garlic into the kerosene and keep covered for 24 hours.
3 Dissolve the soap into the water and mix well.
4 Use a stick to mix the garlic/kerosene with the soapy water.
5 Filter into a storage or spray container.

Application:
- Flick or spray onto infested areas in the early morning or evening.

Tobacco 1 (*Nicotina tabacum*)

Target Organisms:
- Aphids, cabbage worms, caterpillars, flea beetles, grain weevils, leaf miners, mites, stem borers, thrips, bean and wheat rust, potato fungus, leaf curl virus.

Ingredients:
- 1 kilogram crushed tobacco.
- 100 grams Soap Flakes.
- 15 litres Water.

Procedure:
1 Use a stick to mix the tobacco and water together thoroughly.
2 Leave covered for one day.
3 Filter into another container.
4 Add soap flakes.
5 Leave covered for one more day.

Application:
- Flick or spray onto infested areas in the early morning or evening.

Note:
- Tobacco is very toxic. This solution must be used carefully. Avoid getting the solution in your eyes or mouth, or on your skin. Make sure to wash all equipment thoroughly after use.
- In China, irrigated rice crops are protected against stem borers by immersing tobacco stalks in the flooded paddy fields. Approximately 150-300 kg of stalks are used per hectare.
- Some crop species affected by leaf curl virus can be dusted with tobacco powder before being transplanted to the field. This can help prevent attack by thrips which spread the virus.

Tobacco 2 (*Nicotina tabacum*)

Target Organisms:
- Aphids, cabbage worms, caterpillars, flea beetles, grain weevils, leaf miners, mites, stem borers, thrips, bean and wheat rust, potato fungus, leaf curl virus.
- This solution does not affect ladybugs or their larvae.

Ingredients:
- 250 grams crushed tobacco.
- 30 grams Soap Flakes.
- 10 grams Lime ($CaCO_3$) - (Optional)
- 4 litres Water.

Procedure:
1 Boil water.
2 Put tobacco and lime into boiling water and simmer for 30 minutes.
3 Add soap flakes, cover and allow solution to cool for 12 hours.
4 Filter into a storage or spray container.

Application:
- Flick or spray onto infested areas in the early morning or evening.

Note:
- The lime ($CaCO_3$) will increase the solution's effectiveness, but is not necessary.

Flour

Target Organisms:
- Many types of small insects, including adult mites and their eggs and larvae.

Ingredients:
- 2 cups fine White Flour (wheat or rice).
- 5 to 10 litres Water.

Procedure:
1 Mix the flour and water together until the flour is completely dissolved. This will be easier if the water is slightly warm. Let the solution cool before using it.

Application:
- Flick or spray this mixture onto plants in the morning only. As the solution dries out in the sun the insects will become stuck.
- The solution will fall off after a few days depending on the weather. This means that photosynthesis will not be greatly affected, but we will need to apply more solution if the pest problem continues.

Turmeric (*Curcuma longa*)

Target Organisms:
- Ants, caterpillars, flies, fungi, nematodes, some storage insects.

Ingredients:
- 500 grams Turmeric Roots.
- 20 litres Soap Solution.
- 2 litres Water.

Procedure:
1 Finely chop or pound the turmeric.
2 Put the turmeric in the water.
3 Leave covered for 24 to 36 hours.
4 Filter the solution into another container.
5 Before using, dilute with 20 litres soap solution.

Application:
- Flick or spray onto infested areas in the early morning or evening.

Note:
- Turmeric powder can be used to prevent attack by storage pests.
  To do this, mix 1 part turmeric powder with 50 parts of the grain or legumes to be stored. (eg: 1 kg turmeric : 50 kg grain).

Drumstick Tree (*Moringa oleifera*)

Target Organisms:
- Damping off, specifically the fungus *Phytium debangemun,* which can attack seedlings in very wet conditions.

Ingredients:
- Leaves of Moringa.

Procedure:
1 Strip leaves of tree and break or chop into smaller pieces.
2 Stems should be removed or chopped very finely.

Application:
- Mix the leaves into the seedling soil one week before sowing.

Tomato Stems (*Lycopersicon lycopersicum*)

Target Organisms:
- Cabbage worms, diamond back moth.

Ingredients:
- Tomato Stems, as much as you can find.
- Water (enough to cover tomato stems in a pot).

Procedure:
1 Finely chop or pound the tomato stems.
2 Boil the water.
3 Put the tomato stems in a container with the boiling water.
4 Put a lid on the container and leave for a minimum 5 hours.
5 Filter the solution into a storage or spray container.

Application:
- Flick or spray onto infested areas in the early morning or evening.

Note:
- It is best to apply this solution when you see the adult pests near your plants. The solution irritates the adults and helps prevent them from laying eggs.

Tomato Plant (*Lycopersicon lycopersicum*)

Target Organisms:
- Cabbage worms, diamond back moth.

Ingredients:
- 1 fully grown Tomato Plant (harvest the fruit first).
- 2 litres Water.

Procedure:
1 Finely chop or pound the tomato plant and boil the water.
2 Put the tomato plant in a container with the boiling water.
3 Put a lid on the container and leave for a minimum 5 hours.
4 Filter the solution into a storage or spray container.

Application:
- Pour the solution over the seedling soil one week before sowing.

Note:
- When the solution is ready, it must be used immediately to be effective. Be sure to completely cover the plants with the solution.
- You can add one cup of soapy water to make the solution more effective.

Papaya Leaves (*Carica papaya*)

Target Organisms:
- Coffee rust, powdery mildew.

Ingredients:
- 1 kilogram Shredded Papaya Leaves.
- 1 litre Water.
- 4 litre Soap Solution.

Procedure:
1 Cut or shred the papaya leaves into small pieces.
2 Shake the leaves in the water for about five minutes.
3 Put the leaves in a cloth and then drain the water through them into another container. Squeeze the leaves until there is no more water left.
4 Mix with the soap solution and keep for 30 minutes before using.

Application:
- Flick or spray onto infested areas in the early morning or evening.

Note:
- When the solution is ready it must be used immediately to be effective. Be sure to completely cover the plants with the solution.

Papaya and Kerosene

Target Organisms:
- Powdery mildew, coffee rust.

Ingredients:
- 1 kilogram Fresh Papaya Leaves.
- 6 teaspoons Kerosene.
- 10 litres Water.
- 10 litres Soapy Water.

Procedure:
1 Chop or pound the papaya leaves.
2 Mix the papaya leaves, kerosene and water thoroughly.
3 Cover and leave the solution for a minimum three hours.
4 Filter the solution into a storage or spray container.
5 Add the 10 litres of soapy water.

Application:
- Flick or spray onto infested areas in the early morning or evening.

Note:
- When the solution is ready it must be used immediately to be effective. Be sure to completely cover the plants with the solution.

Neem (*Azardirachta indica*)

Target Organisms:
- Cabbage caterpillars, melon beetles, grasshoppers.

Ingredients:
- 100 grams Neem Seed.
- 200 millilitres Soap Solution.
- 2 litres Water.

Procedure:
1 Dry the seeds in the shade. This may take a few days depending on the weather.
2 Shell the seeds and then grind the kernels into a fine powder.
3 Mix the seed powder with the 2 litres of water.
4 Cover and leave for 6 hours.
5 Add one cup of soap solution.
6 Pour mixture into storage or spray container.

Application:
- Flick or spray onto infested areas in the early morning or evening.

Note:
- When grinding the neem seeds, be careful to avoid breathing in too much dust. Wash hands and all equipment.

Yam Bean (*Pachyrrhizus erosus*)

Target Organisms:
- Aphids, army worms, cabbage worms, diamond-back moths, flea beetles, Mexican bean beetles, stink bugs, many types of caterpillars.

Ingredients:
- 1 kilogram mature Yam Seed.
- 200 litres Water.

Procedure:
1 Crush or pound the seed until it is a coarse powder.
2 Put into the water and stir well.
3 Filter through a cloth into a storage or spray container.

Application:
- Flick or spray onto infested areas in the early morning or evening.

Note:
- Always check the strength of the solution by applying to a small area first.

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CAN 6

Section 6: Plants

Parts of Plants
Propagation
Some Useful Plants
Nutrient Needs of Plants

Overview

The plant is the basic unit of agriculture. No form of life can live on earth without plants, and their ability to change sunlight and raw materials into food for people and animals.

Fig 70.1: Parts of Plants

Plant Structure

Plants have two important parts:

1 *The Root System:* The parts below ground that absorb water and nutrients from the soil and hold the plant firmly in the ground. These parts include the bottom stem, roots, and root hairs.

2 *The Shoot System:* The parts above the ground that allow the plant to breath, get sunlight, and reproduce. These parts include the Stem and branches, leaves, flowers, fruits and seeds.

Basic Plant Parts

Roots

The roots are the part of a plant that grows into and through the ground to absorb water and nutrients from the soil. Roots also help anchor plants in the ground and keep them stable. We usually forget to think about plant roots because they are hidden in the soil. However, strong, healthy roots are necessary to produce strong, healthy crops. Phosphorus and potassium are very important for good root development.

Plants usually have one or several main roots from which many smaller roots emerge, similar to branches on the trunk of a tree. On these small roots are even smaller roots, so small that they can be difficult to see. These are called root hairs and they are used to take in water and nutrients. Root hairs are very fragile, so it is important to handle them carefully when transplanting or when cultivating beds and fields.

It is difficult for roots to develop in heavy clay soils or beds that have been poorly prepared. There are two main reasons for this. One, the denser the soil the more difficult it is for roots to grow and spread out to find important nutrients. Two, dense, clay soils usually hold too much water and not enough air. For the root and root hairs to live in the soil there must be enough oxygen.

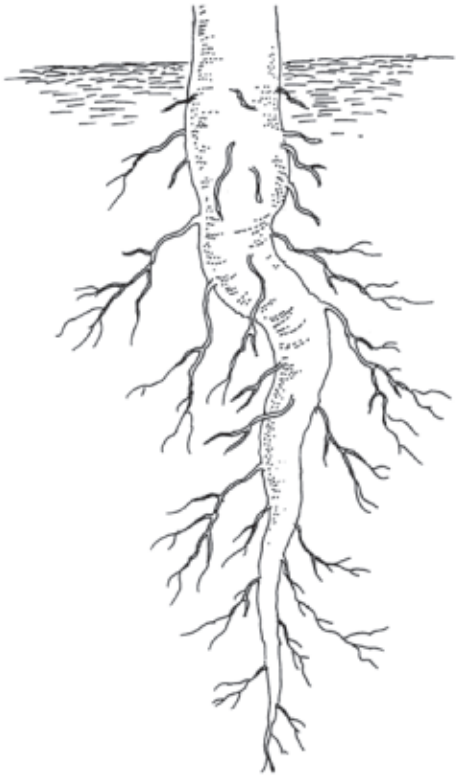

Fig 70.2: Roots

Stem

The stem is the part of a plant that reaches from the roots to the leaves. Stems provide support for the plant, but also carry water, nutrients and air. Strong stems are necessary for good plant development and yield. Phosphorus and potassium are very important for good stem development.

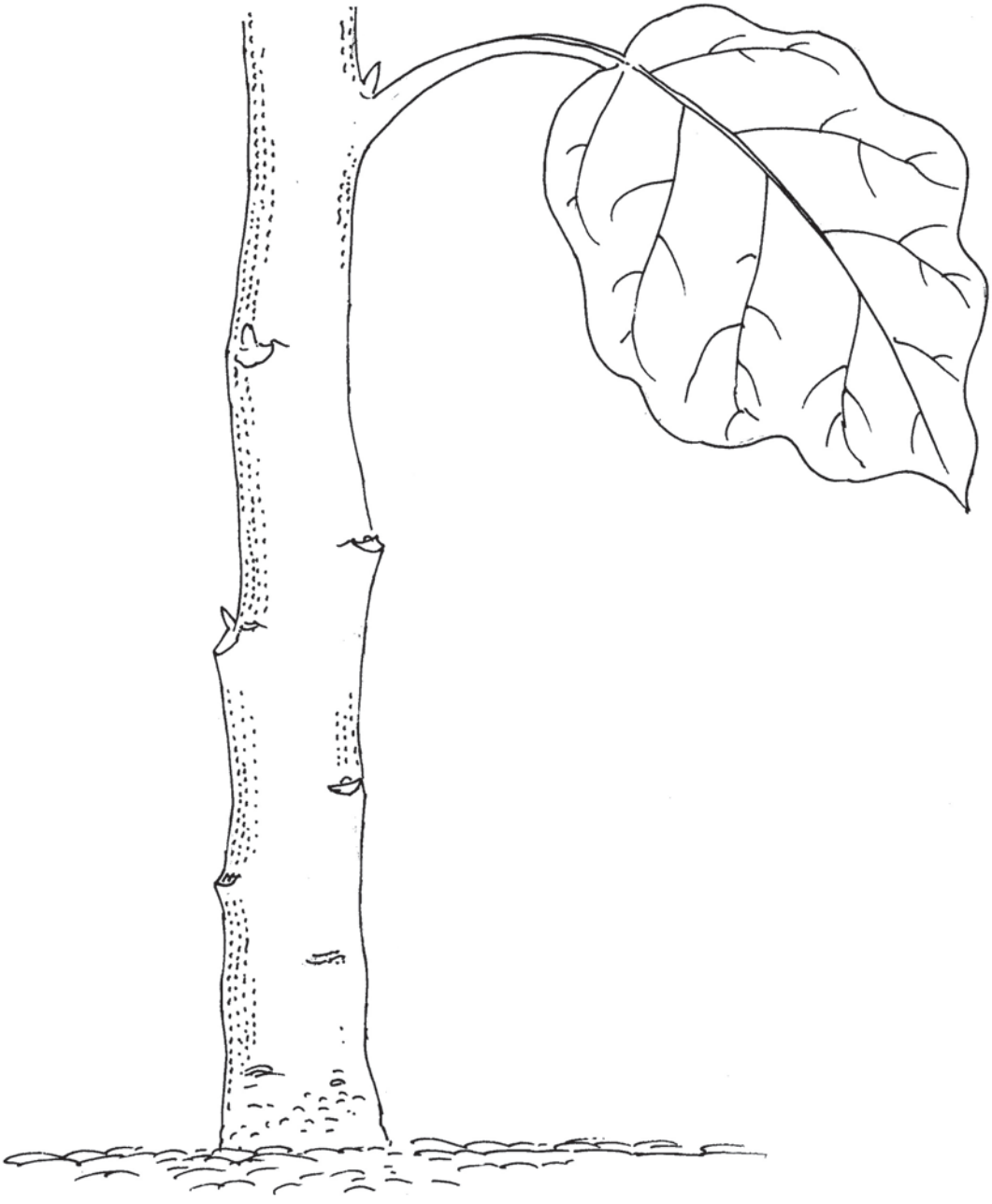

Fig 70.3: Stem

Leaves

The leaves are the engine of the plant because they provide energy for growth. Leaves use sunlight, water, and air to make energy using a substance called chlorophyll. Chlorophyll gives leaves their green colour. A green leaf is the only living thing in the world that can turns the sun's light into energy. This process is called photosynthesis. Nitrogen is very important for good leaf development.

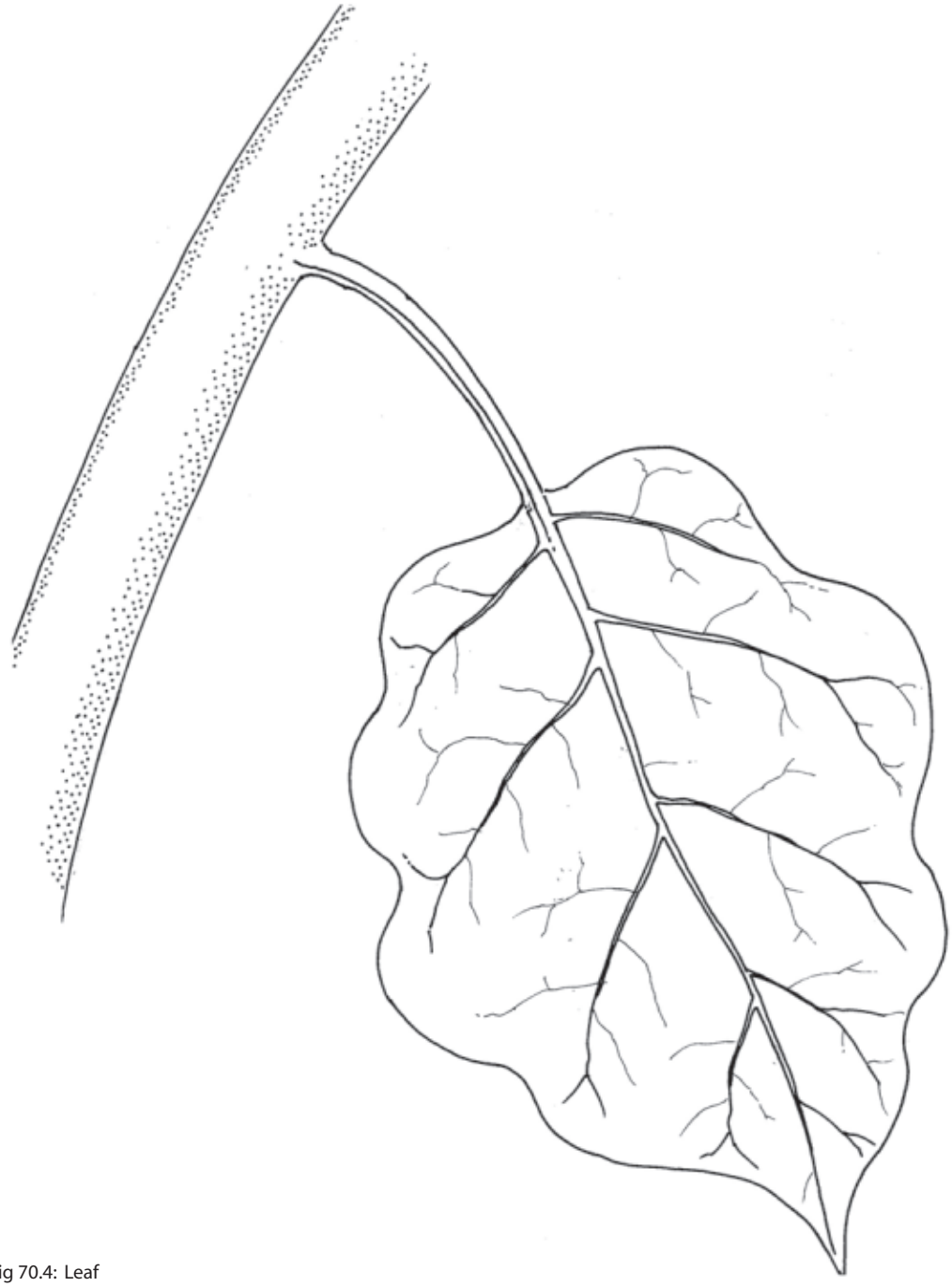

Fig 70.4: Leaf

On the underside of a leaf are very small holes called stomata. Plants use these holes to take in carbon dioxide (CO_2), and send out oxygen and water in a process called transpiration. When it is hot, dry and/or windy, the water inside a plant evaporates through the stomata and the leaves wilt. When leaves wilt, they can not photosynthesise efficiently. So it is important to make sure that plants always have enough water.

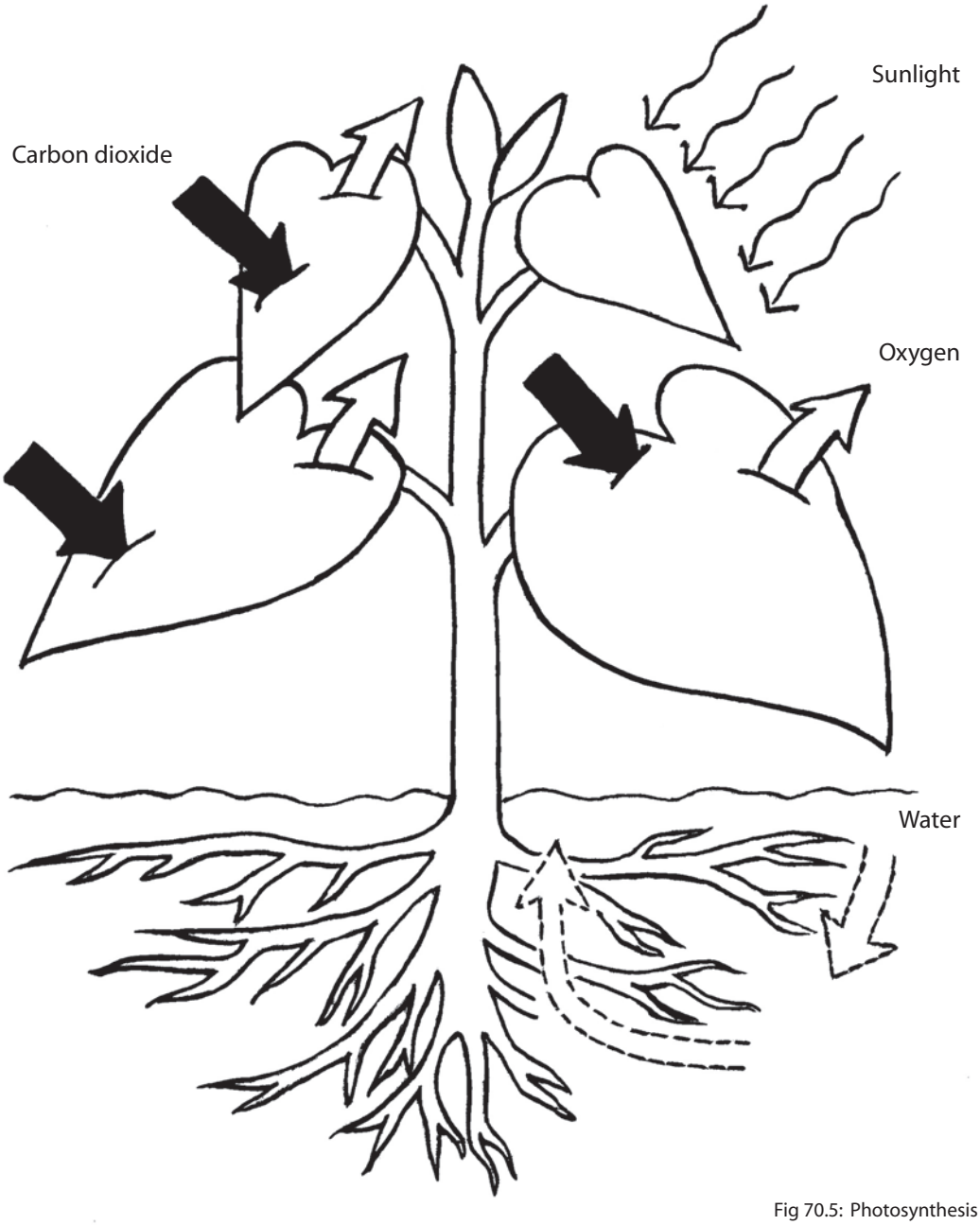

Fig 70.5: Photosynthesis

Flower

Without flowers there would be no fruit or seeds. Flowers are the way that most plants reproduce. Flowers can be female, male, or both female and male. Female flowers have ovaries (eggs) that develop into seeds when they are fertilized by pollen from male flowers. Pollen from male flowers can be carried by wind or insects such as bees and ants. Many types of flowers have bright colours and sweet smells to help attract these insects. Plants that are both female and male do not need other plants to help them reproduce.

Fig 70.6: Flower

Fruit and Seed

Fruits develop from ovaries inside female flowers that have been fertilized by pollen. Inside a fruit there are seeds. A seed is much like an egg. Inside every seed there is a small plant. Around the outside of this plant is a supply of food ready for the first stages of the plant's development. Around the outside of this food is a shell to help protect what is inside.

Seeds from strong, healthy plants will produce healthy future plants. To help improve the yield of future crops, it is important to carefully select and store seeds for the next growing season. Seeds that are too young, too old, or damaged by insects or fungus will have poor growth. (See Section 2: Seeds)

Fig 70.7: Fruit

Overview

Seeds are the products of sexual reproduction; they have male and female parents. For vegetables, annuals, biennials, and perennials, the most common method of reproduction is by seed. Plants grown from seed have things in common with both their parents. If we do not want the qualities of both parent plants, but only one of them, we have to reproduce the parent plant asexually. This process is called *asexual propagation*.

Propagation can be done by:

- Cutting
- Layering
- Grafting

Cutting

A *cutting* or *stake* is a part of a plant that can be cut off and grown again. For some species of plant, a stem or branch can be cut off and put into water, soil, or compost, where it will grow roots and develop into plants identical to their parents. In the tropics, many useful tree species can be reproduced by cuttings. Farmers often use cuttings to plant living fences from various beneficial species such as *Gliricidia, Moringa, Azardirichta,* and *Broussometia*.

Rooting Hormones - Willow Water (*Salix spp*.)

Rooting hormones can encourage cuttings to develop roots more easily. One solution is known as *Willow Water.*

1 Cut willow stems into 2-3 cm pieces and place them in a small container.
2 Add enough water to cover the willow pieces by about 5 cm. Cover the container and let it stand for 24 hours.
3 Prepare the cuttings you want to propagate less than one hour before step 4.
4 Remove the pieces of willow wood from the water. Put the bottom of the cuttings you have made into the willow water and let them stand over night (12 hours).
5 Remove the cuttings from the water.
6 The cuttings are now ready for planting, but remember this should be done in the early morning or evening.

Layering

Layering is a method of propagating where branches of woody plants are helped to grow roots while they are still attached to their parents. There are two types of layering: Ground Layering, and Air Layering.

1 Ground Layering (or Simple Layering):

a A healthy and flexible branch is prepared by stripping off leaves and buds but leaving the tip.

b At the point where we want the branch to root, a cut is made running upward and joining in the centre of the branch. This can be done on several branches depending on the plant we are using. (Figure 71.1)

c After the cut is made, the branch is gently bent to the ground so that the cut points nearly straight down below the surface. This length of branch is then covered by 7-20 cm of good soil or compost that must be kept moist until the new roots are established, usually one season. Bigger branches will need to be covered by more soil to hold them down securely.

d The tip of the plant is then tied to a bamboo or wooden stake high enough above the ground so that it is not damaged or covered by soil. All of the healthy branches of a parent plant can be prepared the same way.

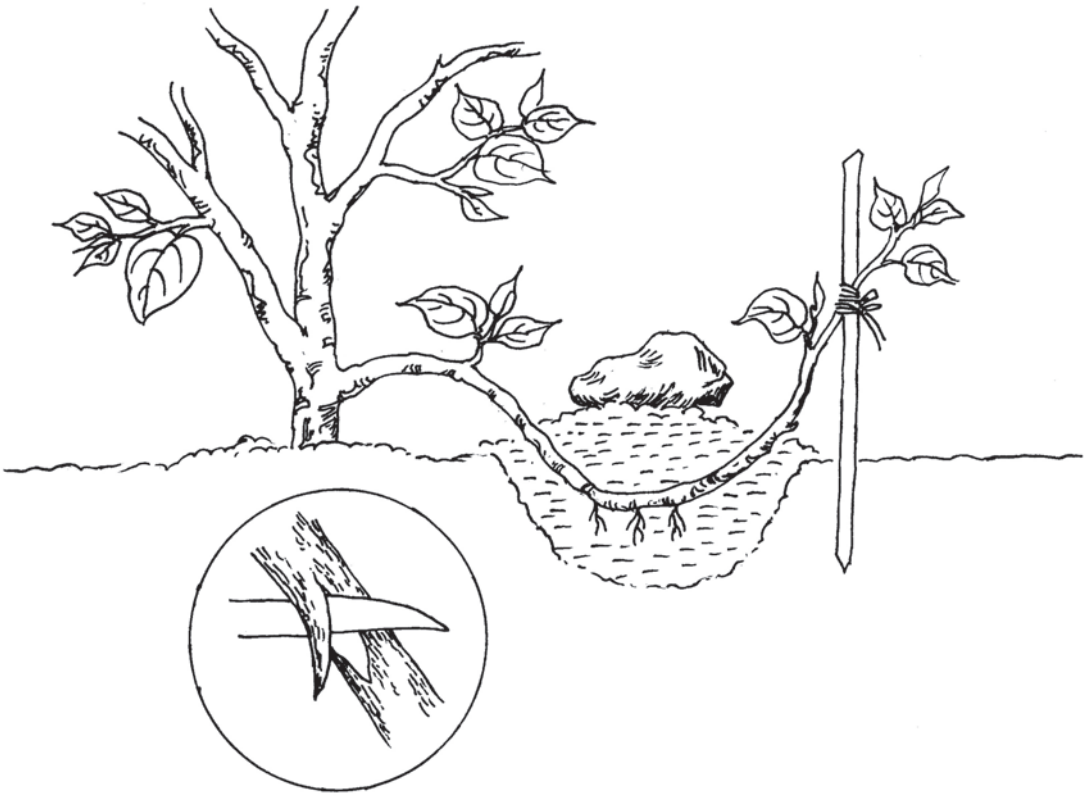

Fig 71.1: Ground Layering

2 Air Layering:

Air layering is very similar to ground layering. It is better to air layer in the wet season, but it can also be done during the dry season as long as there is enough water so that the layering does not dry out.

a Choose a good parent plant that you want to reproduce. Plants must be at least 1 to 2 years old, be healthy, and have branches with strong growth.

b Choose a branch at least the diameter of your thumb.

c Using a clean knife, make a straight and shallow cut between 2 and 4 cm long close to the fork of the branch and stem. Gently peel the bark away. (Figure 71.2)

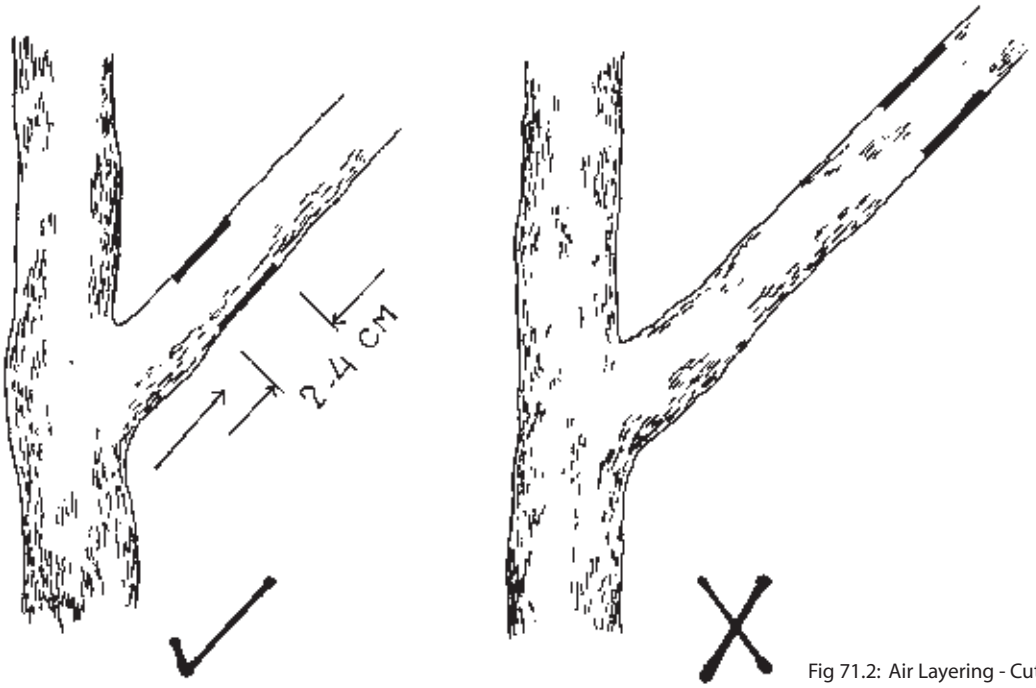

Fig 71.2: Air Layering - Cut

d Collect and wash some coconut husk (or other fibrous material), then squeeze it out by hand until no more water drips. It should still be a little bit moist.

e Add some good soil or compost and wrap it in the moist husk. Wrap this package around the peeled section of branch, then tie off the top and bottom ends with string or tape so that it is air and water-tight. If we use transparent plastic around the package, it will be easier to check for later root growth. (Figure 71.3, Pg. 144)

f In about 30-100 days, the roots on the air-layered branches should have grown enough so that the cover can be removed. The branch can then be cut below the roots near the fork of the branch, and stem, and transplanted.

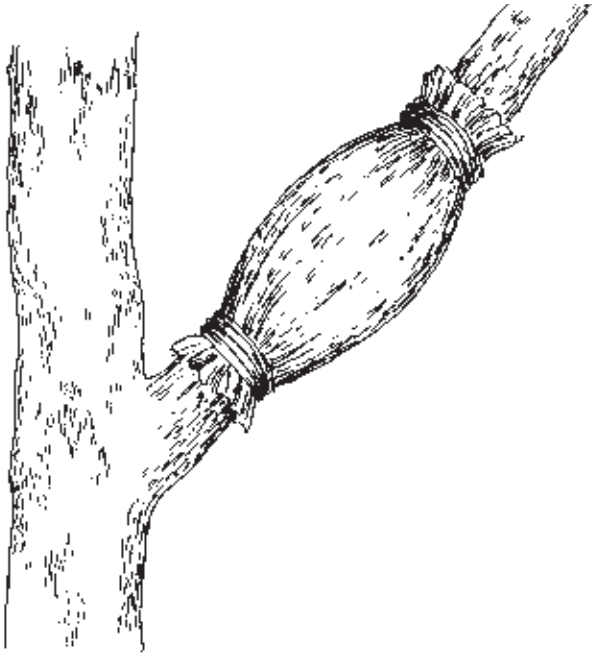

Fig 71.3: Air Layering - Wrap

Grafting

Grafting is a method of reproduction that can be used to combine the best characteristics of two different parents. Joining together parts of two parents will make a new plant that will have the qualities we want from both. For example, good quality fruit and high yield from one plant can be joined with strong roots and disease resistance from another plant. Grafting is done by attaching a cutting from one plant (called the *scion*) to the branch or stem of another (called the *stock*).

Fig 72: Grafting

1 Scion:

The scion means the bud (or eye) of a plant. The plant should be at least three years old and have already proven that it has good characteristics. We should use plants that have given good fruit, high yields, and have proven to be resistant to pests and diseases.

2 Stock:

The stock means the stem or main branch of a plant. The plant should be at least 8 to 12 months old with a stem diameter of at least 0.5 cm. We should use plants that are adapted to local soils and climate, and have shown that they are resistant to pests and diseases. Most stock plants are grown from seeds. The seed should not come from the same tree as the scion or from another grafted plant.

There are several ways to graft plants. These methods have different uses for different plants (Figure 73). However, for all methods of grafting, both scions and stock should be chosen from healthy plants.

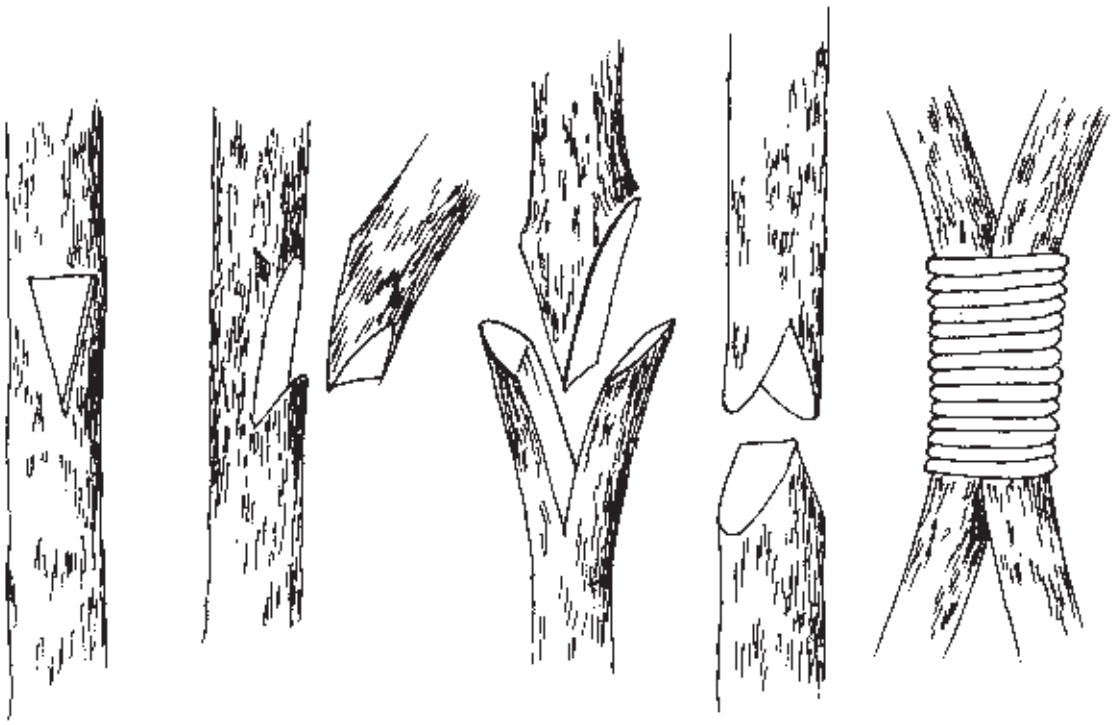

Fig 73: Different Grafting Methods

Bud Graft

A simple way to graft plants is called *budding*. Making a bud graft is good for many types of plants because it is easy and accurate. A bud graft is made by taking a bud (scion) from a healthy plant and attaching it to a main branch or stem of another plant (stock).

Procedure:

1 Choose the scion and stock plants.
2 Choose a bud for the scion. This bud should be healthy and not too old. The bud should be taken from a woody branch approximately the same size as the stock stem that we will attach it to. Cut the branch to a length of 20-30 cm.
3 Cut a small section near the base of the stock plant stem and lift off the bark. Be careful not to cut too deep and damage the wood.

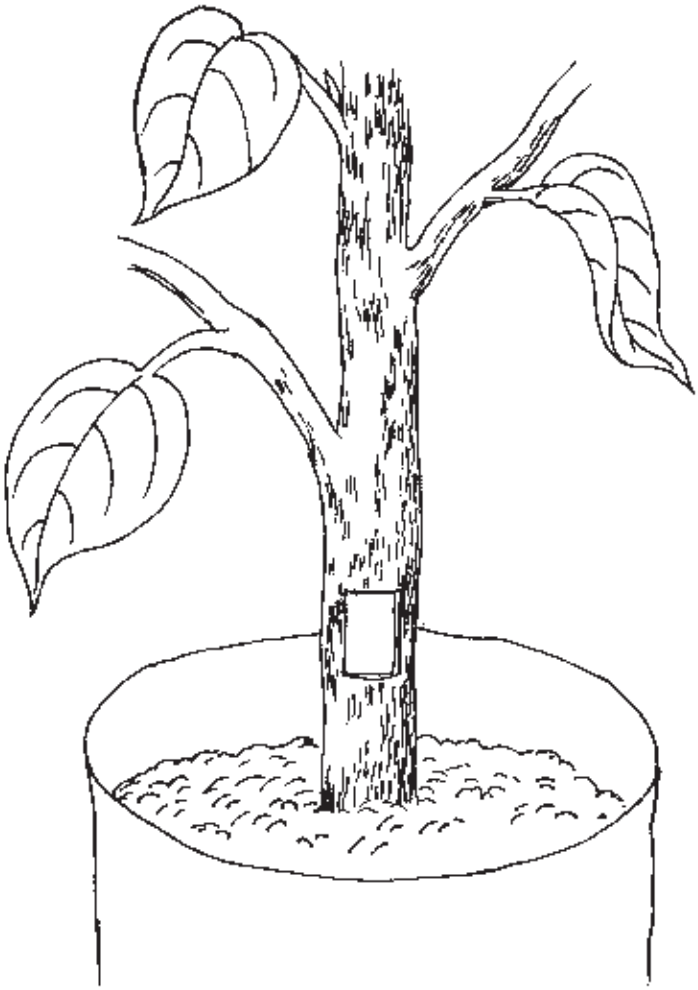

Fig 74.1: Bud Graft - Cut

4 Use a sharp, clean knife. Cut the bud away from the stem so that some of the wood beneath the bud is included. Carefully peel off the bud without damaging it. The bud should be about the same size as the area peeled off the stock plant so that they can be easily joined.

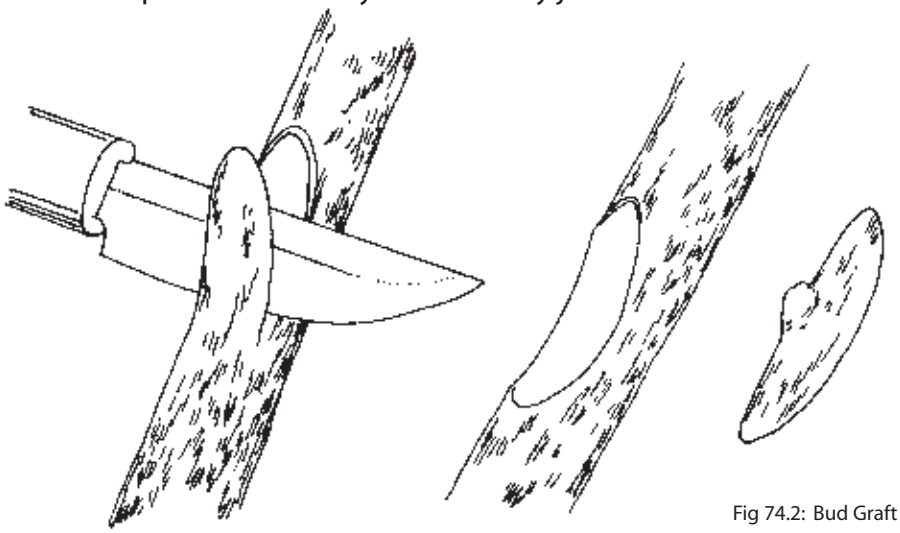

Fig 74.2: Bud Graft - Stem

5 Attach the bud to the peeled section of the stock. Be careful not to damage it.

6 Use tape or plastic to bind the area around the attached bud so that only a tip at the top is visible.

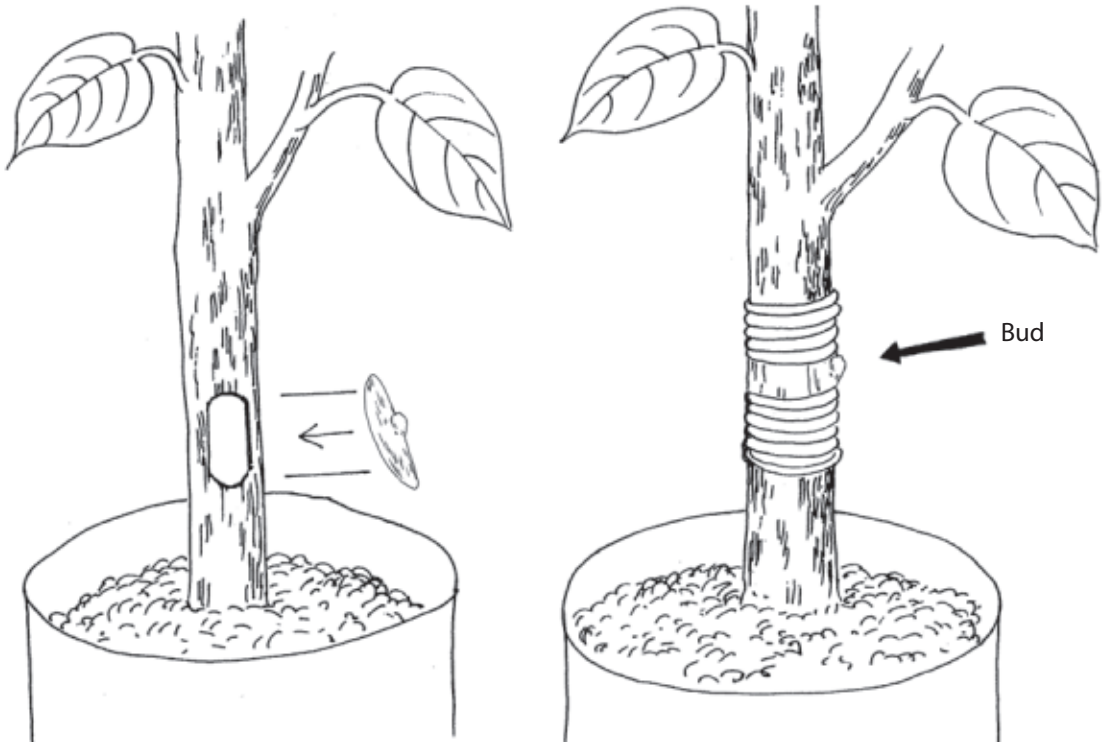

Fig 74.3: Bud Graft - Bind

7 After 2-3 weeks, the attached bud should look green and moist and we may be able to see some new growth. The tape or plastic can be carefully removed not long after this.
8 When the bud has shown enough growth, we should cut halfway through all of the stock plant's branches above and below the graft. If after another 1-2 weeks the bud is still growing we can remove these branches completely with a clean, sharp knife. It may be necessary to support the new growth to stop the graft from splitting.
9 After 2-3 months if the new plant continues to grow well, we can transplant it to a permanent place.

NOTES

Overview

In the Sections on Agro-forestry, Inter-cropping, and Green Manure, we talked about several types of plants and trees that can be useful in many different ways. These types of plants can be called Multi-Purpose species, and there are many good reasons for growing them in gardens and on farms. The best types of Multi-purpose species to grow are the ones that have the qualities listed in the Table: Qualities of Multi-Purpose Species below. Generally, the benefits of Multi-Purpose species can be divided into several areas. These are listed in the Table: Benefits of Multi-Purpose Species on the following page.

Qualities of Multi-Purpose Species	
Multiple Use	Species that have more than one use. For example, *Leuceana* is a legume that increases soil nitrogen, provides edible leaves and seeds and is a good source of fuel wood.
Fast Growing	Species that grow quickly and do not take long to become established and reproduce.
Local	Plants that are found locally and are adapted to the environment. These plants will be better able to resist insects, diseases and weather.
Compatible	Species that do not negatively affect the growth of other species next to them because they do not use too much water or nutrients, or because they do not produce chemicals that would repel beneficial organisms.
Non-Poisonous	Species that are not poisonous to people or animals.

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Benefits of Multi-Purpose Species

NF	Nitrogen - Fixing	Legume species that can collect nitrogen from the air and store it in the soil and in their bodies. These species help to improve soil fertility and often supply beans and pods with a lot of protein.
GM	Green Manure	Species that are grown to improve the quality of soil but are not necessarily legumes. These types of plants provide a lot of organic matter that can be ploughed back into the soil.
E	Edible	Species that have leaves, fruit, seeds, roots and / or flowers that are edible and nutritious.
M	Medicinal	Species that have parts that can be used to make medicines to treat sickness in people or animals. Many of these types of plants also have chemicals that can be used to repel crop pests.
FD	Fodder	Species that can be grown to produce extra, nutritious food for farm animals.
FW	Fuel Wood	Species that can provide good firewood or can be used to make charcoal.
B	Building	Species that provide useful materials for building and making things. This can include branches and poles for housing, fencing, baskets, tools, or leaves for thatch and weaving, etc.

NOTES

There are hundreds of different species of plants that have many types of benefits and we can not mention them all in this Handbook. Some of the species that grow in South East Asia are included in the following Table. We have only used the scientific names of the species. Pictures of some of the species mentioned here are on the following pages.

Species (Scientific Name / English Name)	Benefits
Acacia concinna / Soap Nut	NF / E / M / FW / FD /B
Acacia pennata / -	NF / E / M / FW / FD / B
Azardirachta indica / Neem Tree (Sadao)	E / M / FW / B
Baccaurea racemosa / Neem Tree (Mafai) *B. ramiflora*	E / M / B
Broussonnetia papyrifera / -	GM / FD / B
Cajanus cajans / Pigeon Pea	NF / GM / E / FD / B
Calliandra calothyrsus / Calliandra	NF / GM / FW / B
Carica papaya / Papaya	E / M
Cassia fistula / Golden Shower Tree	NF / M / FW / B
Cycopogon spp. / Lemon Grass	E / M
Flemingia congesta / Flemingia	GM / FD / FW / M
Gliricidia sepium / Cherry Tree	GM / FD / FW
Leucaena diversifolia / Leucaena *L. leucocephala*	NF / GM / E / FD / FW / B
Moringa oleifera / Drumstick Tree	GM / E / M / FD
Parkia speciosa / Patai	NF / GM / E / FD / FW / B
Phyllanthus acidus / Star Gooseberry *P. emblica*	E / M / FD / FW (more usually *P. embilica*)
Pithecellobium dulce / Manila Tamarind	NF / GM / E / M / FD / B
Psidium gaujava / Guava	E / M
Sesbania grandiflora / Sesbania *S. sesbans*	NF / GM / E / M / FD
Tamarindus indica / Tamarind	NF / GM / E / M / FD / FW / B

Acacia pennata

A fast growing legume that provides a good source of Vitamin A and C, phosphorus, and iron. The seeds, pods and new leaves can all be eaten. The plant can be coppiced easily year after year and is useful as fuel wood for starting charcoal fires.

Fig 75.1: *Acacia pennata*

Leucaena leucocephala

A very useful and fast growing legume. The seeds, pods and young shoots can all be eaten and are a good source of Vitamins A and C, iron, and protein. The trees grow strong and are excellent for use in alley cropping and on contour lines. In the cold season *L. leucocephala* can suffer attacks from pests called jumping lice, so it is a good idea to plant many different types of multi-use species together, and not just rely on one.

Fig 75.2: *Acacia leucocephala*

Sesbania grandiflora

A very useful species that many people grow in their gardens because it is so beautiful. The tree is a very good green manure crop and the young leaves, green pods, and flowers can all eaten and used for fodder. They provide a good source of Vitamins A, B and C, as well as iron, calcium and protein.

Fig 75.3: *Sesbania grandiflora*

Cajanus cajans

A very common species that has many uses. This species usually grows for about two years but can easily be reproduced from seed, making it very useful for agro-forestry. The seeds and green pods can be eaten or used as fodder, and provide a good source of protein, phosphorus, iron and Vitamin A. Many farmers mix the old dry pods in animal feed for cattle and goats.

Fig 75.4: *Cajanus cajans*

Moringa oleifera

A quick growing tree, especially from cuttings, that has many different uses. The wood can be used for firewood, while the roots, bark, seeds and leaves are used in traditional medicine. The young pods and shoots are a very good source of calcium, phosphorus, iron, as well as protein, and Vitamins A, B and C for both humans and animals. Every garden or farm should try and grow *Moringa*.

Fig 75.5: *Moringa oleifera*

Psidium gaujava

Guava is not normally considered a multi-use species, but we have included it here because it is one of the best fruit trees to grow in restricted spaces. First, it is fast growing, with some varieties producing fruit within two years. Second, it can produce a large amount of fruit that has more Vitamin C than even limes or lemons. Third, with good care and management, guava has good resistance to many diseases and pests. Fertile soil and careful pruning to keep air flowing through the branches will make for healthy guava trees.

Fig 75.6: *Psidium gaujava*

NOTES

Nutrient Needs of Plants

Key Requirements

1 Light feeder
2 Needs high nitrogen
3 Needs high phosphorus / potassium
4 Tolerates more acidic conditions
5 Tolerates more alkaline conditions
6 Needs pH near neutral
7 Needs good drainage / can't stand wet feet
8 Needs lots of water / tolerates heavy soil
9 Needs lots of water / can't stand wet feet

Plant	1	2	3	4	5	6	7	8	9	Comment
Asparagus (*Liliaceae*)		•	•		•		•			Deep-rooted perennial.
Bean (*Leguminosae*)	•					•	•			Manganese, zinc, and iron essential; use proper bacteria for nitrogen fixation.
Beet (*Chenopodiaceae*)		•	•		•		•			Needs micro-nutrients, especially boron; avoid raw manure.
Broccoli, Brussel sprouts, Cabbage, Cauliflower, (*Cruciferae*)		•	•			•		•		Need calcium, sulphur, and boron.
Carrot, Parsnip (*Umbelliferae*)	•			•			•			Avoid excess nitrogen; need deep soil.
Celery (*Umbelliferae*)		•	•	•				•		High boron demand; needs plenty of humus.
Corn (*Gramineae*)		•	•	•			•			Side-dress when knee-high; needs zinc.
Cucumber (*Cucurbitaceae*)		•	•	•					•	Needs lots of humus; magnesium important.
Eggplant (*Solanaceae*)		•	•	•			•			Plants grow poorly in cool, wet soil.
Garlic, Shallot (*Liliaceae*)	•		•	•			•			Need micro-nutrients and sulphur.
Kale, Collards, Mustard (*Cruciferae*)		•	•	•				•		See Broccoli.

Plant	1	2	3	4	5	6	7	8	9	Comment
Lettuce (*Compositae*)		•	•			•			•	Calcium, manganese, and copper important.
Melon (*Cucurbitaceae*)		•	•		•				•	Needs lots of humus; magnesium important.
Onion (*Liliaceae*)	•		•			•			•	Need high humus; have high sulphur and micro-nutrient needs.
Pepper (*Solanaceae*)	•			•			•			Needs sulfur and magnesium; avoid excess nitrogen.
Potato (*Solanaceae*)		•	•	•			•			Avoid raw manure; more acidic conditions prevent scab.
Spinach, Chard (*Chenopodiaceae*)		•	•		•		•			Have high micro-nutrient needs.
Pumpkin (*Cucurbitaceae*)	•		•	•			•			Needs lots of humus; magnesium important.
Sweet potato (*Convolvulaceae*)	•		•	•			•			Drainage is crucial; tolerates poor soil.
Tomato (*Solanaceae*)			•	•			•			Avoid excess nitrogen.
Turnip, radish (*Cruciferae*)	•			•			•			Avoid excess nitrogen. See Broccoli.

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CAN 7

Section 7: Nutrition

Food and Nutrition
Growth and Development
Malnutrition
Handling, Storing and Preparing Foods

Food

Food is everything we normally eat. Every living thing needs food and water to survive. The food that we usually eat is called our *diet*. Depending on where people come from and which culture they live in, their diet can be very different.

For example, the Karenni diet is made up of rice, some meat, vegetables and fruits, plus beans and insects. The Karen diet is made up of rice, fish paste, meats and vegetables. The Western diet is made up of bread and potatoes, meats, vegetables and fruits, plus things like cheese and milk.

Fig 76: Food is Everything We Normally Eat

Nutrition

Nutrition is all about *what kinds* of food we eat everyday, as well as *how much* food we eat to survive and to be healthy.

Good nutrition helps people to:

- Grow and stay healthy.
- Have energy to work, play, study and think well.
- Protect people from getting sick.

To get good nutrition, people need to eat the right nutrients in the right amounts. Nutrients are the substances in the foods we eat which our bodies use to produce energy and for growth and repair.

Nutrients can be grouped into these different types:

Carbohydrates

Starchy Foods; like rice, bread, corn, noodles, etc.

Fig 77.1: Carbohydrate Foods

Fats

Oily or Fatty Foods; like cooking oil, fat from meat, etc.

Fig 77.2: Fatty Foods

Proteins

Animal or Bean and Nut Foods; like meat, fish, eggs, liver, beans, nuts, seeds, etc.

Fig 77.3: Protein Foods

Vitamins and Minerals

These are found in many types of food, especially fruits and vegetables. We need only a small amount of them.

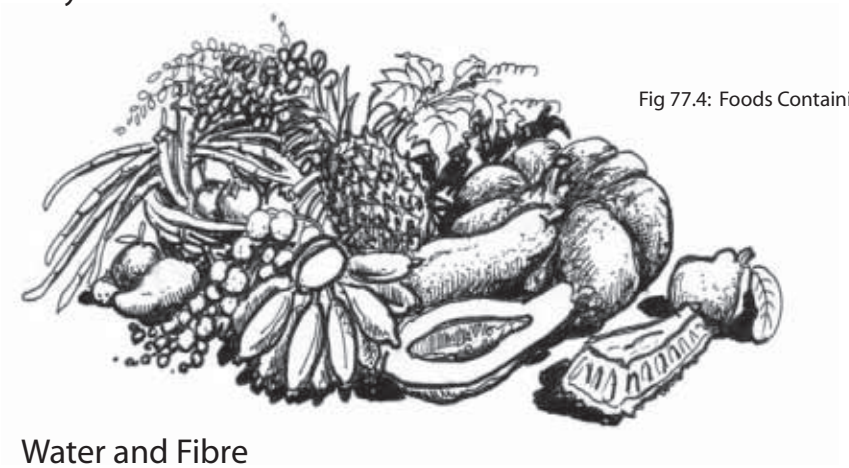

Fig 77.4: Foods Containing Vitamins and Minerals

Water and Fibre

Water and fibre are also nutrients that we need.

Food Groups

Different nutrients do different things for our bodies. When we talk about *what kinds* of foods and nutrients we need to eat for good nutrition, we talk about food groups, which make it easier to identify which nutrients are in which foods.

Foods can be organised into three groups according to the nutrients the foods contain and the benefits they have for our bodies. Each group has a special job or function in our bodies.

The Three Food Groups:

1 *Body-building Foods:* Protein foods.
2 *Energy Foods:* Fats and carbohydrates.
3 *Protective Foods:* Vitamins and minerals.

Fig 78: Different Food Groups

Note:

Remember that all foods contain most nutrients, but some have more of one kind than another kind.

Body-building Food Group

Body-building foods can also be called protein foods. Body-building foods make bodies:

- Grow.
- Help develop strong muscles.
- Help repair the body after illness.

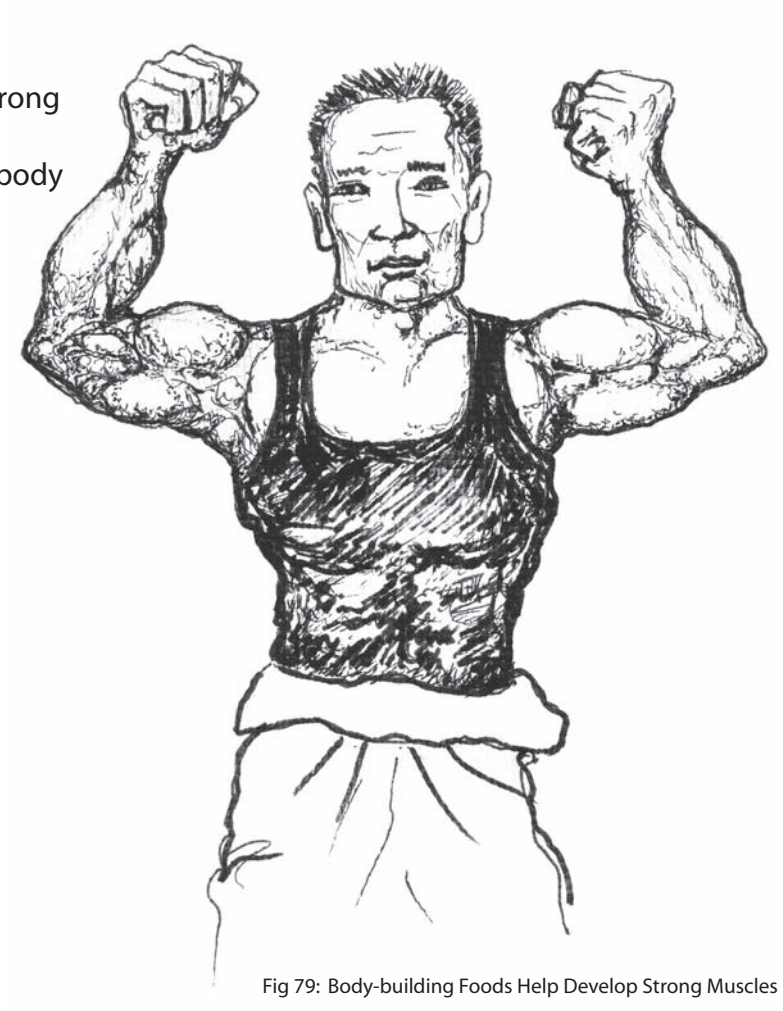

Fig 79: Body-building Foods Help Develop Strong Muscles

Without enough body-building foods, children cannot grow tall or strong. Both adults and children who do not eat enough protein can get weak and sick more easily than other people.

Many body-building foods come from animals, but some body-building foods can come from plants. Some common examples of body-building foods or protein foods are:

Legumes:
Beans and nuts; like calipe and red beans, soybeans and peanuts.

Animal foods:
All meats; like chicken, pork, beef, fish and crab, also eggs and milk.

When we eat protein from animal foods we can use the protein right away. Protein from plant foods must be combined with other foods so our bodies can use it. Here are some examples of how to combine foods to get good protein from plants:

Rice + Beans
or
Peas + Rice
or
Beans + Bread
or
Rice + Groundnuts

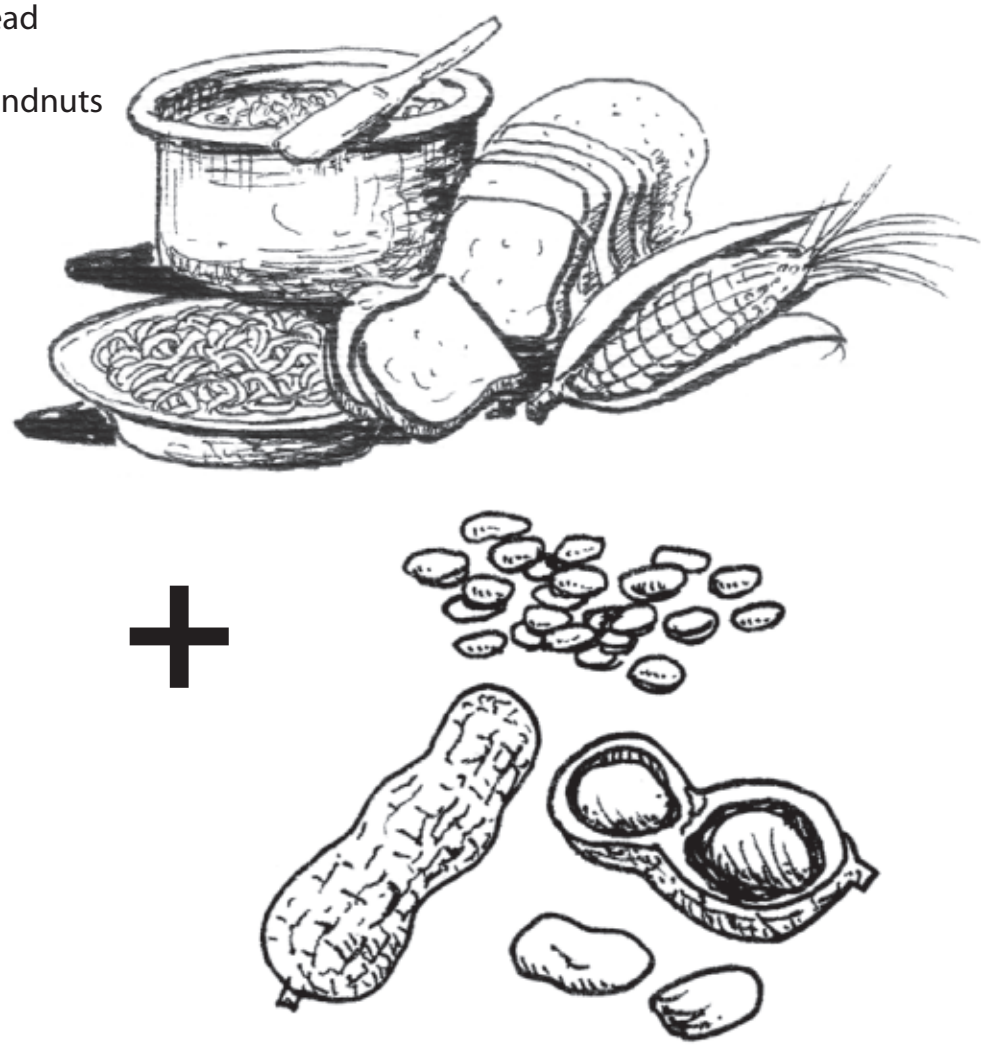

Fig 80: Combining Protein from Plant Foods

Note:

- Children need good protein to grow properly.
- It is important to eat some body-building foods every day.

Energy Food Group

Energy foods are the foods that give people energy. We need energy to do the activities we do every day, like work, play sports, walk, talk, etc. If people do not eat enough energy foods, they can become weak and tired.

Fig 81: Energy Foods Give Strength to do Activities

Energy foods are usually foods with a lot of carbohydrates or fat, which make peoples' stomachs feel full and give them strength to do activities. People choose energy foods to be their *main food* or *staple food*.

Rice is the staple food for most people from Asia. But, other energy foods are also important to eat. Energy food is often yellow or white in colour. Some common examples of energy foods are:

Staple Foods:
Rice, noodles, bread, corn, potatoes and bananas.

Oils:
Coconut oil, cooking oil, fat from pig meat, sugar cane and cow's milk.

Note:
It is important to eat some energy foods every day in addition to rice.

Protective Food Group

Foods with lots of vitamins and minerals are also called *protective* foods. Protective foods are foods that:

- Help our bodies work properly.
- Protect the body from getting many kinds of diseases.
- Help to make strong blood, skin, teeth and bones.

Fig 82: Protective Foods Help Our Bodies Work Properly

Minerals such as iron, iodine and calcium help the body make strong blood, teeth and bones. Minerals can be found in many foods.

Vitamins such as vitamins A, B and C, can also be found in foods from other groups. The best way to get lots of vitamins are from eating fresh vegetables and fruits, especially dark green, orange or yellow vegetables and fruits. Some common examples of foods with lots of vitamins are:

Dark Green and Orange Vegetables:
Fresh Vegetables; such as green beans, pumpkin, morning glory, tomatoes.

Fruits:
Fresh Fruits; such as papaya, mango, jackfruit and oranges.

Note:
It is important to eat some protective foods every day.

Even though vitamins and minerals are very important for health, our bodies need only tiny amounts. If you do not get enough vitamins and minerals in your diet you can develop *vitamin and mineral deficiencies*. You can read about vitamin and mineral deficiencies in the Malnutrition section on page 182. Here are some more details about important vitamins and minerals.

Vitamin A

Vitamin A is very important for our bodies, especially for our eyes.

Fig 83: Vitamin A is Important for Eyes

What it Does

Vitamin A has three main functions for our bodies:

1 It keeps our eyes healthy and helps us to see well, especially at night.
2 It is important to keep the immune system working and prevents disease.
3 It is very important for growth in children.

Foods

Vitamin A comes in different foods. Vitamin A can be found in animal foods and it can also be found in plant foods.

Fig 84: Foods Containing Vitamin A

Some of the best places to find vitamin A include:

- Liver.
- Eggs.
- Animal milk.
- Dark orange and yellow fruits like papaya or mango when they are ripe.
- Orange vegetables, like bright orange pumpkin.
- Dark and medium dark green leaves like spinach, amaranth, kale and all dark green leaves.
- Breast milk, particularly the colostrum, the milk that comes during the first few days after birth.

For our bodies to absorb vitamin A, we need to eat some fat with it. Therefore, it is important to try and use a little bit of fat or oil when eating or cooking foods with vitamin A in them.

Vitamin B1 or Thiamine

There are many different types of Vitamin B. Vitamin B1 is called *thiamine*. Vitamin B1 is very important for nerve and muscle functions.

What it Does

Vitamin B1 helps our body *burn* the fuel that it gets from the carbohydrates we eat. The more carbohydrates we eat, for example if we eat a lot of rice, the more vitamin B1 our bodies need.

Foods

Vitamin B1 is found in many foods, especially in pork and beans. Other foods we eat often which contain vitamin B1 include:

- Yellow beans and other beans.
- Unpolished, home pounded rice.
- Peanuts.
- Meats.
- Eggs.

Fig 85: Foods Containing Vitamin B1

Note:

Rice contains a lot of B1, but the B1 gets removed when the rice is polished.

It is important to know that chewing betel nut and drinking tea destroys B1 if they are consumed during or just after meals. To get the most vitamin B1 from the food you eat, wait at least 1 to 2 hours after eating before you chew betel nut or drink tea.

Fig 86: After Eating Wait Before Chewing Betel Nut

Vitamin C

Vitamin C is important for developing healthy skin, gums and joints.

What it Does

Vitamin C is very important in protecting our bodies, especially for fighting infections like coughs, colds and other infections and in repairing wounds like cuts and burns. Vitamin C also helps our body to absorb iron, which is a very important mineral.

Fig 87: Vitamin C Helps Fight Coughs and Colds

Foods

Vitamin C is found in all fresh fruits and vegetables, but is highest in *sour* fruits and vegetables. Some of the best foods to find vitamin C include:

- Oranges.
- Lime.
- Papaya (green).
- Mango (green).
- Pomelo.
- Guava.
- Tomato.
- Potato.

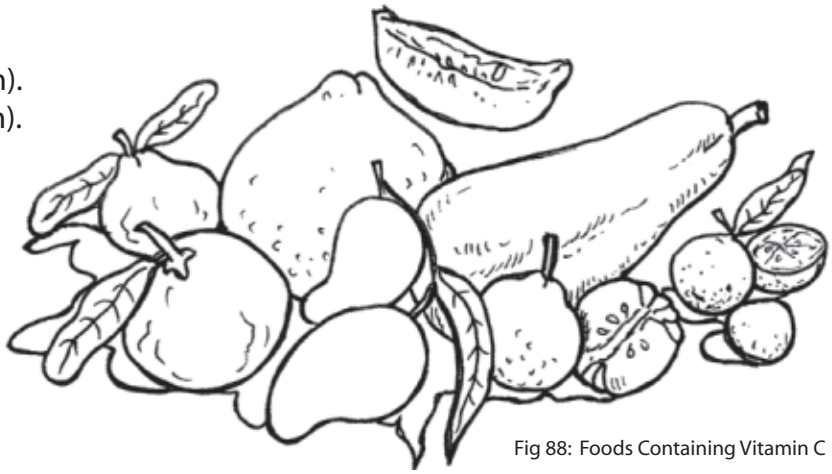

Fig 88: Foods Containing Vitamin C

Iron

Iron comes from two types of foods. Iron is found in foods from animals and foods from plants.

What it Does

Iron is a mineral that helps the body build strong blood and keep the blood healthy. Iron helps carry oxygen all over our body through the blood.

Fig 89: Iron Keeps Blood Strong

Foods

Iron from animal foods is more easily absorbed by our bodies than iron from plant foods. Iron from plant foods are harder for our bodies to absorb. In fact, on a strict vegetarian diet, it is difficult for us to get enough iron.

Our body can absorb iron from plant foods more easily if we eat it together with foods that contain vitamin C. For example, if we put lime juice on morning glory, our body can absorb more of the iron.

Children get iron from breast milk until they are about 4 to 6 months old. After that, their diet needs to include iron foods. Because women menstruate and lose blood every month, the iron lost in the blood needs to be replaced.

Foods which have a lot of iron include:

- Meat (all types, especially liver, kidney, heart. Pork, chicken, duck and beef).
- Dark green leafy vegetables.
- Beans.
- Eggs.
- Fish.

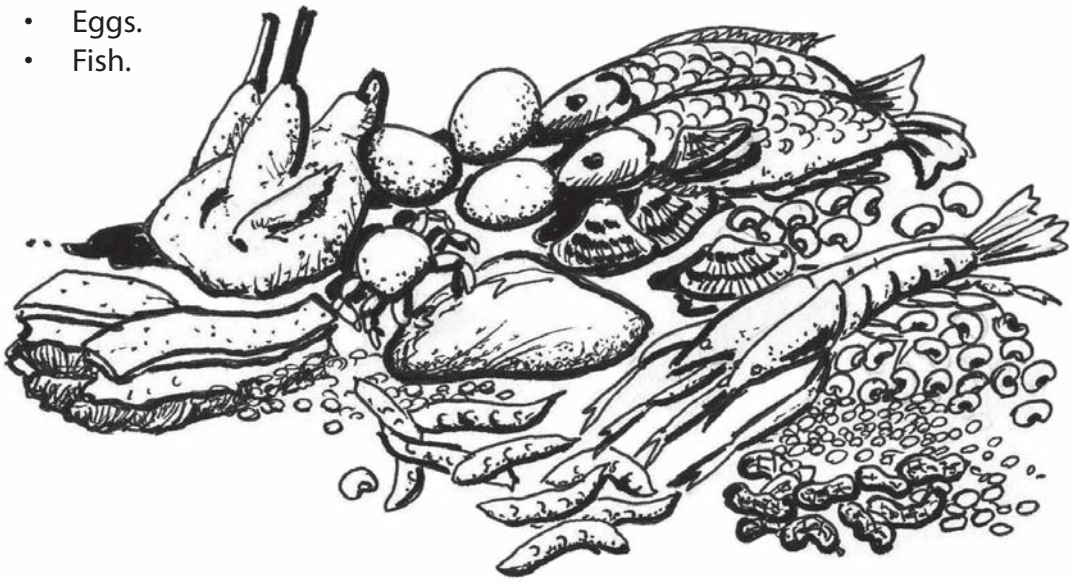

Fig 90: Foods Containing Iron

Note:
It is important to try and eat plenty of foods that have iron in them.

Iodine

What it Does

Iodine helps to regulate growth in children, the way our bodies use energy and keep warm and how fat or thin we are. Iodine also contributes to the development of our brain.

Foods

Iodine comes from foods grown in or near the sea and the animals that eat them. Because many people live in the mountains, far from the sea, they may not get enough iodine.

The best way to get iodine is from *iodised salt*. Be sure to use iodised salt for cooking and seasoning food. If there is no iodised salt available, iodine drops should be added to water or salt.

Calcium

What it Does

Calcium is very important for building strong bones and teeth. Calcium is also very important in the normal growth of children.

Foods

The best foods which contain calcium are:

- Small fish eaten with the bones.
- Milk.
- Dark green vegetables.
- Dark green leaves.

Fig 91: Small Fish with Bones are High in Calcium

Eating in a Healthy Way

All people need a good balanced diet in order to stay healthy. People need food from all groups to have good nutrition. This is because the foods in each food group have special functions in our bodies. If we only eat foods from one group, we will not be getting the nutrients from the other groups.

It is not healthy to eat only oil everyday, or only eggs everyday, or only morning glory every day. We must try to choose some foods from each group to have a good mix of body-building, energy and protective foods.

If we do not get a good mix of body-building, energy and protective foods, we can get malnutrition.

It is especially important that children get food from all food groups. This is because children can get sick and malnourished more easily than adults. Children are growing fast and many of the nutrients are very important for growth.

Sick people also need to be sure to eat from all three food groups. Often sick people do not want to eat, but this is very dangerous. If sick people do not have enough body-building, energy and protective foods, their bodies cannot *fight* the disease properly. It is most dangerous for sick children, who can get very weak and die if they do not eat enough food and drink enough liquids.

For example, if someone has diarrhoea they must continue to eat and drink, or they will not have energy to fight the disease in their body. It will be more difficult for them to get better if they do not continue to eat good foods.

Fig 92: Healthy Foods

Note:

- It is important to know that eating foods from only one food group is not healthy. In addition to rice, try to eat some foods from all food groups every day.
- All people, men, women and children need food from all the food groups to stay healthy and strong.

NOTES

Overview

Good nutrition is essential for the healthy growth and development of children. Children 5 years and under are at the highest risk of malnutrition. They are also at risk of protein and energy deficiencies and vitamin and mineral deficiencies.

Food Needs for Mothers and Babies

People need different kinds of foods and different amounts of foods as they grow from babies, through childhood and into adulthood. This is because as children grow, their bodies change and the amount of activities they do changes. Women also have special needs for nutrition, depending on if they are pregnant or breast feeding.

Fig 93: Child Growth and Development

Pregnant and Breast Feeding Women

Good nutrition during pregnancy and breast feeding are especially important for the health of the mother and baby.

A well nourished mother should gain at least 8 to 12 kilograms during her pregnancy because the mother is eating for two people; herself and her growing baby. This means she must eat more. She must eat more body-building foods, more energy foods and more protective foods, especially foods with plenty of iron and vitamin A.

Lactating women need even more food and plenty of liquids to make good quality breast milk for their babies.

Fig 94: Breast Feeding Mother

Infants

Infants From 0 to 6 Months Old

Only breast milk is the best food for infants. It is the only food they need until they are about 6 months old.

Babies who are breast fed are healthier, grow stronger and are less likely to get sick than babies who use bottled milk. Also, if a mother uses a bottle but does not keep her hands, the bottles and the water very clean, that baby will have a greater chance of getting serious infections.

Infants From 6 Months

Breast milk is the best food for babies, but breast milk alone is not enough after about 6 months. When babies reach 6 months old, they start to become more active and need more food than just breast milk. Also, they need vitamins and minerals, like vitamin A and iron.

Babies still need breast milk, but now they also need other foods. Mothers should continue breast feeding their babies at the same time as starting to introduce other foods.

Fig 95: Feeding First Foods

These other foods are called *first foods*. First foods are very important for the health of all babies. Babies should be introduced to first foods slowly and very carefully. These first foods must be very clean, very soft and must include foods from all the food groups in addition to rice. Infants should be fed small meals before breast feeding.

Every community has its own traditional first foods for babies. But sometimes these traditional foods do not have enough energy, proteins or vitamins and may cause malnutrition in the child. It is also easy for small babies to get diarrhoea if their first foods are not prepared carefully and cleanly.

When making first foods for babies, there are a few special things that parents need to know:

1 First foods must have high amounts of protein, energy and vitamins and minerals.
2 First foods for babies must be soft, smooth and easy to digest.
3 First foods must be as fresh and clean as possible because babies can get infections and get sick easily.
4 First foods must be inexpensive and easy to prepare.

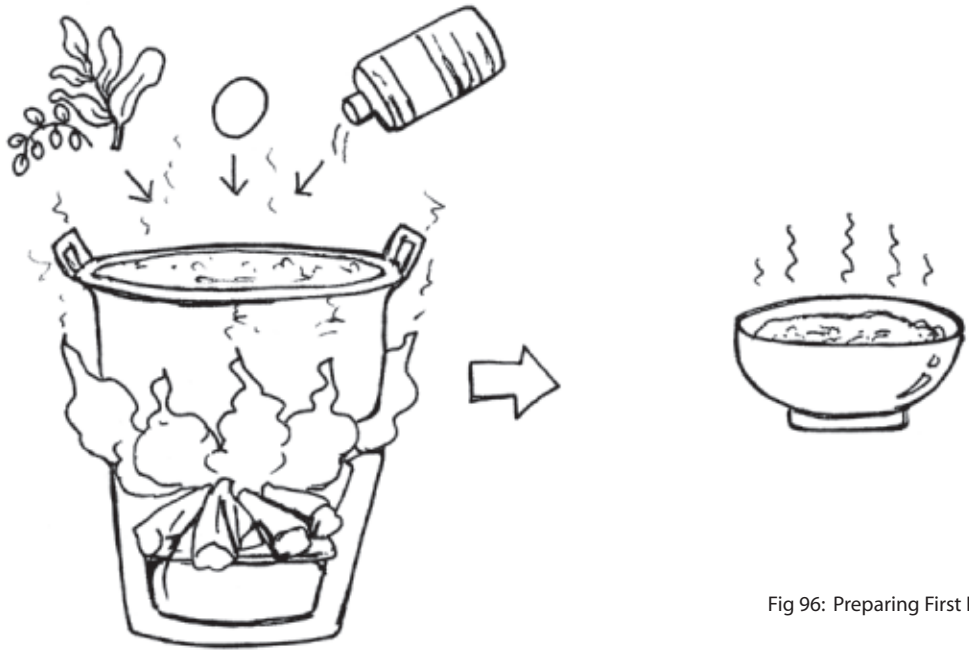

Fig 96: Preparing First Foods

Nutritious first foods can be made from foods that people normally eat in this area. For example, first foods can be made from:

- Soft fruit, such as papaya and banana.
- Chicken eggs and duck eggs.
- Dark green vegetables.
- Rice soup.
- Beans.
- Pumpkin.

Fig 97: Healthy Infant

Here are some simple recipes for making nutritious first foods:

First Food Recipe One

Ingredients:

- Yellow beans.
- Rice.
- Pumpkin.
- Green vegetables.
- Oil.
- Egg, Fish or Meat (optional).

Procedure:

1. Soak one spoonful of dry yellow beans in water for several hours.
2. Add one or two spoons of dry rice, one or two pieces of pumpkin and then add clean boiled water. Mix all of this food together until it is soft.
3. Then add some cooked green vegetables and a little oil.
4. If you have an egg, fish or meat, add them to the mixture. Then boil the whole mixture together until it is very soft.

Cooked rice and beans can also be used but be sure to heat vegetables and meat well and mash mixture until very soft.

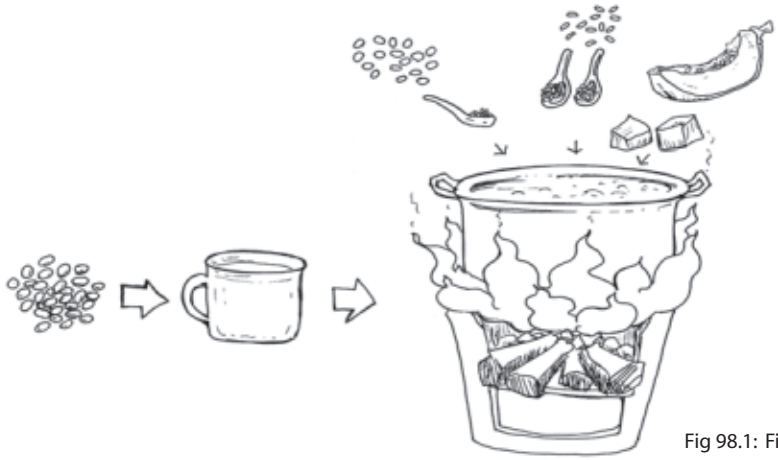

Fig 98.1: First Food Recipe One

First Food Recipe Two

Ingredients:

- Banana or papaya.
- Lime or orange juice.

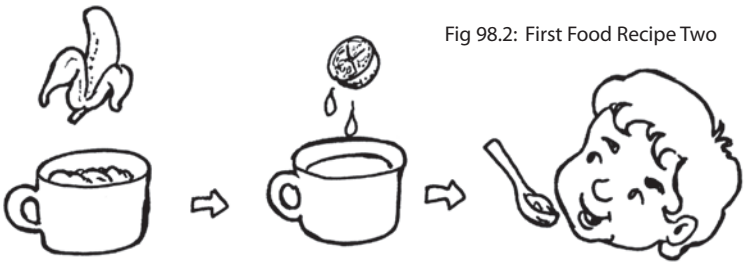

Fig 98.2: First Food Recipe Two

Procedure:

1. Using a spoon, mash one banana or some pieces of papaya in a cup until it is completely soft.
2. Squeeze lemon or orange juice into the cup and mix well.

Older Children

Children who are over 2 years old have similar needs for food as adults. The amount of food may be different, but the types of food are the same. Children need plenty of body-building foods in addition to energy foods and protective foods.

Fig 99: Good Foods for Healthy Children

The most important thing to remember is that the diet must include foods from all of the food groups in addition to rice. This means eating some protein foods, some carbohydrates, some fats and some foods with vitamins and minerals every day.

Younger children need to eat more often than adults. It is best for younger children to eat about 5 or 6 times per day while adults only need to eat 2 or 3 times per day.

Abnormal Growth and Development

Abnormal growth and development means that something happened to the child's body which has affected growth or the ability to develop normally as other children do.

Many things can cause abnormal growth and development during a phase of a child's life. Abnormal growth can happen before the person is born (while still inside the mother), after they are born or even during adulthood.

Fig 100: Abnormal Growth and Development

In most cases it is very difficult to know exactly what causes abnormal growth and development. In some cases however, it is clear that malnutrition has contributed to abnormal growth and development.

We know that growth and development can be affected by nutrition:

Before Birth: If a mother is malnourished or not receiving enough vitamins and minerals, such as iodine.

After Birth: If the child is malnourished or not receiving enough vitamins and minerals.
If the child has infection or disease.

Note:
Good nutrition, including giving breast milk, is the *most important* factor in making sure that children grow and develop properly.

NOTES

Overview

Feeling hungry is a signal for our bodies to eat more food. When we are hungry, we need to *fill up* our bodies with healthy, nutritious food. But what happens if we don't get enough food or enough nutrients?

When we don't have enough food and nutrients, our bodies begin breaking down fat and muscle and uses it for fuel. If this happens for a long time we become thinner and we lose fat and muscle mass.

When someone does not get enough food or enough of the right kinds of food for a long time, they become *malnourished*.

Fig 101: Malnourished Child

Malnutrition can cause many problems. Malnourished children are more likely to have learning difficulties and they are more likely to become ill and die. Malnourished adults may feel tired, become very thin and may not be able to work or take care of their children.

Many things can cause malnutrition, here are some examples:

- Not eating enough food or enough of the right kinds of foods.
- Worm infections.
- Other severe infections, like TB, malaria, pneumonia and diarrhoea.
- Poor feeding habits from a mother to her child.

Identifying Malnutrition in Children

There are many ways to identify malnutrition in children. Here are a few examples of how to identify malnutrition in your community:

- Child stops growing and stops gaining weight.
- Child does not have energy, does not want to play and may sleep a lot.
- Child gets sick often.
- Later, the child may have loose skin, be very thin and have an 'old man' face
- Sometimes the child may also look swollen at the legs, arms and face.

Fig 102: Physical Appearance of the Malnourished Child

Note:
If a child does not eat properly for a long time, they may not grow properly.

Vitamin and Mineral Deficiencies

Another kind of malnutrition is vitamin and mineral deficiency. It is very important to know that vitamin and mineral deficiencies are caused by not eating enough foods with vitamins and minerals in them. Vitamin and mineral deficiencies can also be caused by eating foods which destroy vitamins, like betel nut or tea. Symptoms of vitamin and mineral deficiencies vary depending on which vitamin or mineral is lacking in our diet.

For more information on the benefits of vitamins and minerals and the foods which contain them, see the section Protective Food Group on page 166. The following pages outline some common vitamin and mineral deficiencies.

Vitamin A Deficiency

Vitamin A deficiency happens when the body does not get enough Vitamin A from foods. If we do not have enough vitamin A in our foods, we can develop problems with our eyes and may become blind. Children with vitamin A deficiency will become sick more often and are more likely to die. Children who do not get enough vitamin A will not grow properly.

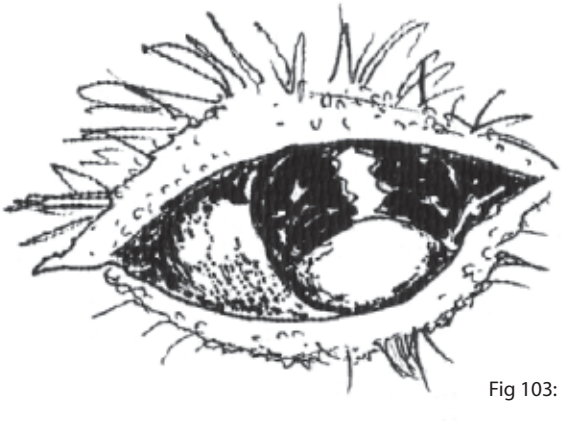

Fig 103: Effects of Vitamin A Deficiency on the Eye

Children are especially susceptible to vitamin A deficiency.

How to Prevent Vitamin A Deficiency

- Good nutrition, for example eating from all food groups every day and eating foods high in vitamin A. (See Pg. 167: Vitamin A)
- Getting treatment for infections.
- Taking vitamin A supplements from a clinic.

Vitamin B1 Deficiency

Vitamin B1 deficiency happens when a person does not eat enough foods with vitamin B1. Vitamin B1 deficiency is commonly called *Beri Beri*. Beri Beri makes people feel weak, especially in the legs. Infants can become ill and die very quickly if they are lacking enough vitamin B1.

Beri Beri can also be caused by eating a diet that is mostly rice, or when betel nut and tea are chewed and drunk during meal time. Beri Beri happens most often in women of child bearing age and their infants, but also sometimes it can happen in active young men.

How to Prevent Vitamin B1 Deficiency

- Good nutrition, for example eating from all food groups every day and eating foods high in vitamin B1. (See Pg. 168: Vitamin B1 or Thiamine)
- Avoid chewing too much betel nut or drinking too much tea, especially near or after meal times.

Vitamin C Deficiency

Vitamin C deficiency happens when the body does not get enough Vitamin C from foods. Vitamin C deficiency is called *Scurvy*. Scurvy makes people's gums become swollen and bloody. Scurvy also makes people's joints feel painful. Scurvy can cause death.

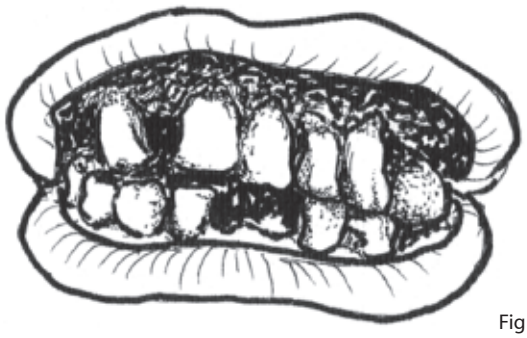

Fig 104: Effect of Vitamin C Deficiency on the Gums

People who do not get enough Vitamin C may also develop iron deficiency (Anaemia) because vitamin C helps the body to absorb iron.

How to Prevent Vitamin C Deficiency

- Good nutrition, for example eating from all food groups every day and eating some fresh foods every day. Foods high in vitamin C.
  (See Pg, 169: Vitamin C)

Iron Deficiency

Iron deficiency is called *Anaemia* and happens when the body does not get enough iron. Anaemic people look very pale and feel very tired. Anaemia is a serious problem because it reduces people's ability to work and it affects children's ability to learn.

Anaemia may make a pregnant woman more likely to become very sick or die in childbirth. Anaemia may make a baby's birth weight low or cause a baby to die early in childhood.

Fig 105: Anaemia in Pregnancy

Iron deficiency anaemia is caused by not eating foods with iron, or having a disease like malaria or a hookworm infestation. Iron from foods can be absorbed better by the body if eaten with foods that contain vitamin C .

How to Prevent Iron Deficiency

- Good nutrition, for example eating from all food groups every day and eating foods high in iron together with vitamin C. (See Pg, 170: Iron)
- Feed children over 6 months with iron rich foods in addition to breast milk.

Iodine Deficiency

When someone does not have enough iodine in their food, their body cannot function properly and they get *Iodine Deficiency Disorder* (IDD). Their throat becomes bigger and bigger. When the throat becomes enlarged, we call this a goitre.

Fig 106: Goitre from Iodine Deficiency

IDD is especially dangerous for girls and women of child bearing age because IDD in pregnancy can effect the brain development of the fetus, newborn or infant. In some cases, if the mother has IDD the fetus will die in the womb. Sometimes the baby will survive delivery, but will be underweight and have mental and physical problems. Once a baby is mentally handicapped, there is no way to treat the condition.

Iodine is only found in foods that are from, or grown near the sea. If people live in mountain areas they are at risk of iodine deficiency.

How to Prevent Iodine Deficiency

- Use salt that has iodine added (iodised salt). (See Pg, 171: Iodine)
- Add iodine to water or salt by yourself.

Calcium Deficiency

Calcium deficiency happens when the body does not get enough calcium from foods. If children do not get enough calcium, they will not grow properly and will be very short. If adults do not get enough calcium, their bones can break easily.

Fig 107: Calcium Deficiency in the Elderly

How to Prevent Calcium Deficiency

- Eat enough calcium foods every day. (See Pg, 172: Calcium)
- Get exercise, for example walking, working, house cleaning, etc.

Identifying Malnutrition in Your Community

Using Your Eyes

Young children must be watched very closely for signs of malnutrition. Some early signs to watch out for are:

1 *Changes in Mood:* Malnourished children may stop smiling, stop making happy noises and may seem irritable.
2 *Changes in Activity:* Malnourished children may move around less, walk less and may not want to play. They may want to sleep more, may not want to learn how to sit up and may not want to go to school.
3 *Changes in Look:* Malnourished children get thinner, may look unhappy and may not be as tall as other children their age.

You should also look out for signs of vitamin and mineral deficiencies, such as tiredness, night blindness (*chicken eyes)*, etc.

Using Your Head

Look at what foods people have available to them. If there is not enough food or only rice, then the family may be at risk of malnutrition. Look at how mothers feed their children.

Preventing Malnutrition in Your Community

Malnutrition cannot always be prevented, but good nutrition and education about good nutrition will help. There are many reasons why adults and children can become malnourished. They include:

- Not enough foods.
- Not enough of the right kinds of foods.
- Not having enough money to buy extra foods or places to grow foods.
- Illness.
- Moving from place to place.
- Weaning children only on rice.

It is always important to help the community understand what they can do to prevent malnutrition. The CAN Handbook can help by showing people how to grow healthy foods and help people understand what foods are important to eat.

NOTES

Overview

How food is handled before it is eaten can have a big effect on the nutrient content. Handling means how the food is treated during picking, preparation and storage. Storing means how and where the food is kept before eating. Preparing means how the food is cut, cleaned or cooked for eating.

Fig 108: Clean Fresh Food

Keeping Food Safe and Clean

Sanitation is an important part of food handling. Keeping food clean means keeping food safe. When food becomes unclean it becomes unsafe and may make you sick. Clean, safe food should not have any:

1 *Bad bacteria:* Bad bacteria can cause diarrhoea or more severe illnesses. It is especially important to keep bad bacteria away from children's food.

Fig 109: Bad Bacteria in Food Can Make You Sick

2 *Parasites:* Parasites can live in our intestines and cause illness over time. Examples of parasites are, worm eggs and cysts. Things that carry bad bacteria and parasites to food include:
   - Dirty hands.
   - Flies, cockroaches and other insects.
   - Rats, mice, chickens and other animals.
   - Dirty containers and dishes.
3 *Toxins:* Toxins and harmful chemicals can cause diarrhoea and vomiting, paralysis and even cancer. A common toxin in this area is aflatoxin.
4 *Harmful chemicals:* Some farmers use pesticides and other chemicals on their crops to kill insects and to help their crop grow faster.

How Food Becomes Contaminated

When food is unsafe we say the food is *contaminated*. Food can become contaminated very easily and in many different ways. Here are some examples of how food can become contaminated:

- People do not wash their hands before they prepare food.
- People prepare food with water that contains human or animal faeces.
- Eating raw food without washing or peeling it first.
- Putting food into dirty containers.
- Eating food that dropped on the ground.
- Not covering cooked food.
- Flies or other pests are around where food is sold, cooked or eaten.
- Human faeces are not disposed of correctly and flies, rats and other animals can get to them and then to your food.
- Nuts and other foods are not dried properly or become moist and then mouldy.
- Farmers overuse pesticides.

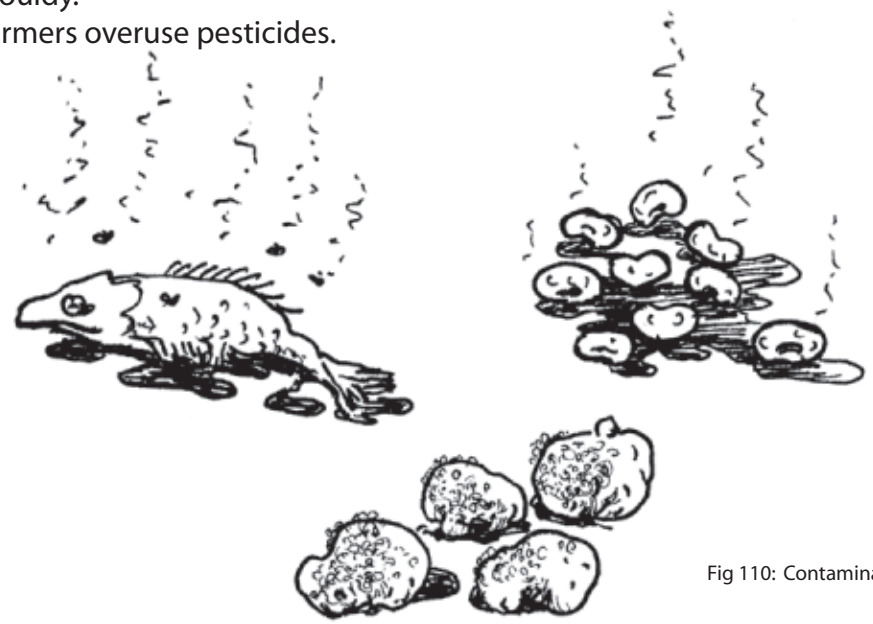

Fig 110: Contaminated Food

How to Prevent Contamination of Foods

There are many simple things you can do to prevent foods from becoming contaminated. It is easy to keep food clean if you remember these simple things:

1 Wash hands with soap before cooking and before eating.
2 Use clean water to wash and cook foods.
3 Cook food well.
4 Keep food covered before and after cooking.
5 Wash plates and spoons between meals.
6 Do not cough, spit, or scratch your hair near food.
7 Do not pick your nose or lick your fingers when preparing food.
8 Do not eat food that has dropped on the ground. If you want to eat it, wash it well first.
9 Use latrines and keep pests away from faeces.
10 Prevent mould from growing, like regular mould and aflatoxin by drying legumes, cereals, or chillies well and storing them in a dry place. Do not eat mouldy groundnuts.

Fig 111.1: Wash Hands with Soap

Fig 111.2: Wash Plates and Spoons

Fig 111.3: Use Latrines

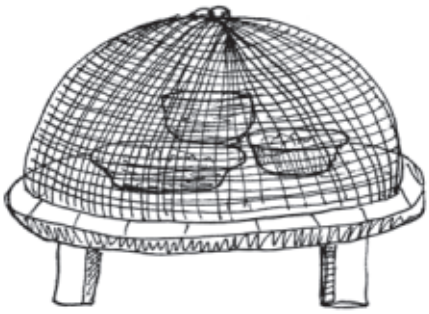

Fig 111.4: Keep Food Covered

Danger Signs of Contaminated Food

It is often possible to see if food is contaminated. Use your eyes, nose and taste to check for signs of contamination. Here are some examples of what to look for:

- Bad smell. Food smells sour, rotten or not normal.
- Unusual taste. Food tastes like acid, tastes sour or fermented.
- Mould is growing on food. You can usually see and taste the mould.
- Meat is soft, has a bad colour or smells bad.
- Fish has dull eyes, has soft flesh and loose scales.
- Vegetables which are supposed to be dry are damp or wet.

Fig 112: Danger Signs of Contaminated Food

Food Storage and Preparation

It is very important to prepare and store foods in the right way. The following pages show how to prepare and store different kinds of foods. If you do not store or prepare food well, some changes can happen. These changes can affect the nutrition of the foods. Here are some examples:

Changes in Food That is Not Stored Properly:

- Vitamin C is lost when food is stored for a long time.
- Other nutrients are lost if food spoils, becomes mouldy or is eaten by insects.

Changes in Food That is Not Prepared Properly:

- Vitamin C is lost when food is cut into small pieces or left out for some time before cooking.
- B vitamins are lost when rice is washed many times.

How to Preserve Nutrient Loss During Storage and Preparation

Different foods require different kinds of storage and different preparations. Storing and preparing foods well will help keep food nutritious.

Roots and Tubers

Root vegetables and tubers like potatoes, yams, cassava, etc.

Fig 113: Roots and Tubers

Handling and Storing:

1 Store in a dark cool place, in baskets or on slated shelves where air can circulate.
2 Gather carefully, do not bruise or cut the skin.
3 Clean off any dirt.
4 Do not allow to sprout.

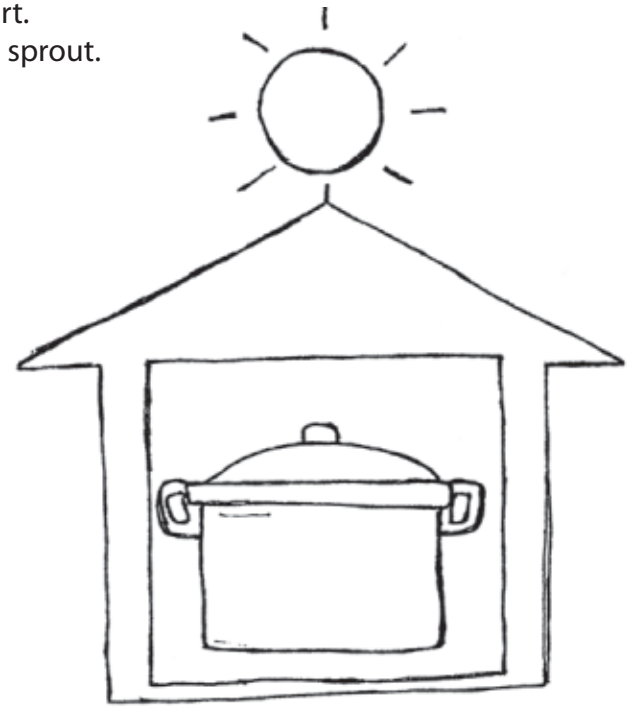

Fig 114: Store Food in a Dark, Cool Place

Preparing:
1 Scrub skins well to remove dirt.
2 Peel thinly and cut pieces the same size.
3 Cook in a small amount of water.

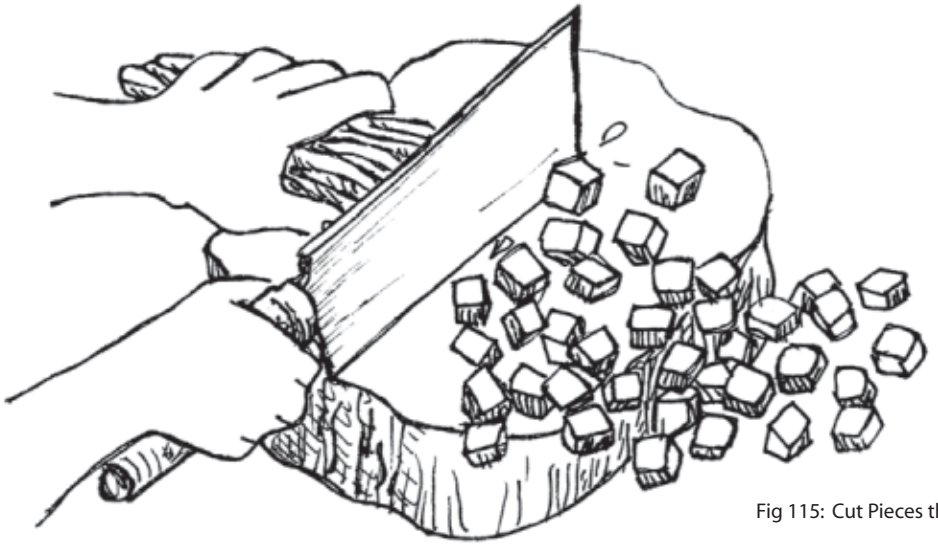

Fig 115: Cut Pieces the Same Size

Cereals
Cereals and grains like rice, flour, bread, etc.

Handling and Storing:
1 Keep in dry, clean, covered containers. (plastic bag)
2 Store in a cool dry place.

Preparing:
1 Wash rice only once.
2 Do not stir rice a lot.
3 Use the extra water to cook other foods.

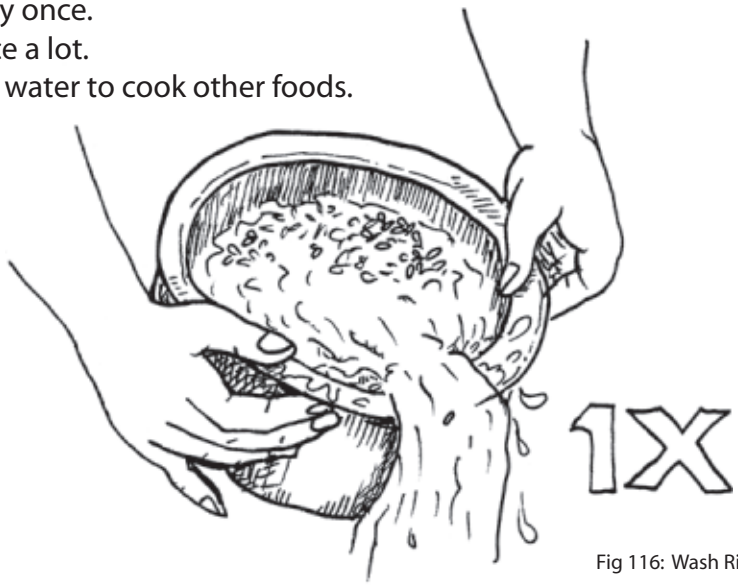

Fig 116: Wash Rice Once

Beans & Nuts

Beans and nuts like green beans, groundnuts, cowpeas, etc.

Fig 117: Beans and Nuts

Handling and Storing:

1 Pick groundnuts carefully so shells do not break.
2 Remove dirt.
3 Clean and dry well before storing.
4 Store in a clean, dry pan or jar with a cover.
5 Rub dry peas with cooking oil before storing (1 spoon per 1 Kg and mix with clean, dry ash).

Preparing:

1 Soak dried beans and peas before cooking to shorten the cooking time and use the same water for cooking.

Vegetables

All vegetables including dark green leafy vegetables.

Fig 118: Vegetables

Handling and Storing:

1 Pick in the early morning or late afternoon, or pick when needed to avoid storing.
2 Store in a cool, dry place.
3 Keep stems in water and cover leaves with banana leaf.
4 Do not let cabbage, long beans or cucumber get wet before storing, if wet they will rot faster.

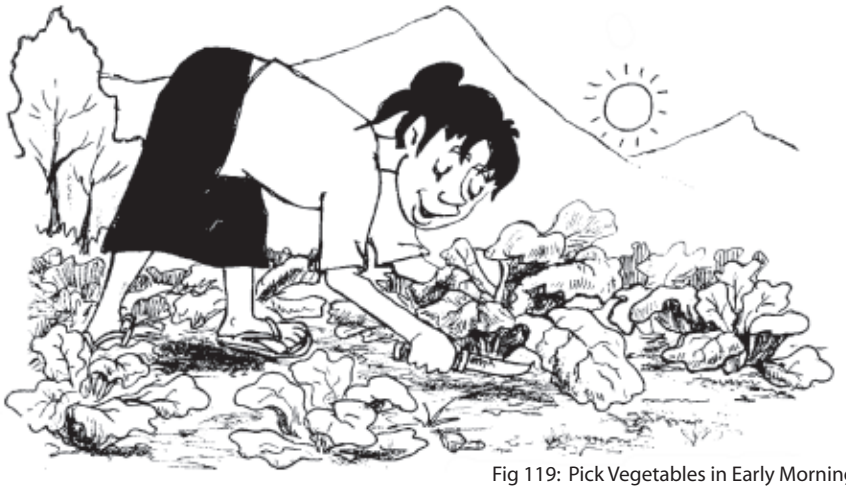

Fig 119: Pick Vegetables in Early Morning or Late Afternoon

Preparing:

1 Clean well before chopping.
2 Chop into medium size pieces, not small pieces.
3 Cook immediately after chopping.
4 Do not soak in water before cooking.
5 Cook in a small amount of water or oil until just tender but still bright green, yellow.
6 Cook until just tender or in stews and soups.
7 Cook with a small amount of oil for more vitamin A.
8 Always cover the cooking pot.
9 Save and eat seeds. Wash and dry seeds well, store them in a container.

Fig 120: Cook in Small Amount of Water With the Cover On

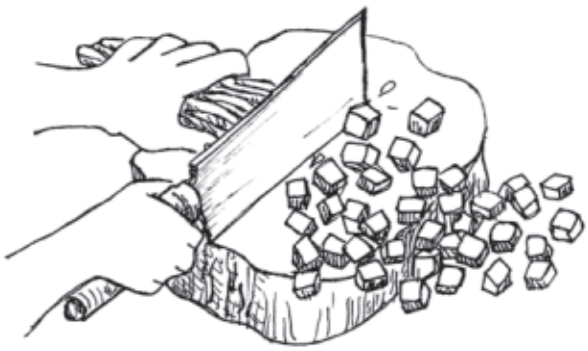

Fig 121: Chop into Medium Pieces

Fruits

All fruits including citrus, guava, papaya, mango, etc.

Fig 122: Fruits

Handling and Storing:

1 Pick and handle fruit carefully to prevent bruising.
2 Store in a cool place where air can circulate around the fruits.

Preparing:

1 Eat as soon as possible after picking.
2 Eat with iron-rich foods to get more iron in the diet.

Animal Foods

Animal foods including meat, chicken, eggs, etc.

Fig 123: Animal Foods

Handling and Storing:

1 Keep cool and covered until ready to use.
2 Clean eggs well, store in a cool place.

Preparing:

1 Use a separate board for chopping meats and other foods.
2 Always wash hands before and after handling meat, fish or chicken.
3 Cook meats until just tender, but be sure to cook thoroughly.
4 Do not cook fish until it is very crispy, cook only until it is just tender.

Food Processing

There are ways to process foods so we can keep them safe and use them over a longer period of time. But, foods can change and nutrients can be lost when we process and prepare foods. Many important vitamins and minerals can be lost between the picking and the eating of food. There are ways to reduce these losses.

Food processing means doing something to food to preserve or keep it, so that it lasts longer. Processing food changes the food, for example it can:

- Remove toxins or other bad substances.
- Make food easier to handle or store longer.
- Make food easier to prepare or cook.
- Make food taste better.
- Make food easier to digest.

There are several different methods of processing food. The following pages explain some common methods.

Drying

Some food can be dried. Drying can be done in the sun or in the shade under plastic sheets.

How it Works

- Drying removes water from food.
- Prevents bacteria and other things from growing, like mould on beans and chillies.
- Prevents foods from going bad or becoming inedible.
- Breaks down the plant so it is easier to digest.

How it Changes Food

- Drying destroys most of the vitamin C and some vitamin A in the food.

How to Preserve Nutrients

- Dry fruits and vegetables quickly.
- Dry vitamin A rich foods by first putting them in boiling water for 2 minutes and then dry them in the shade.

Examples of Dried Foods

- Dried fruits; like banana or chillies.
- Dried leaves; like pumpkin leaves.
- Dried beans; like yellow beans.
- Dried meat; like dried fish.

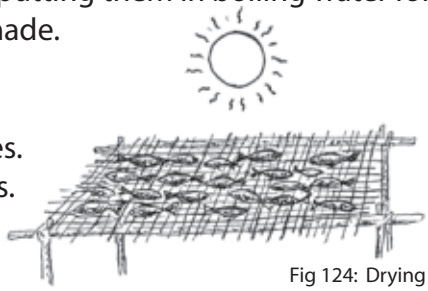

Fig 124: Drying Fish in the Sun

Milling

Milling is usually done with grains and cereals.

How it Works

- Milling removes the outer husk of the cereal, or pounds it to flour.

How it Changes Food

- Some of the fat, protein and most of the fibre is removed from the food.
- Milling increases the proportion of starch in the food.
- Some of the B vitamins, particularly B1 is removed from the food.

How to Preserve Nutrients

- Mill foods at home, this will keep more of the vitamins in the food.

Fig 125: Milling Cereal

Examples of Milled Foods

- White polished rice.
- Yellow beans.
- Rice and yellow bean flour.

Fermenting, Salting & Pickling

Fermenting, salting or pickling is usually done with vegetables, or fish and meat.

How it Works

Fermenting:

- Some types of fermentation encourage only growth of good bacteria, like yoghurt. While some fermentation stops bacterial growth by producing acid, like fishpaste.

Salting & Pickling:

- Salt removes water from the food so bacteria cannot grow in it.

How it Changes Food

- Increases the salt content of the food.
- May increase B vitamins in the food.
- Sour fermentation may increase absorption of iron and zinc.

Examples of Fermented, Salted & Pickled Foods

- Fish paste, shrimp paste, rat paste and frog paste.
- Salt fermented vegetables, like phak dong.
- Salted fish.

Fig 126: Fermented Fish Paste

Germination
Germination means growing beans or seeds so some greens sprout from the seeds.

How it Works
- Sprouting beans or seeds provides different nutrients than just the seed alone.

How it Changes Food
- Germination increases the vitamin C in food.

Examples of Germinated Foods
- Mung bean sprouts.

Cooking
Cooking food is most commonly done to prepare foods for immediate eating. Sometimes cooking is also used to preserve foods.

How it Works
- Cooking kills bacteria and enzymes that destroy the food.
- Cooking breaks food down so it can be eaten and digested.

How it Changes Food
- Cooking reduces the vitamin C in food. Some vitamin C goes into the cooking water and some is lost in the steam.
- Boiling or frying food for a long time without a cover on the pot reduces vitamin A.
- Cooking with oil increases vitamin A.
- Cooking or eating iron foods with vitamin C increases the amount of iron the body will absorb.

How to Preserve Nutrients
- Cook vegetables in only a small amount of water.
- Cover the cooking pot while cooking to keep the vitamins in.
- Use cooking water from vegetables and rice to make other foods because the vitamins are in the water.
- Use lemon, tamarind, or eat vitamin C fruits with meals to increase iron for the body.

Fig 127: To Preserve Vitamin A Cover the Pot

Examples of Cooking Methods

- *Boiling and stewing:* Cooking foods in hot water that is discarded later, or cooking foods in water that will be eaten with the food.
- *Steaming:* Cooking food in only the small amount of water needed to be absorbed by the food.
- *Frying:* Cooking food in hot oil.
- *Grilling:* Cooking food directly over wood fire or hot coals.

Fig 128: Boiling and Stewing

Fig 129: Steaming

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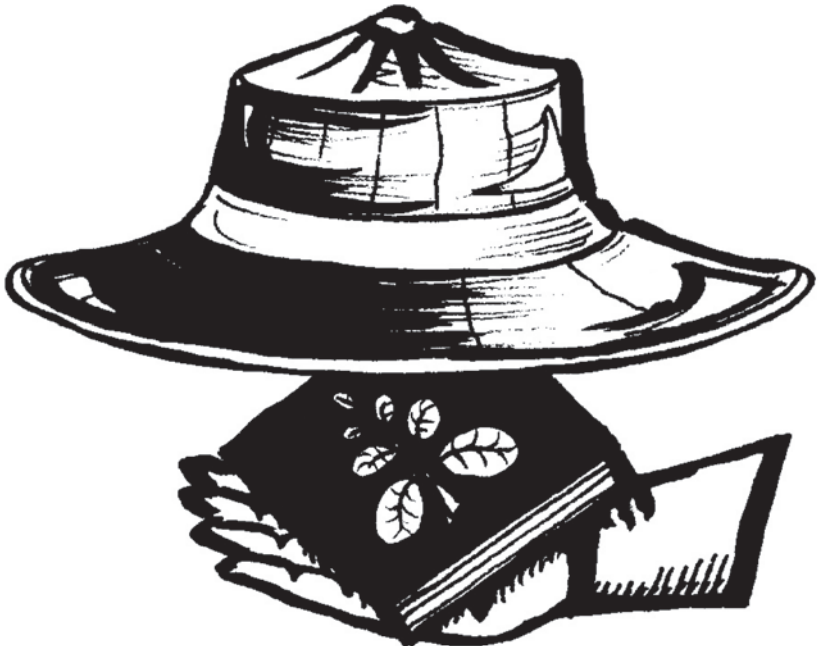

Section 8: Resources

Glossary of Terms
References

Glossary of Terms

Term	Definition
Acid	A chemical substance with a pH of less than 7.0. The opposite of alkali. (Foods with acid in them taste sour, e.g.: Lime).
Alkali	A chemical substance with a pH of more than 7.0. The opposite of acid. Limestone and many types of soap are all slightly alkaline.
Alley Cropping	To grow crops between rows of beneficial plants or trees.
Annual	Yearly. Plants that grow, produce seeds and die within one year. (e.g.: A mustard goes from seed to seed within one year).
Ash	The grey or black powder that is left after something has been burnt. (e.g.: Wood ash, charcoal ash). Wood ash is slightly alkaline and contains many valuable nutrients such as potassium. It can also be used on plant leaves and stems to reduce attacks by insects such as aphids and caterpillars.
Bacteria	Very small organisms that can only be seen by a microscope. Some bacteria can be bad because they cause disease like diarrhoea. Some bacteria are good because they help to break down dead things and put nutrients back into the soil. Our stomachs have good bacteria in them that help us break down food.
Carbohydrate	One of the substances in food that people, plants and animals get energy from. Sugar, rice, vegetables, sweet potatoes, etc., all contain carbohydrates.
Carbon	A very common element found in and needed by nearly all living things. Charcoal is often over 90% carbon.
Chemical	Any element or mix of elements that can be in chemical reactions and can change other substances and make new substances. (e.g.: the chemical formula for water is H_2O: two hydrogen elements and one oxygen element).
Clay	One of the smallest particles that make up soil. As rocks and soil erode, particles become very small and form clay. A clay particle is less than 0.002 mm wide in diameter.
Contaminated	Some thing or place that is dangerous because of bad bacteria, virus, or chemical. (e.g.: A river can be contaminated by pig manure. Crops can be contaminated by using pesticides).
Contour	The shape of an area of land. Lines on a map that show the rise and fall of land are contour lines.
Crop	The plants that we grow for food, to sell, for animals to eat, or to make the soil better. (e.g.: A rice crop to eat and sell).

Term	Definition
Decay	To slowly break down into very small pieces; also called rot or decomposition. (e.g.: When organisms decay, they become soft and smell badly, and then they go back into the soil and make it more fertile). Bacteria and chemical reactions are very important for decay.
Density	The number of things or people that are in a place. (e.g.: Refugee camps can have a very high density of houses because there are many people living in the same place).
Disease	A sickness caused by bacteria, virus, contamination, or poor nutrition. All living organisms can be affected by disease.
Element	A chemical substance that is made up of only one kind of atom. (e.g.: Hydrogen, nitrogen, oxygen, lead, carbon.)
Energy	The power to make things work comes from the sun, water, wind, carbon, etc. Energy from the sun is called solar energy.
Erosion	The way that soil and rocks are broken into smaller pieces and carried away by water or wind.
Evaporation	When a liquid changes into a gas. (e.g.: When water is boiled it turns into steam).
Experiment	A test that is done to prove an idea or discover what happens when we do things in a particular way.
External	Outside, not inside, the opposite of internal. Something that comes from another place and is not found locally.
Fertile	Soils that are fertile have a lot of nutrients and micro-organisms that produce high yields. Animals that are fertile are able to breed and produce many healthy young.
Fertiliser	A substance that people put onto or into the soil to increase nutrients so that plants grow better. There are two groups of fertiliser: organic fertilisers and chemical fertilisers. Organic fertilisers are made from animal, vegetable and/or mineral substances and can be made by farmers themselves. Chemical fertilisers have basic plant nutrients (like nitrogen, phosphorous, etc.), but are made artificially in factories. Chemical fertilisers do not contain all plant nutrients, bacteria or other beneficial organisms that help make soil healthy. Using too much chemical fertiliser can make soils less fertile and unsustainable to use.
Fodder	Crops or plants grown naturally that are used for feeding animals. (e.g.: In the hot season cattle are given dried rice straw as fodder).
Fungicide	A poison that kills fungus.

Term	Definition
Fungus	A simple kind of plant that grows fast and has no flowers or leaves. Fungus is very important in the decay cycle. Mushrooms and mould are examples of fungus.
Germination	When a seed starts to grow. Different types of seeds germinate in different ways, but they all need water, oxygen, light and heat.
Harvest	To collect crops and plants when they are ready to use. (e.g.: In Burma, people usually harvest rice between November and December).
Herbicide	Any type of poison that kills plants, both crops and weeds.
Input	Something that is brought into a place. (e.g.: When a farmer buys chemical fertiliser from a shop to use at his farm, he is using an external input).
Insecticide	Any type of poison that kills insects, both pests and natural enemies.
Internal	On the inside of something, the opposite of external. (e.g.: A farmer that uses only internal resources only uses things that can be found on his farm or local area).
Legume	A group of plants that can use bacteria to collect nitrogen from the air and store it in the soil and in themselves. These plants grow their seeds in pods and contain a large amount of protein. Examples include mung bean, long bean, cow pea, pigeon pea, etc.
Life Cycle	All the changes that a living thing goes through from birth to death. (e.g.: a butterfly starts as an egg, changes into a caterpillar, changes into a cocoon, then changes into a butterfly).
Lime (powder)	A substance made by burning limestone rock. Lime is an alkali and can be added to acidic soils to make them more neutral.
Loam	Dark soil that is made of rock particles that are smaller than sand particles but bigger than clay particles. Plants usually prefer loam soil because it lets in air and is good at holding water and nutrients.
Micro-Nutrients	An element that living organisms need in small amounts to grow and be healthy. Examples of micro-nutrients for plants include zinc, copper, manganese, etc.
Micro-Organism	A very small living thing that can only be seen with a microscope. (e.g.: bacteria, virus).
Moisture	Very small amounts of water in the air, on surfaces, or in the ground. (e.g.: Plants pull moisture from the soil into their roots).
Natural Enemy	An organism that kills and eats pests. (e.g.: A cat is a natural enemy to a rat; a spider is a natural enemy to a grasshopper).

Term	Definition
Natural Resource	Anything from the natural environment that people use to live, to make things, or to sell. Examples include water, soil, trees, rocks, metals, etc.
Nematodes	A very small type of worm that lives in the soil and can damage the roots of plants. Nematodes are usually a pest to crops.
Nitrogen	A very common and important element that has no smell, colour or taste. The air we breathe is made of 79.1% nitrogen. Legume plants can collect nitrogen from the air and turn it into protein.
Nutrients (soil)	A substance that helps plants and animals grow and be healthy. Many nutrients come from elements in rocks, the air, soil and water. Other nutrients come from the decay of dead organisms.
Organic	Anything that is living or that was part of a living thing. The opposite is inorganic, something which has never lived (e.g.: A rock).
Organic Matter	Anything that is or was alive and will decay when it is dead.
Organism	Any living thing, plant, animal, human, insect, bacteria, fungus, etc.
Output	Something that is taken out of a place. (e.g.: When a farmer sells some of the crop he has grown on his farm to a shop, this is called an output).
Perennial	Plants that live longer than one year.
Pest	Any type of organism that eats or damages crops. Examples include rats, caterpillars, grasshoppers, nematodes, etc.
Pesticide	Any type of poison that kills living organisms, especially plants and insects. Insecticides and herbicides are examples of pesticides.
Phosphate	A common element that is a very important nutrient for plants. Large amounts of phosphate can be found in some types of rocks and animal manure (especially bat manure). Most chemical fertilisers contain phosphate and if too much is used, it can contaminate soil and rivers.
Poison	Any type of substance that can cause sickness or death if it is eaten, breathed in, or taken in through the skin. Some poisons can act very quickly, while other types can take a long time to have an effect. Pesticides are an example of poisons.
Pollen	The male seed in the flower of a plant that is carried by the wind, insects or animals to fertilise a female flower.

Term	Definition
Potassium	An element needed by all living organisms so that they can use other nutrients. Plants need potassium to make proteins and cell walls. Animals need potassium for skin, muscles and nerves.
Protein	A substance in food that all living organisms need to grow and stay healthy. Proteins are made of nitrogen, hydrogen, carbon and oxygen. Protein is very important for muscle growth and repair.
Recycle	To make something that is no longer useful or wanted into something that can be used again.
Repel	If something repels other things it has or does something that makes them want to stay away. (e.g.: we can use tobacco to keep insects away from crops because it smells and tastes bad).
Reproduce	When animals and plants reproduce, they make new young animals or plants.
Sand	Small particles of rock that make up many types of soil. They have a diameter between 0.05 mm and 2.0 mm wide. Sand particles are bigger than silt or clay particles.
Saw Dust	Very small bits of wood or dust made by cutting wood. Saw dust contains a lot of carbon and is sometimes mixed with manure or other fertilisers to make compost.
Silt	Very small particles of rock that make up many types of soil. They have a diameter of between 0.002 mm and 0.05 mm. Silt particles are smaller than sand particles, but larger than clay particles.
Slope	The side of a hill or mountain. Steep slopes have a high angle (i.e. $>30^{o}$), low slopes have a small angle ($<30^{o}$).
Solution	A mixture of two or more substances in which a liquid or solid has been dissolved in another liquid. (e.g.: Soap powder dissolves in water). Water mixed with another substance.
Species	One of the groups into which we can divide all organisms. Members of the same species look similar and can reproduce young that can also reproduce. Humans belong to one species. Cows and buffaloes are two different species.
Survey	The word 'survey' can have three meanings: • To measure land carefully before something is built. • To ask questions to find out what people think about something. • A careful study that is done before work begins on something.
Sustain	To be able to continue doing something for a long time. (e.g.: by planting trees, people can sustain their supply of firewood; by using animal manure and compost, the farmer is able to sustain his farm).

Term	Definition
Transpiration	The way moisture from the soil is passed up through the roots and stems of plants and out through the leaves.
Transplant	To move a plant from one place to another.
Viable	Something that can be done or will succeed. A viable seed or egg is one that will grow into a plant or animal.
Virus	Very small organisms that can cause disease. Viruses are smaller than bacteria and can not be treated in the same way. In plants, some viruses change the colour of leaves or cause tumours, but the signs are often difficult to tell from other types of diseases.
Vitamin	A chemical compound in food that all animals need to grow and be healthy. There are many different types of vitamins and they can have different benefits. Vitamin A is good for eyesight, Vitamin C helps us fight disease. Fresh fruit and vegetables are the best sources of vitamins.
Weed	Any type of plant that grows in the same place as crops and competes for space, water and nutrients.
Yield	The amount of food or material that comes from a plant or animal, or from an area of land.

Note: With thanks to Glenda Kupczyk-Romanczuk's *"Environment Words",* 2006.

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