Our School Garden

A guide to organic school gardening in Fiji

Introduction

The high incidence and burden of Non-Communicable Diseases (NCDs) in Fiji is contributing to widespread social and economic problems that affect individuals, families, communities and the nation.

According to the World Health Organisation (WHO), in 2008 NCDs accounted for 77 per cent of deaths in Fiji (WHO 2010). It is likely that this figure will increase over the coming years, with global deaths due to NCDs projected to increase by 17 per cent between 2005 and 2015 (WHO 2009).

In an attempt to address this health crisis, there is a global consensus that the focus should be on prevention rather than cure. Schools have been identified as one of the most cost-effective settings for running health promotion programs designed to prevent key risk factors responsible for non-communicable diseases, principally poor nutrition, physical inactivity, smoking, and irresponsible alcohol consumption.

One health promotion initiative being introduced throughout schools in Fiji is school gardening. School gardens provide students with the knowledge, skills and opportunity to grow and eat fresh fruits and vegetables, whilst also promoting physical activity. It is hoped that by encouraging these behaviours early in life, students will adopt healthy attitudes and behaviours that will continue into adulthood.

This handbook is designed to be a resource for primary school teachers and aims to provide simple, relevant and practical information on gardening to inform their theoretical and practical instruction of students.

ACATA TRUST FIJI

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This handbook is available online at www.acatatrust.org

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garden organic

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www.foodforlife.org

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SECTION ONE

Gardening 101

Raised Garden Beds

A raised garden bed can be as simple as a mound of soil that is higher than the surrounding soil level. Or, you can mound the soil in a framework of timber, like a bottom-less box. Stacked concrete blocks and other materials can also be used as a framework.

The simpler form of raised bed is constructed by mounding soil into a ridge approximately 12 inches (approximately 30 cm) high with sloping sides and a top surface 18 to 24 inches (approximately 45 to 60 cm) wide. This ridging method provides the benefits of a raised bed and requires less energy and expense. The disadvantage is that it may erode and the sloping sides may have to be rebuilt after heavy rain or wind.

Some of the advantages of the ridging technique can be achieved by diffing parallel walkways into the existing garden plot and placing the soil from the walkways onto the plant growing area. The sides of the walkways (ditches) should be sloped to prevent soil collapse.

A framed raised bed offers all the advantages of a mounded raised bed without the problems of erosion or soil movement. It also provides an elevated working platform for planting and weeding. The framework for the bed should be built so the soil does not bed or dislodge the frame.

Benefits of Raised Beds

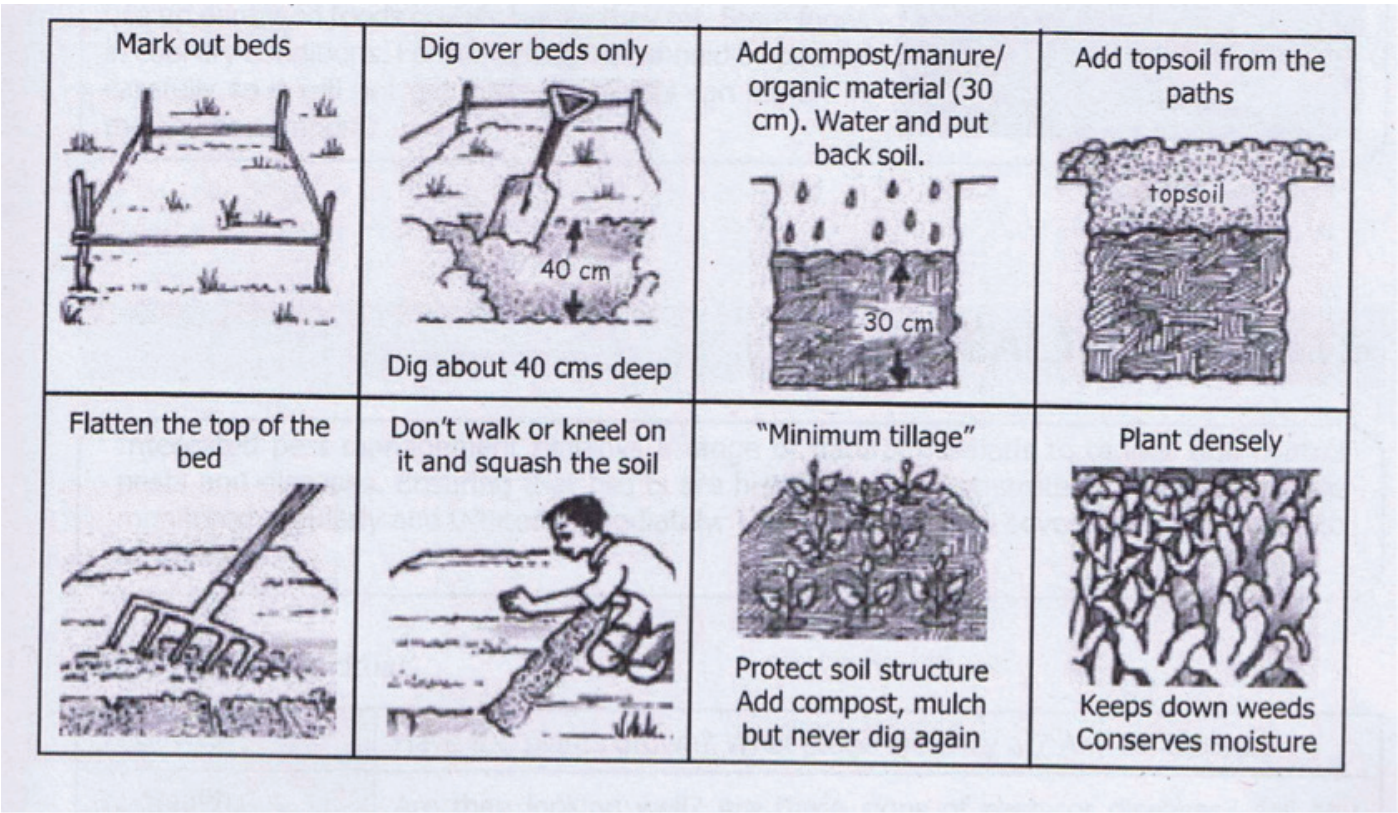
- Plant growth is enhanced through soil warming, which results from an increased drainage capability and an increase in the exposure of the soil surface to the direct rays of the sun.

- Productive growing areas can be developed in locations where conventional gardening techniques are not possible. Raised beds reduce the effort and back bending involved in planting, weeding and harvesting.

- Many raised beds are intensively managed and therefore have high production rates per square foot.

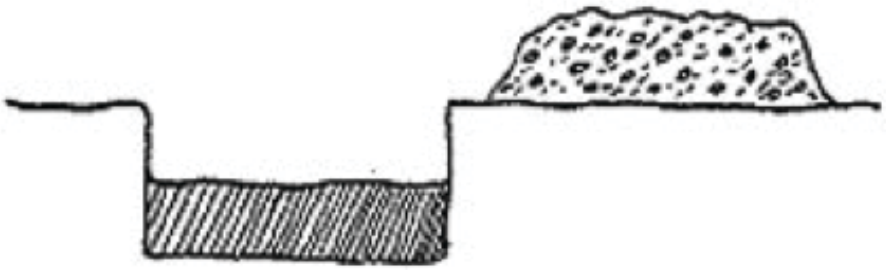
Preparing the soil

The Food and Agriculture Organization of the United Nations recommend the following method for preparing the soil for raised garden beds (*see next page*).



Source: Food and Agriculture Organization of the United Nations 2005

Another method for preparing the soil for a raised garden bed is to double dig the soil.



Source: Starbuck, C.J 2003

Double digging involves removing the topsoil the depth of a spade, setting the soil aside and then l oosening the subsoil another spade's depth (*see above*). Finally, the topsoil is returned with added amendments, such as compost, manure or other fertilizers. This labour-intensive soil preparation method provides an excellent rooting zone for plants. However, less-intensive methods also permit satisfactory plant growth.

Avoid hauling in new layers of soil without mixing them into existing soil. Distinct layers of soil create barriers through which water will not readily penetrate and roots will not easily grow.

Container Gardening

If you have limited space for a vegetable garden, you may like to try growing vegetables in containers. You can use almost anything to grow your vegetables in as long as it's big enough and provides adequate drainage.

To ensure adequate drainage try adding a 5 to 10 centimetre layer of coarse material such as gravel at the bottom of the container and make holes in the base of the container if there are none already.

Preparing the garden beds

Source: ACATA Trust Fiji and Tei Tei Taveuni (top)

Drainage holes should be 1 to 2 centimetres wide and there should be at least 5 holes per 30cm². Excess water will drain from these holes and prevent root rot.

Container gardening also offers the added advantage of being moveable to allow plants to get maximum sunlight and to escape violent weather conditions. They are also fantastic for beautifying the school compound.

Container gardening represents an excellent opportunity to incorporate the three R's (Reduce, Reuse, Recycle) into your garden. Try using some of the container ideas below.

Container Ideas:

- Half barrels or drums e.g., 200 litre metal or plastic drums used to transport non-toxic contents etc.
- Paint tins
- Empty containers e.g., FMF Breakfast Cracker containers etc.
- Old car tyres
- Plant pots
- Wash tubs
- Plastic bags
- Potato sacks

Choose a container large enough for the plants. Simply put, bigger containers suit bigger plants (or lots of little ones). If possible, move the container to its final position before filling. Containers can be too heavy to move when full.

Planting and Transplanting

In general, there are two methods of planting crops; direct seeding and transplanting.

Direct Seeding

Sowing seeds directly into the garden is the easiest and least expensive way to grow fruits and vegetables. Large seeds are usually the most suitable for direct sowing such as peas, beans, corn, pumpkins, cucumbers, and watermelons. Other crops which should be sown directly in their final position are those which don't tolerate being transplanted such as carrots and other root crops.

Smaller seeds can also be sown directly, although they may require some sort of protection from harsh sun, heavy rains and strong winds. A protective covering can be constructed using coconut fronds, potato sacks or shade material supported by a simple frame over the garden bed.

Seeds planted directly in the garden can be drilled (poked), broadcast (sprinkled) or planted in little furrows (lines). Direct seeding in rows using the furrow seeding method is recommended when planting out your school garden.

Direct Sowing Methods

- Drilling seeds is as simple as poking a hole in the soil to the appropriate depth and then covering it with soil.
- Broadcasting seeds is a common method for grass or wildflower seeds. Broadcasting involves sprinkling seeds over the planting area and covering them with soil or lightly "scratching" in the seed.
- Furrow seeding is often used with crops such as carrots. Dig a shallow furrow in the soil where you want your seeds to go and then drop in a line of seeds. Cover the seeds and pat gently. Furrow-planted crops may need to be thinned to the recommended spacing listed on the seed packet. Thinning is done once the plants begin to grow.

Source: California School Garden Network 2010

Moisture needs for your direct sown seeds

- Use a watering method that delivers a "gentle spring rain," e.g., watering can or hose fan attachment. It may take many passes of light sprinklings to be sure the soil is moist beyond the depth of the newly planted seed.
- Avoid flooding your newly planted area as this can wash away seeds and/or cause your soil to form a "crust" on the top, which makes it difficult for some seeds to push through the soil.
- Keep an eye on your seedbed, and keep it constantly moist. Depending on the weather, you might need to water daily.

Source: California School Garden Network 2010

Seed Spacing

When directly sowing seeds it is critical to consider seed spacing. If plants are forced to grow too close together, they may produce little or no yield as they compete with each other for sunlight, water and nutrients. Plants that are spaced too closely are also susceptible to mildew diseases as air circulation around each plant is prevented by overcrowding.

If seeds are large enough to handle, such as beans and corn, it's fairly easy to space them correctly. Simply make a furrow at a depth approximately three times the seed's diameter, and sow the seeds at the recommended distance from one another. This should be indicated on the seed packet. *Alternatively refer to the guideline in Appendix 1 which was adapted from the Ministry of Agriculture's "Crop Farmer's Guide"*. You will need a ruler or measuring tape to space seedlings correctly, or you can make a measuring stick from a strip of wood that you can mark with measurements.

Sowing small seeds is a lot trickier as they are harder to handle. When sowing garden beds with fine or small seeds such as carrots, it is common to tap them off the palm of your hand or sprinkle seeds by taking a pinch between finger and thumb.

Both techniques usually require follow up thinning to ensure that crops are properly spaced and will develop normally. To prevent the need for excessive thinning out of crop after germination, aim to sow seeds evenly and thinly.

Direct seeding using the furrow method involves sowing directly into furrows in rows across garden beds. It is easy to make furrows across garden beds with the point of a hand trowel. Seed is then placed or sprinkled thinly along the furrow and the correct amount of soil is pushed from the side of the furrow to cover the seed. The garden bed is then gently watered to make sure soil is settled around the seeds. Seed packets on sticks or homemade signs can be used to keep track of which seeds are where.

TIP: The depth you plant your seed depends on their size. As a general rule, seeds should be sown at a depth approximately two times their diameter. Seeds buried too deep may not be able to struggle through the soil to the surface.

Thinning Out Seedlings

Thinning out is the process of removing excess seedlings to improve the health and yields of those that remain. The idea is to leave the healthiest ones in place whilst also ensuring that they are spaced correctly. If you are thinning pants in the soil, thin to final spacing in stages to allow for any loss from pests and diseases. Leave seedlings just clear of neighbouring plants at each stage.

If you are thinning out seedlings in pots or trays, leave seedlings growing in the centre rather than around the edges. This allows every plant an equal amount of growing space.

To thin out seedlings you can gently pull out excess plants, cut them close to the ground with scissors or pinch out unwanted seedlings with a thumbnail and forefinger. If you intend to transplant the seedlings you are thinning out, remove seedlings with as much root and moist soil as possible.

Seedlings should be thinned when they are approximately 2 to 3 inches in height and have 1 to 2 sets of true leaves. True leaves differ from cotyledons or "seed leaves" which function as the first food factories for the developing plants. Cotyledons will begin dying off slowly once the first set of "true leaves" emerge.

As this can be a traumatic process for the plants which remain, you should attempt to thin your plants out in the late afternoon or the early evening so that the remaining plants have time to adjust before being exposed to the heat and sunlight. Having damp soil also helps, as it makes it easier to pull the plants out intact and with less damage.

TIP: Don't leave thinnings lying around as the scent released by crushing leaves can attract pests. Thinnings can be put into the compost if they are not transplanted.

Protected Seed Beds

Some crops, especially leafy brassicas and lettuce, are better sown in a protected seed bed. The resulting young plants are then transferred to their final growing position once they have developed a few true leaves and are large enough to handle.

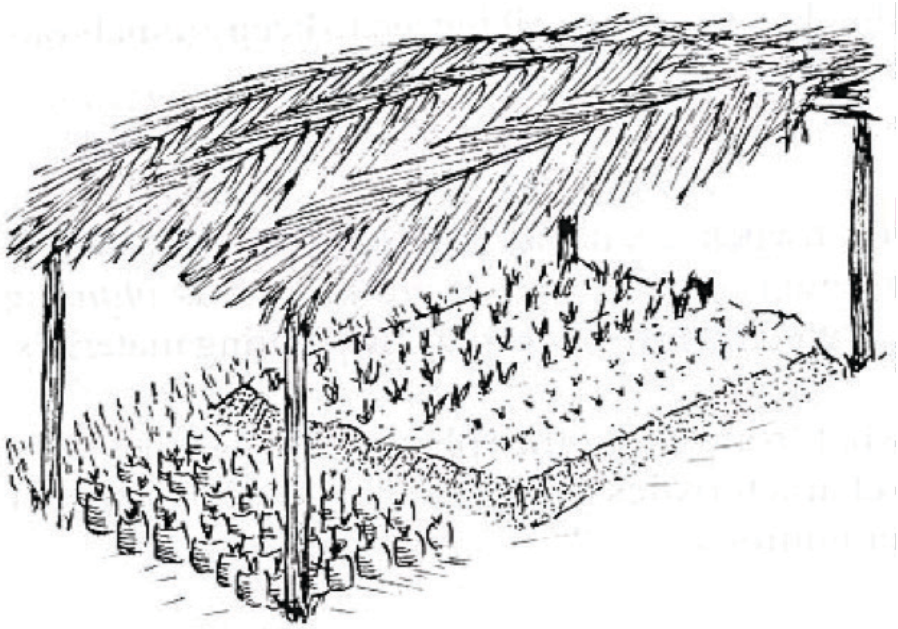
Protected seed beds come in many different shapes and sizes but all provide seedlings with protection from harsh environmental conditions by either providing overhead shelter or by permitting seedlings to be grown indoors or in a greenhouse.

Some examples of protected seed beds include:

- A nursery bed (a raised garden bed with some sort of protective covering e.g., coconut fronds, potato sacks, shade material)
- Cardboard boxes
- Small containers e.g., yogurt containers, ice-cream containers, the bottom half of plastic bottles and UHT milk containers that have been cut in half
- Egg cartons
- Toilet paper rolls
- Seedling pots made out of newspaper
- Plastic bags
- Avocado skins or citrus halves
- Re-usable seed trays with compartments
- Plastic pots

Protected seed beds;

Source: California School Garden Network 2010



Source: Nutrition Programmes Service Food and Nutrition Division 2001

How to Make a Newspaper Pot

Materials:

- Empty tin can
- Sheet of newspaper (approximately 39cm x 30cm)
- Plastic container e.g. recycled ice cream tub
- Potting mix
- Seeds

Instructions:

1. Place a sheet of newspaper flat on to a table, with the longest edge of the paper at the top of the table.
2. Fold the paper in half lengthways with the folded edge nearest to you.
3. Turn the paper so that the folded edge is to the left (this will be the top of your finished pot).
4. Place the empty tin can on the newspaper with the opening of the can to the left, leaving a gap between the bottom of the can and right-hand edge of the newspaper. Tightly roll away from you.
5. Place the can upright with the opening of the can placed downwards on to the table.
6. Fold the remaining paper in neatly and firmly to make the base of the pot.
7. Turn the can over and, holding it tightly, push down firmly on to the table.
8. Clasp carefully and extract the tin can.
9. Your pot is now complete. Make some more, fill with potting mix and place the filled pots in a recycled container to give support. Sow the seeds and watch your plants grow. When plants are large enough the whole pot can be planted in the ground as it will decompose and the roots grow through.

Source: Garden Organic n.d.

Soil Preparation

If you are sowing small seeds in a pot, tray, bag, box etc., soil taken directly from the ground can be too heavy and wet. Seeds germinate and grow more quickly in a mix especially made for growing seedlings.

You might like to try a mix of rested mill mud or soil. Alternatively you might like to try a mix of soil and rested manure or compost. Adding sand or sawdust can also help with drainage. Play around with the soil mix to find out what works best.

Drainage

Adding sand or sawdust will help the water drain through the soil, but if there is no holes for drainage at the bottom of a container, the soil will become water logged and the seedling will develop root rot and die.

To prevent this from happening simply make several holes at the bottom of each container to allow the water to drain. For some of the plastic containers, you might also like to put a few holes in the sides of the container. If holes are only on the base of these containers the soil mix can become sodden if the containers are sitting on a solid surface.

Make sure the holes are big enough to let the water drain but not so big that your soil will wash out of the container during watering.

Sowing Seeds

Be sure not to sow seeds too closely together, particularly in containers. For example, plant only 2 seeds in an empty yoghurt container and 1 seed in each compartment of an egg carton. If you sow too many seeds in each container, leaves won't dry quickly enough after watering in the crowded conditions, and your seedlings will become slimy, and rot. This problem is called 'damping-off'.

Put the containers where they are protected from the hot sun, strong winds and heavy rains, but remember that they need some sunlight to grow. If they don't get enough light your seedlings will be thin and weak. Water the pots when necessary to keep the soil mix damp.

Soft drink and large juice bottles (with their bases removed and lids on) can be placed over the containers to help keep the soil mix damp so that you don't need to water so often.

When your seeds have germinated, unscrew the lids of the bottles to allow air to move around the plants.

TIP: Mice and other animals love eating seeds and, if they are short of food, they may sometimes dig them up and steal your seeds at night. The drink bottles will also protect your seeds from mice.

TIP: Use ice block sticks and a permanent marker to label your seedlings.

Hardening Off

Seedlings that have grown in a protected seed bed will need to be hardened off to acclimatise them to the harsher environmental conditions they will experience once transplanted. When seedlings have 1 to 2 sets of true leaves, harden them off for about ten days, giving them a little more sun and weather every day.

Start on a mild day, exposing your seedlings to the sun for a few hours. Ensure that you do not expose them to the sun during the hottest part of the day until much later. Gradually increase the amount of time seedlings are exposed to the sun and other elements over the ten day period. At the end of the ten days your seedlings should be ready to be transplanted.

Transplanting

Once your seedlings have become large enough to handle and have been hardened off, it's time to transplant.

Before transplanting seedlings into garden beds, make sure the soil in the garden bed is thoroughly damp. If you transplant seedlings into dry soil and only water around the seedlings, dry soil in the bed will draw the water away from your seedlings, and they will start to wilt.

Seedlings in Containers

If you are transplanting seedlings which have been grown in a container rather than a nursery bed, you must first assess whether they are ready to be transplanted.

To check if seedlings are ready for planting into beds, choose a potted seedling that looks large enough to be planted. Gently place one hand, palm downwards across the top of its pot so that the stem of the seedling sits loosely between your first and second fingers.

Then turn your palm upwards and, with your other hand, tap firmly on the base of the pot as you can see in the photos below. The mix should slide out of the pot in one piece (just like cake out of a cake tin) when seedlings are ready to plant in beds.

If the seedling and mix slides out easily, carefully replace the seedling back in its pot so it won't dry out. If other seedlings are about the same size as the one you tested, your seedlings are ready to be planted into a garden bed. However, if the soil mix falls apart in your hand, carefully re-pot the seedling, water it gently, and wait another week or so before planting out your seedlings.

Source: Organic School Gardens 2010

New seedlings with coconut shells to protect against the sun

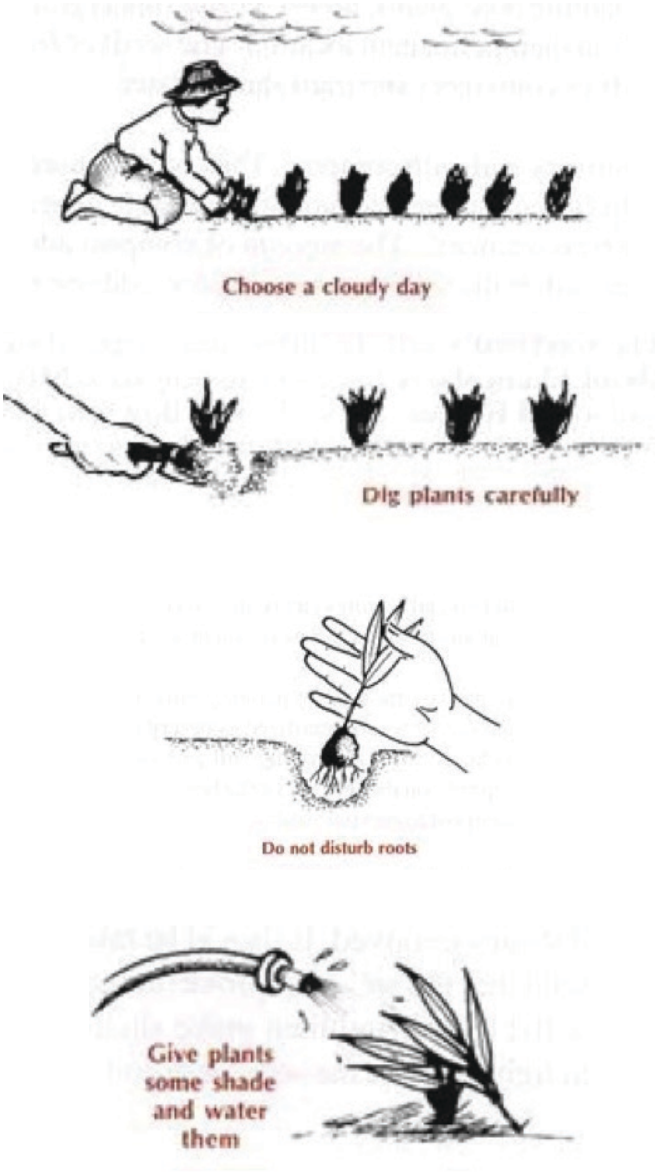
Source: ACATA Trust Fiji

Seedlings in Nursery Beds

If you are transplanting seedlings that have been grown in nursery beds, it is common to wait until seedlings have at least two sets of true leaves (after the cotyledons).

When transplanting, the roots of the plant should be disturbed as little as possible. Use a hand fork or spade to carefully lift up the seedlings, taking as much soil as possible with them during the transplant. The planting hole should be deep enough to accommodate the plant's roots.

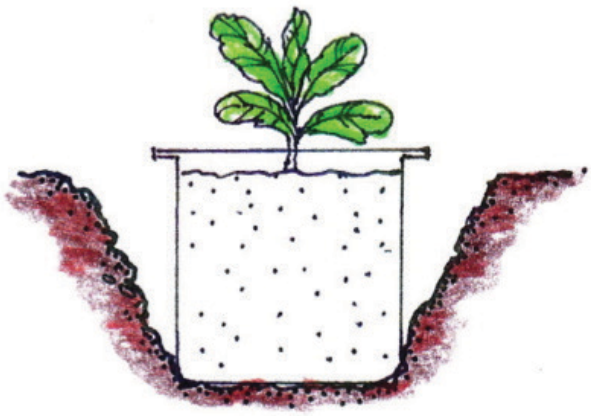
As transplanting can be a very stressful process for young seedlings, it is important to ease their transition by choosing a cloudy day and by giving them plenty of water after transplanting.



Source: Nutrition Programmes Service Food and Nutrition Division 2001

Planting Rosette Seedlings

When planting seedlings of plants that grow leaves in a circular cluster (rosette) supported by a very short stem instead of growing leaves along a step, make sure you don't plant them any deeper than they are in the seedling pot. The rosette seedlings will rot if the part where the new leaves form is buried in soil. Check that the planting hole is not deeper than the seedling pot before turning out the seedling.



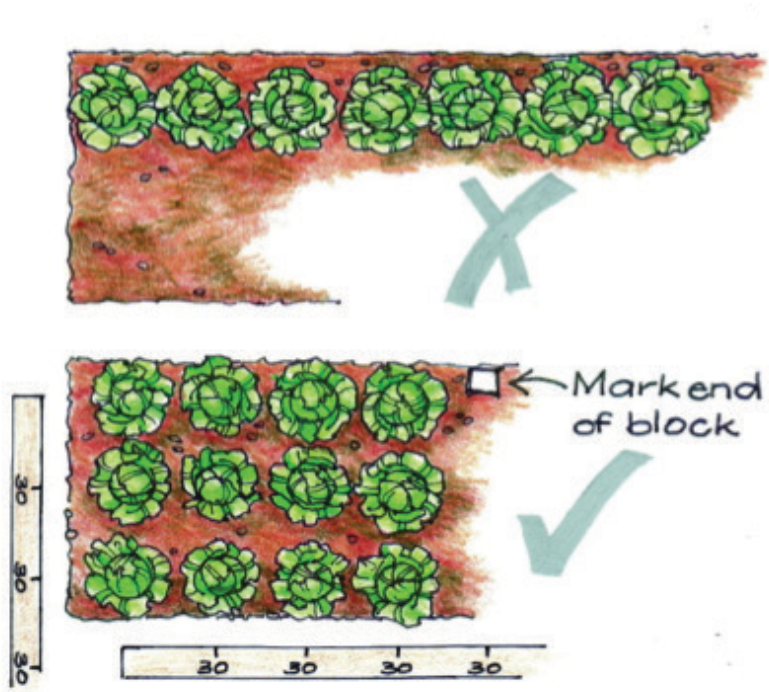
Source: Organic School Gardens 2010

TIP: Seedlings of tomato, corn, broccoli and green beans can all produce extra roots along their lower stems if they are planted slightly deeper, or hilled up as they grow.

Spacing Seedlings

You can find how far apart to plant your seedlings on the back of the seed packet or in the seed spacing guideline in this book. If you don't have enough of the same type of seedlings to fill a whole bed, plant each variety in a block as shown below, and not in long rows. The reason seedlings should be planted in a block of short rows across a bed is because long rows make it hard to plan crop rotation. Crop rotation is very important in keeping soil and plants healthy and is covered further in *Section 2*.

First measure the distance you need between rows of plants. Mark each row across the bed with the point of a hand spade. Then along each row, measure how far apart each seedling needs to be planted, and mark each spot by digging a small hole. Mark the end of each block with something that will remind you where the end is after your crop has been harvested and the vegetables removed.



Source: Organic School Gardens 2010

Watering

Plants release a mist of water through special holes in their leaves when the air around them is dry. Doing this creates a vacuum inside plants that sucks water from the soil through the roots into the plants to replace the water lost through the leaves. Plants can open or close these special holes to adjust the amount of water that is released. This process is called 'transpiration'. In very hot weather, plants release a lot of water through their leaves to keep cool, rather like the way our skin sweats on hot days. In very windy weather plants also lose a lot of water because the water they release gets blown away.

If there is not enough water in garden soil to replace the water released into the air, the softer cells of plants collapse and the plants wilt. Small plants may not recover if they become very wilted, and may die.

Plants that do not have enough water become water stressed. Stressed plants send out smells that encourage pests to attack them. Water stress also weakens plants' defence systems so that they are unable to resist diseases.

Watering Advice

- Water seeds and seedlings gently to prevent soil and seeds from being washed away.
- Don't drown plants by over-watering. If they need a lot of water, give it in stages.
- Water the soil, not the plants. Get the water to the roots. Water on leaves can hurt plants. Water droplets on leaves are like tiny magnifying glasses. Strong sunlight is concentrated through the droplets and can scorch the leaves of plants.
- Don't use a sprinkler because a lot of water will evaporate into the air, wasting water. Sprinklers also wet leaves which encourage mildew diseases if leaves of stressed plants can't dry quickly.
- Only water plants when they need it. An easy way to tell if plants need watering is to poke a finger (up to the top joint) into the soil. If the soil feels damp, the plants don't need watering. If the top centimetre or so of soil feels dry, give the plant a thorough watering. Plants watered in this way develop stronger root systems, and will be more resistant to dry or windy conditions.
- Watering plants in the morning or evening when it is cool saves water as it doesn't evaporate.

Water Management for Wet Areas or Wet Seasons

- Dig holes and canals to drain water.
- Add compost to drain clay soil.

- Grow plants that love water e.g., dalo.
- Protect young plants from heavy rain.
- Grow plants on trellises and use containers.
- Don't mulch too much.

Water Management for Dry Areas or Dry Seasons

- Use "grey water" from washing.
- Harvest rainwater with gutters and water tanks.
- Grow crops near the water.
- Prevent run-off, put beds across slopes and build up edges.
- Water by hand rather than using a sprinkler.
- Use a lot of compost and mulch.
- Provide shade for young plants.
- Remove competitive weeds that steal water.
- Grow dry-climate crops (e.g., mung bean, eggplant, sweet-potato, mango, okra).
- Water plants individually with sunken tins or upended bottles.
- Make water traps e.g., keep the water in by digging a shallow trough round the plant.

Naselesele Primary School students watering beans

Source: Tei Tei Taveuni

Mulching to Save Water

Mulch saves water! Mulch stops water evaporating from the soil surface on hot days and helps water to spread through soil so that the water you put on your garden will cover a wider area. Mulch helps humus keep soil damp, and your plants will need watering less often.

Mulch provides a sunshade for earthworms, and all the helpful bacteria and fungi in your topsoil. They need damp humus and soil to live and work in. Mulch also helps keep soil cooler in summer and warmer in winter.

Organic mulches are the best for your garden. Soil creatures break them down to add more humus to your soil. Mulch hay, straw, sugar cane residue, lemongrass tops, wilted grass clippings, green manures, and well-rotted animal manures.

If you put mulch on beds too thickly or in tightly packed pads, the mulch will be like a thatched roof that keeps ALL the rain out.

Organic mulches should be teased out or fluffed up before putting them on garden beds or around trees or shrubs.

A layer of teased-out mulch 5cm thick allows rain to trickle through to the soil while still stopping humus and topsoil from washing away in heavy rain. It keeps soil cool enough for earthworms and microorganisms, and keeps the soil surface dark so that week seeds won't germinate. When compost is used as mulch, it still needs to be covered with a 2-3cm layer of hay or grass clippings or the living microorganisms in compost will die if they are left uncovered on the soil surface.

Put mulch on your garden after watering or rain, and always keep mulch 10cm away from the stems of larger plants. The best time to mulch beds is after you get them ready for planting so that earthworms and helpful bacteria can get working on the organic matter dug into the bed. Water your garden under the mulch, as watering though the mulch takes a long time.

To make watering larger plants under mulch easier, you can use large plastic drink bottles with the cap and base removed. Bury the neck of each bottle about 6cm into the topsoil near the outside edge of the plant leaves. Water the plant by filling the bottle. If the water drains quickly, keep filling the bottle until it drains out slowly. This method will help you to water plants quickly without wasting water, as water will go straight to the root area where it is needed.

In vegetable gardens where some plants need frequent watering or extra plant food, fluffed-up 'sausages' of organic mulch between rows of plants make watering easier.

Watering Source: Organic School Gardens 2010

Weeding

Another regular job for gardeners is keeping the garden area free of weeds. Many weeds are strong growers and will quickly take over your garden unless you remove them before they become a nuisance.

Naselesele Primary School students mulching with cut grass

Source: Tei Tei Taveuni

Weeds also need water to grow, so allowing weeds to grow in garden beds will mean less water for your plants. Mulch on garden beds will certainly help to stop weeds growing, but you must remove weeds from around the outside of your garden beds too, because some weeds provide a home and food for garden pests that spread diseases to the plants you want to grow. You don't want these weeds anywhere near your food crops.

It is important to remove weeds before they can produce seeds. Weeds can produce hundreds of seeds from one plant. If weeds are allowed to drop their seeds, you will have weed problems in your garden area for many years.

Weeds without seed heads can be put into your compost heap and recycled into compost for your garden.

You can get rid of weeds easily when they are very small by pushing a trowel or special hoe backwards and forwards across the soil surface. Then cover the soil with mulch and the weeds will break down to add more organic matter and food for plants.

Don't use poisons to kill weeds, these aren't good for your health and also kill fungi that help to keep your soil healthy.

Below are some good organic methods for managing weeds in your garden.

Prevent weeds

- Fill up the space between plants with mulch or ground cover (e.g., pumpkins, sweet potatoes, cucumber, water melons, and legumes such as cowpeas).
- Create shade with multi-layer cropping to deter weeds.

Remove weeds

Remove weeds when the ground is damp by digging them, pulling them, or cutting them off under the surface. Try to catch them small, or at least before they go to seed.

Avoid weedkiller, it can kill good insects and good plants, poison the soil and harm children.

Use weeds

Weeds can be used as mulch or compost (but not if full of seeds) either by adding it to your compost heap or digging it as green manure.

Leave a patch of flowering weeds

Flowering weeds can attract beneficial insects.

Weeding Source: Organic School Gardens 2010

Naselesele Primary School student weeding corn

Source: Tei Tei Taveuni

SECTION TWO

Organic Gardening Methods

Organic Gardening

Organic gardening uses natural methods to grow crops. Organic gardens do not use insecticides, weedicides and other harmful chemicals, but instead use methods that aim to build good soil structure and fertility, support beneficial soil biology, and control pests, diseases and weeds. Organic gardening has a number of benefits including:

Cost

Organic gardening is a lot cheaper because you don't have to pay for expensive chemical fertilisers, or harmful pesticides and weedicides for example.

Environmental protection

Using chemicals in your garden can have a huge negative impact on the environment.

- Chemical fertilisers can run into water sources which can damage delicate eco-systems and lead to water sources becoming un-usable and killing species that live in or drink from the water source. It can also make the water source dangerous for use by humans.
- Chemical sprays for controlling pests and diseases can kill beneficial bacteria and fungi in the soil as well as other soil organisms such as worms. Some are also so strong that they can kill birds and other animals that feed on the pests sprayed with these chemicals.
- A lot of energy and resources are expended in making and transporting these chemical sprays. This process leads to an increase in greenhouse gas emissions which pollute the environment and contribute towards global warming.

Health Benefits

A lot of the chemicals we use in the garden remain in and on the crops we grow.When we consume these crops we also consume these chemicals which can have a negative impact on our health. This section details organic gardening methods that will help you achieve good crop yields without harming the natural environment or the people who live and work in it.

Crop Rotation

If annual vegetable crops are grown in the same place year after year, there is a tendency for soil borne pests and diseases to become a problem and for plant health and vigour to decline. To avoid this it is good practice to move the crops around the growing area. This is known as crop rotation.

Why use Crop Rotation?

Pest and Disease Control

Plants which belong to the same family are grouped together when planning a rotation. Related crops are prone to the same soil-living pests and diseases. Moving them around in an organised rotation helps to prevent the build- up of problems.

Nutrient Requirements

Plants need nutrients in varying amounts and take them from different levels within the soil depending on the species and root depth. If you grow the same kind of crop in the same place season after season, the nutrients that the plant needs are quickly exhausted, the plants grow weak and stunted and quickly come under attack from waiting pests and diseases.

Soil Treatments

Crops vary in the soil treatments that they require. When a crop rotation is used, crops that require the same soil treatments are kept together as much as possible. This helps to ensure that they have the best possible growing conditions. It also means that over the course of the rotation the whole growing area will receive the same treatment.

Weed Control

Some plants have dense foliage like cabbage and lettuce. These are good at suppressing weeds because they stop light reaching the soil. Others, such as onion and carrot, do not. Alternating plants with these different growth habits helps to keep weeds under control.

How long should the rotation be?

The longer the rotation the better, but the usual length is 4 years as this is the number of years it takes for most soil-borne pests and diseases to decline to harmless levels. This means that crops return to their original site after 4 years. If the soil is already infected with persistent problems, try to extend the rotation of susceptible crops even further.

How do you plan a rotation?

Crop rotation may appear to be very complex, but once you start planning you will find that it is relatively straightforward. The following, outlines the basic principles of crop rotation:

1. Make a list of all the vegetable types and quantities that you want to grow over a season.
2. Group plants together by plant family. To find out which are related refer below.
3. Draw a plan of the growing area. Divide it into equal sized sections according to the number of years that you want the rotation to last. Try 4 to start with. Distribute the crops that you want to grow within these sections. The first rule is to try and keep families together; if a section is to hold more than one family, try and keep those with similar growing requirements together. Using a bed system can make this part of crop rotation easier.
4. You may find that it is difficult to divide your area up into 3 or 4 equal sized sections as the quantity of one type of vegetable might be too large. In this case reduce the amount of plants you are to grow rather than abandoning the rotation.
5. Keep records of what actually happened, not just what you planned. Use this information when planning for the next year.

TIP: A typical rotation will include a fertility-building green manure (legume) that is grown to enrich the soil. For further information refer to Section 3.

TIP: Don't be too rigid with your rotation plan. If plants are showing signs of nutrient stress you may need to grow a fertility building crop earlier than planned. If a field in a rotation has a long standing weed problem, it may be necessary to change the plan to avoid growing weed susceptible crops there.

Source: ACATA Trust Fiji

Plant Families

Below is a list of the main families of vegetable crops and their nutrient requirements.
Understanding the nutrient requirements of each family of plants will help you order your rotation.

Plant Family	Main Crops	Nutrient Requirements
Solanacae (Tomato family)	Tomatoes Peppers Chilli Eggplants Potatoes	Need high levels of nitrogen and potassium for fruit formation and should be grown after a fertility building crop or applying compost. Animal manures, especially poultry are high in nitrogen. Levels of potassium can be boosted by adding well-rotted compost or small amounts of wood ash.
Brassicae or Cruciferae (Cabbage family)	Cabbage Cauliflower Broccoli Radish	These need high levels of nitrogen and should be grown directly after a fertility-building crop. Levels of nitrogen can also be boosted by poultry manure. They grow best on heavier soils and need high levels of organic matter.

Cucurbits (Cucumber family)	Cucumber Pumpkin Melon Squash Zucchini	These will generally grow with more moderate levels of nutrients so are a good second crop after fertility building (although cucumbers may need slightly higher levels). They need well drained soils with high organic matter content. This family grows well with corn.
Alliums or Liliaceae (Onion family)	Onions Shallot Chive Garlic	These need more moderate levels of nutrients and too much manure can cause thick or double necks. They are best grown as a second or third crop in the rotation. Good drainage is essential.
Apiacae or Umbeliferae (Carrot family)	Carrots Celery Parsley Coriander Fennel	Carrots grow better with lower levels of nutrients (applying manure will cause them to fork). They are best grown as a second or third crop in the rotation.
Legumes (Bean family)	Cowpea Pigeon pea French bean Long bean Soy bean Winged bean	Legumes fix their own nitrogen so it is not necessary to add animal manures as this will just suppress the bacteria that fix nitrogen. The plants still require adequate potassium and phosphate which can be added through composted plant material or small amounts of wood ash. Contrary to popular belief, growing a bean as a cash crop does not increase the fertility of the soil as nearly all the nitrogen fixed is in the beans that are removed when the crop is harvested. It can be thought of as a 'nitrogen neutral' crop that fixes the nitrogen it needs. They are therefore a good crop to have at the end of a rotation when soil fertility is not so high.
Grasses and Cereals (Poaceae family)	Corn Sorghum Millet	Most cereals will yield poorly if placed at the end of a rotation when soil fertility is low, so the placement in the rotation is often dependent on how important the yield of the cereal is relative to other crops.

Root and Tuber Crops

There are a wide range of root and tuber crops that are well adapted to growing in the lowland humid tropics. These come from a range of families listed below:

- Sweet Potato or Kumala (Convolvulaceae family)
- Cassava or Tapioca or Tavioka (Euphorbiaceae family)
- Yams or Uvi (Dioscoreaceae family)
- Taro or Dalo (Araceae family)

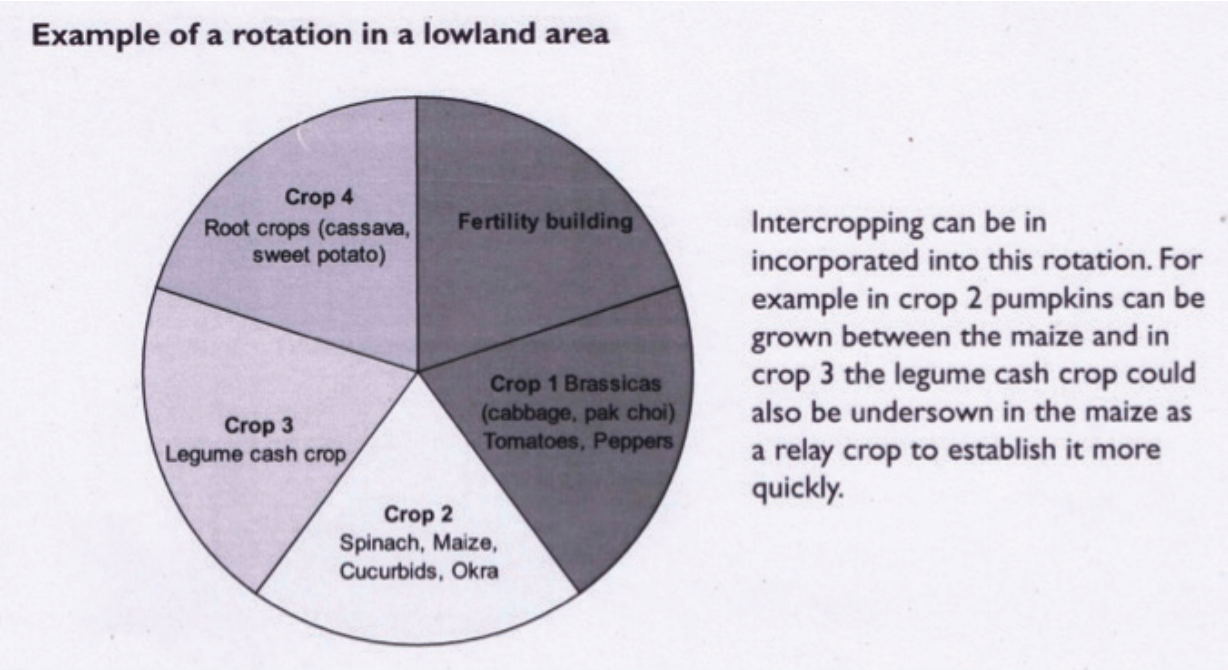
Most of these require moderate levels of nutrients. Too much nitrogen will usually encourage excessive leaf growth at the expense of root growth. A free draining soil with good levels of organic matter is normally required.

TIP: If you want to grow fruits and vegetables that don't fit into one of the major plant families include an "other" or "miscellaneous" category into your crop rotation.

Crop sequences in a rotation

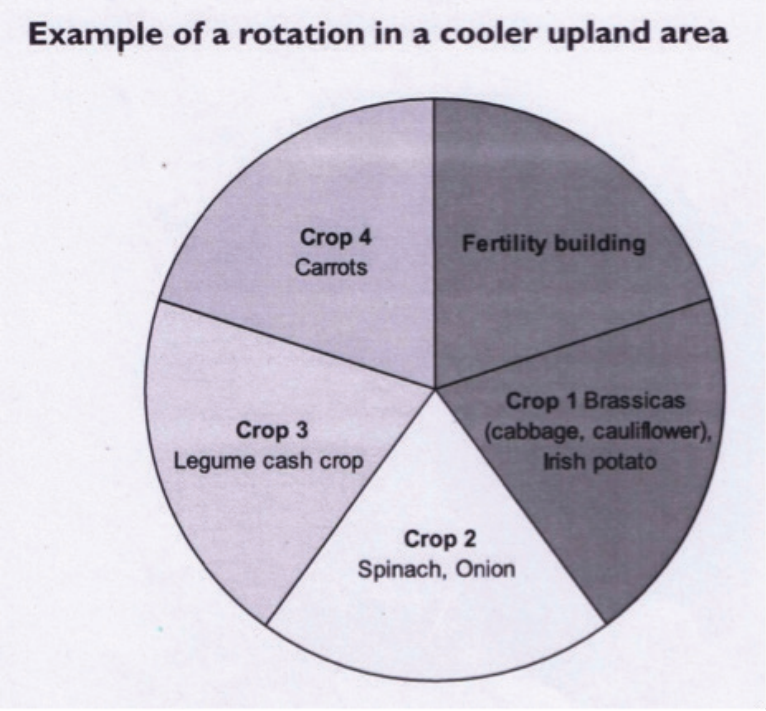
A general framework for planning a rotation is set out below. This can form a loose basis for planning. In practice, a rotation is always flexible.

Example of a rotation in a lowland area



Source: HDRA- the organic organisation n.d.

Example of a rotation in a cooler upland area



Source: HDRA- the organic organisation n.d.

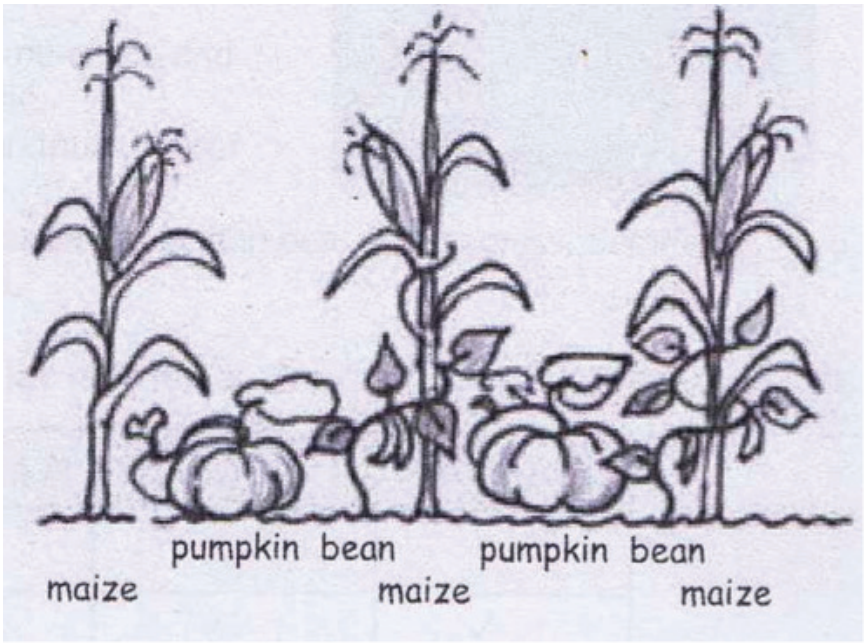
NOTE: These examples include a legume cash crop. This rotation can be replaced by vegetables from a different plant family when adapting these examples to the school setting.

Intercropping

Intercropping is the practice of growing different crops close to one another. Intercropping has a number of benefits including:

- More efficient use of resources such as water, nutrients, light and land area
- Lower incidence of pests, weeds and diseases than when a single crop is grown alone

A common intercropping combination is to put tall plants next to ground creeping plants. This combination provides advantages for weed control and land use. For example, you might like to try planting corn with beans and pumpkins.



Source: Food and Agriculture Organization of the United Nations, 2005

In this example, the corn is the most important crop and produces very good yields in the intercrop system. The beans and the pumpkin do not yield as well as when they are planted alone, but they can be seen as an added bonus.

Other common intercropping combinations include:

- Deep- rooted plants next to shallow- rooted plants
- Broad leaved plants next to narrow leaved plants e.g., Chinese cabbage with carrots

Below is a table listing the root depths of commonly grown garden vegetables.

Crop name	*Root Depth*	*Crop Name*	*Root Depth*
Broccoli	Shallow	Garlic	Shallow
Cabbage	Shallow	Long bean	Medium
Carrot	Medium	Melon e.g., Watermelon	Medium to Deep
Cassava or Tapioca/ Tavioka	Deep	Millet	Deep
Cauliflower	Shallow	Onion	Shallow
Celery	Medium	Peppers e.g., Capsicum	Medium
Chickpea	Medium	Pigeon pea	Medium
Chilli	Medium	Potato	Medium
Chive	Shallow	Pumpkin	Deep
Coriander	Medium	Radish	Shallow
Corn	Medium	Sorghum	Deep
Cowpea	Medium	Sweet potato or Kumala	Medium
Cucumber	Medium	Tomato	Deep
Eggplant	Medium	Yam or Uvi	Medium
French bean	Medium	Zucchini	Medium

Source: Garden Organic n.d.

Relay Cropping

Another type of intercropping is relay cropping. Relay cropping is when the next crop is sown before the current crop has been harvested. This allows the next crop to be established more rapidly without a break. This is commonly used for green manures that can be under-sown in the vegetable crops. For further information refer to Section 3.

Companion Planting

Companion planting is the practice of strategically planting different combinations of plants in close proximity to either:

- Enhance each other's growth and flavour
- Prevent pest and/or disease problems
- Attract beneficial insects

According to Tei Tei Taveuni, the following herbs have been observed to repel certain pests, prevent some diseases, and enhance the growth and flavour of particular plants.

Herb	Fijian Name	What it does
Basil	Tamole	Improves flavour of tomatoes, repels thrips, flies and mosquitoes.
Chives/leeks/ spring onions	Varasa	Improves growth and flavour of tomatoes and carrots.
Chili	Rokete	Prevents root rot and other fusarium diseases.
Coriander	Dahnia	Repels aphids and spider mites.
Garlic		Repels aphids in cucumbers, peas, lettuce and celery.
Marigold		Kills nematodes, deters whitefly when planted with tomatoes, and deters beetles when planted with pumpkins.
Mint		Deters white cabbage moths, ants, rodents, flea beetles, fleas, aphids and improves the health of cabbage and tomatoes.
Radish		Good repellent for cucumber beetle and rust flies.

Tomato Harvest

Source: Tei Tei Taveuni

The table below lists some commonly grown vegetables and their best companion plants.

Vegetable	Fijian name	Best Companions (vegetables/herbs)
Beans	Beans	Cucumber, corn / radish
Capsicum	Capsicum	Onions, tomato / parsley, basil
Carrot	Karote	Lettuce, beans, spring onions, tomato
Chinese Cabbage	Kaveti ni Jaina	Beans, celery, onion / basil, mint, garlic
Corn	Sila	Peas, beans, tomato, cucumber, squash, sunflower/radish
Cucumber	Kuikaba	Beans, corn / radish
Eggplant	Baingani	Beans, pumpkin, peas, carrot, capsicum / marigold
Kumala	Kumala	Bush beans
Spring Onion	Varasa	Carrots, celery
Lettuce	Lettuce	Cucumber, onion, spinach, cabbage, carrot, tomato / basil, radish, garlic
Okra	Okra	Lettuce, eggplant, capsicum, cucumber, melons / basil
Pumpkin/Squash	Papukeni	Corn, beans, eggplant, peas, radish, cucumber, lettuce / marigold, radish
Spinach	Spinach	Radish
Tomato	Tomata	Onion, capsicum, lettuce, carrot, celery /marigold, basil, mint, radish,garlic
Watermelon	Meleni	Pumpkin, squash, corn, radish, beans, peas, lettuce / marigold
Zucchini	Zucchini	Tomato, spinach, corn, capsicum, squash / parsley

SECTION THREE

Organic Fertilisers

Compost

Compost is organic matter (plant and animal residues) which has been rotted down by the action of bacteria and other organisms, over a period of time. Many types of organic matter, such as leaves, fruit and vegetable peelings and manures can be used to make compost. The end produce is very different from the original materials. It is dark brown, crumbly and has a pleasant smell.

Compost has a number of benefits including:

- Compost improves the structure of the soil. It allows more air into the soil, improves drainage, and reduces erosion.
- Compost helps to stop the soil from drying out in time of drought by holding more water.
- By improving soil structure, compost makes it easier for plants to take up the nutrients already in the soil. Compost may also improve soil quality by adding nutrients. This can help to produce better yields.
- Compost can reduce pest and disease problems in the soil and on the crop. The crop will be stronger and healthier and therefore resist pest and disease attack.

Compost is a better way of feeding plants than using chemical fertilisers. These fertilisers provide nutrients for plants but do not improve soil structure or quality. They usually only improve yields in the season in which they are applied. Compost is not washed away through the soil like chemical fertilisers, so the beneficial effects are longer lasting.

Plants that are grown with chemical fertilisers are also more attractive to pests because they have more green sappy growth.

Making Compost

Ingredients

Compost works best with alternating layers of carbon rich and nitrogen rich materials, collected in a ratio of 2 to 1 by volume.

Carbon-rich materials (brown)

- Course, dried leaves for example breadfruit, dried grass and sugarcane (preferably chopped)
- Paper and cardboard
- Seaweed

Nitrogen-rich materials (green)

- Sappy green material for example green cut grass, banana leaves, dalo leaves, crop residues (the remainder of a crop that has been harvested, unless recently sprayed with a herbicide) etc.
- Kitchen scraps
- Manure from chickens, pigs, cows, horses or goats
- Urine can also be added to speed up the composting process if nitrogen content low

Other additives

- Ash from fire or kiln (high in potassium)
- Soil from the top 10cm of cropped land. This is not essential but a sprinkling may reduce nitrogen loss from hot heaps. It may also be used to cover a heap.

What to keep out of compost

- Materials such as plants which have been recently sprayed with pesticides or herbicides
- Meat scraps and dairy products, as these may attract rats and other pests
- Persistent perennial weeds. These should be killed by laying out in the sun to dry, or even burning, to avoid them spreading. The dried material or ash could then be added to the heap
- Non-organic materials such as metal or plastic
- Materials with hard prickles or thorns
- Large amounts of materials that are diseased
- Human waste
- Cat and dog faeces

How to make compost

1. If the ground is likely to be wet make a base 20 cm high with coarse plant material such as twigs or banana stems to help air circulation and drainage.
2. Add a 30cm layer of brown material like died coarse grass, breadfruit leaves or seaweed.
3. Add a hand width layer of soft, green material that is easily decomposed such as fresh grass, fruit, vegetable scraps and manure.
4. Add some old compost or a sprinkling of sand.
5. Ash can be lightly sprinkled through the heap to add nutrients such as phosphorous (P), potassium (K) and trace elements such as zinc (Zn) and boron (B).
6. Water the whole pile well.
7. Repeat all these layers except the base layer until the heap reaches 1 to 1.5m high. After 3 weeks turn the heap.

Turning the heap

- Within 3 weeks the heap will have shrunk and it is important to turn it to add more oxygen.
- Turn the heap by taking it apart, place the material from the outside to the middle. If dry add water and if wet, add dry material.
- Turning the heap every 3 weeks will speed up compost formation, turn more regularly if possible.

Managing a compost heap

- Consider where to build your compost heap to ensure it is close to where you will be adding compost to your garden. Also, be mindful that rats may be attracted to the kitchen waste.
- Moisture loss in the dry season can be reduced by building the pile in the shade of a tree.
- Banana leaves or a tarpaulin can be used to cover the heap and keep it from getting too wet with loss of nutrients. Building the stack angled like a roof will also assist water run-off. If the heap becomes too wet, open it up and spread the materials to dry before re-heaping.
- Ensure compost is moist like a squeezed sponge. Water regularly (twice a week) if dry. In dry weather the heap may need to be watered and covered with grass, mud or soil to reduce evaporation.
- The compost heap needs to be greater than 1 m x 1 m to be able to retain enough heat.
- A bamboo pole with slots cut into it can be put in the heap to increase air circulation.

Troubleshooting Your Compost

Slow decomposition: Not enough nitrogen-rich material, add manure or sappy green leaves.

Heap becomes too hot: Too hot for too long can kill microbes, if heap feels hot, re-heap it.

Wet, or foul-smelling heap: Too much nitrogen or too moist, pull heap apart and add high- carbon absorbent materials such as dried leaves and mix. Protect pile from rain.

Dry centre and little or no decomposition of materials: Turn pile, thoroughly soaking each layer as it is replaced. Cover with banana leaves, grass, mud or soil to retain moisture.

Dampness and warmth only in middle: Increase amount of material in pile and moisten.

Damp, sweet-smelling heap but no heat: Add more nitrogen-rich materials such as fresh manure or sappy green leaves.

Matted, undecomposed layers of leaves or grass clippings: Break up layers with a garden fork or shred them, then re-layer pile. Avoid adding heavy layers of leaves, grass clippings, or paper unless first shredded.

Large undecomposed items: Screen out undecomposed items and use as starter for next pile.

Source: Martin & Gershuny 1992

How to use compost

- When preparing a soil bed for sowing, compost can be mixed with the top 10cm of soil. It should not be dug in any deeper as crop roots will not be able to take up the nutrients released by the compost.

- If you have a limited supply of compost, place a small amount of compost directly into the planting holes.

- Compost can also be used for mulching between crops or around trees. Compost that has not fully decomposed can be used for this; it will continue to mature on the ground and animals in the soil will draw it into the soil where it will decompose further. When using compost as mulch it should be covered with a thin layer of dried grass or chopped up sugarcane. This will avoid loss of nutrients due to direct exposure to sunlight and heat.

- Compost can also be mixed with soil and used for raising seedlings.

Green Manure

Green manures, often known as cover crops, are plants which are grown to improve the structure and nutrient content of the soil. They are cheap alternatives to artificial fertilisers and can be used to complement animal manures.

Growing green manure is not the same as simply growing a legume crop, such as beans, in a rotation. Green manures are usually dug into the soil when the plants are still young, before they produce any cop and often before they flower. They are grown for their green leafy material which is high in nutrients and protects the soil.

It is also possible to grow a legume from which a bean crop can be harvested and then dig the plant remains into the soil. These plant remains will not break down into the soil so quickly and will not be as good for the soil as younger plants but they will still add some nutrients to the soil for the next crop.

Benefits of using green manures

Greater soil fertility

Green manures recycle nutrients and add organic matter to the soil. They help prevent nutrients being washed out of the soil. The nutrients are taken up by the green manure and held inside the plant. When the nutrients are needed for the next crop the plants are dug into the soil or used as mulch on top of the soil. This helps to increase crop yields. Legumes and other nitrogen fixing plants which take nitrogen from the air to the soil are particularly beneficial.

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Improved soil structure

Green manures improve soil structure, letting more air into the soil and improving drainage. Green manures help sandy soil hold more water and not drain so quickly.

Prevention of soil erosion

Green manures help to stop the soil being carried away by wind and rain. The roots penetrate the soil and hold it in place.

Weed control

Green manures help to control weeds. Bare soil can become quickly overgrown with weeds which can be difficult to remove. Green manures cover the ground well and stop weeds growing beneath them, by competing for nutrients, space and light.

How are green manures used?

Green manures in rotation

Growing green manures as part of a crop rotation is an important part of an organic farming system. They help to build soil fertility and are particularly useful when grown before crops which need a lot of nutrients.

Green manures can be used in rotation:

- Whenever there is no crop in the ground, rather than leaving the land bare and allowing weeds to grow and nutrients to leach out of the soil.
- As break crops, when there is only a short time between main crops.

Timing of sowing is important. The green manure must be ready to dig in before the next crop is sown. There should not be a long gap between digging in the green manure and planting the next crop. This is to prevent nutrients from the green manure leaching out of the soil, before being taken up by the next crop.

TIP: The plants take a short time, usually about two weeks, to rot down into the soil before the next crop is sown.

Green manures and undersowing

Undersowing involves growing a green manure at the same time as a crop, among the crop plants. Sometimes they are sown with the crop or slightly later when the crops are already growing. This reduces competition between the green manure and the crop.

For example, a corn crop may be drilled in rows, then a green manure broadcast between the rows once the maize plants are a few centimetres high. The green manure crop will grow slowly when the corn crop is still in the ground, but once the corn has been harvested it will establish much more rapidly than if it was sown afterwards. This method means that no extra time is spent preparing the land and sowing the green manure.

Long-term green manures

Green manures can be grown for more than one season and used in the following ways:

- When restoring poor soil. Using green manures over a long time has a greater benefit on soil fertility and structure
- When preparing new land for use, especially to help control difficult perennial weeds
- Where land is to have a long fallow period
- To provide green material that can be cut and carried to other fields. Green manure can be harvested for digging in, mulching, composting or feeding livestock

Green manures for mulching

Green manures can be cut and left on the soil surface as a mulch. Mulching releases nutrients slowly but has some advantages:

- Mulching helps to prevent weed growth
- Mulching protects the soil from erosion
- Mulching keeps the soil moist by reducing evaporation

How to grow green manure:

- Sow seeds in rows, or broadcast them across the soil and rake into the surface using a gentle chopping motion to cover the seeds with soil. If you pull the rake across the bed, a lot of the seeds will end up in a pile.
- Give the bed a gentle watering and keep grain seeds damp by watering the bed when necessary, but don't water legume seeds again until they have germinated as too much water can cause legume seeds to rot. If the weather is very dry, you can cover the bed surface with a very thin layer of organic mulch (about 1cm thick). When your green manure crop has germinated, all you have to do is to water it occasionally if weather is very dry.
- Once the land is needed for cropping, chop the foliage down and leave it to wilt.
- Dig the plants and foliage into the top 25cm of soil. Helpful soil bacteria, fungi and other creatures will start breaking down the leaves, stems and roots of your green manure crop and turning it into humus (the end product of compost).
- After digging in, the site should be left for two weeks or more before sowing or planting out as decaying green materials can hamper plant growth.

Digging in green manures

- Green manures should be left for about two weeks after being dug in before the next crop is sown
- Digging is easier if the plants have been chopped into small pieces
- If digging in is difficult the plants can be dug in roughly, left for a few days and dug over again
- Younger green manure plants are easier to dig into the soil than older ones and land will be ready to use more quickly after they have been dug in. Soil organisms find it difficult to break down and decompose old, tough plants. If this happens green manures can be cut and composted instead.
- For most green manure plants, the best time to dig in is just before flowering begins, otherwise it becomes tough and woody. Also, if it is left to go to seed it may become a weed nuisance in later crops.

What green manures can I grow?

There are many types of plants that can be used as green manures. Legumes (peas and beans) are particularly beneficial because they increase the amount of nitrogen in the soil. In the tropics they are also more common than non-legumes.

You might like to try growing the following crops as green manures:

- Cowpea
- Pigeon pea
- Macuna bean
- Winged bean

Student cutting in green manure

Source: ACATA Trust Fiji

Macuna Beans

Why plant Macuna beans?

- Macuna can be used as a green manure crop to rapidly improve soil fertility. Many consider this the best 'cover crop' for this purpose in the Pacific.
- It builds organic matter which makes soil more fertile.
- It allows for longer use of land before fallow or even permanent cultivation.

How to grow it

- Plant seeds after your final harvest. The crop will need some weeding during the first six weeks, but once established it will cover the ground vigorously and will not need any further weeding.
- For best soil improvement slash and mulch the plant when it is flowering – leave some vines for seed for the next crop.

How to use it

- Slash the beans when they are flowering and either leave the leaves and vines as mulch on the soil or dig them into the soil. This is the time when nitrogen production is at its highest, which is better for the soil.
- Leave some vines to produce mature seeds. Collect the black velvety seed pods when dry and store them for the next planting. Don't store for too long- keep replanting and producing fresh seeds each crop.

PLEASE NOTE THAT MUCUNA BEANS ARE NOT RECOMMENDED FOR EATING. THIS CROP IS FOR IMPROVING THE SOIL WHICH IT DOES VERY WELL.

Problems to look out for

Don't let the mucuna become a weed in your garden. This plant needs to be carefully managed by the farmer.

Source: Jansen, Tutua & Logan 2013

Seaweed Fertiliser

Seaweed is a wonderful fertiliser, great as a mulch that builds the soil and excellent in compost

Why is it so good?

As seaweed grows in the ocean it accumulates a broad range of nutrients important to plants. Seaweed contains plenty of boron, a nutrient vital for the formation of cell walls and growth of plant tissue. Adequate boron also makes plants much more resistant to pest and disease attack.

Seaweed also contains natural plant hormones that support plants when you transplant them in the garden. It's also useful for improving the germination of seeds. Large seeds, if soaked for 24 hours in seaweed fertiliser can improve rates of germination.

Seaweed contains complex carbohydrates which the soil microbes really love. The carbohydrates provide two really important functions for the garden. Firstly, it stimulates the microbial fungi in the soil and these assist plants in their uptake of nutrients, especially phosphorus. The beneficial soil microbes also assist in defending plants from soil borne diseases by fighting off 'the bad guys'. If you have a sandy soil seaweed fertiliser can also act as a wetting agent, helping to hold the precious water in the root zone of plants.

How to make your own liquid seaweed fertiliser

1. Use a 10 litre bucket with a lid
2. Fill bucket almost to the top with seaweed
3. Add 2 litres of water and close the lid
4. Leave for 2 weeks
5. Strain out the liquid and use the rotting seaweed as a mulch or in your compost heap
6. Mix half a cup of seaweed solution and mix with ¾ of a cup of fresh water and sprinkle on plants as a fertiliser and pest control.

Source: Tei Tei Taveuni

Mill Mud

What is mill mud?

Mill mud is a nutrient rich by-product of the sugar milling process. It is comprised mainly of soil, natural impurities in the sugar cane, and fine particles of fibre. It is sometimes mixed with mill ash from the boilers. Mill ash is produced at the boiler station of the sugar mill where crust fibre is burnt after the cane juice has been removed.

What nutrients are available in these mill bi-products?

When applied to soils mill mud and mud/ash mixtures are an important source of the following macro and micro nutrients:

- Nitrogen
- Phosphorus
- Potassium
- Sulphur
- Calcium
- Magnesium

It should be noted that the nitrogen content of mill mud is relatively low and should be supplemented with other organic fertilisers with high nitrogen content such as animal manure to improve plant growth.

Resting mill mud

Before applying mill mud to your garden you must ensure that it has had time to "cool". If you apply mill mud when it is too fresh or "hot", it can be detrimental to plant germination and growth.

A resting period of at least 6 months is recommended for mill mud. If you plan on using it earlier you can try mixing the mill mud with soil, dividing it into smaller heaps for resting, or mixing or turning the heap regularly.

Composting Mill Mud

Composting mill mud can also significantly reduce the amount of time it needs to be rested. Composted mill mud will typically be ready for use in 4 weeks.

Site Selection

Select a site on raised ground and not easily flooded during heavy rains. The site should also be shaded and not exposed to direct sunlight.

Ingredients

- Soil: 100kg (divide into 4 parts)
- Animal manure: 50kg (divide into 3 parts)
- Grass clipping, straw, leaves: 25kg (divide into 3 parts)
- Mill mud: 50kg (divide into 3 parts)

The amount of each ingredient listed in kilograms is designed to be a guide and can be reduced depending on the amount you have available. However, it is important to keep the ratio consistent.

Method

1. Spread 1 part soil on the ground and sprinkle with water.
2. Spread 1 part animal manure over soil and sprinkle with water.
3. Spread 1 part mill mud over animal manure and sprinkle with water.
4. Spread 1 part grass clippings/straw/leaves over mill mud and sprinkle with water.
5. Repeat steps 1 to 4 until you have 1 part soil remaining. Use this soil to cover the compost heap and sprinkle with water.
6. Cover with a tarpaulin or banana leaves to keep the heat inside and prevent the rain from washing away the nutrients.

Monitoring

1. Check the temperature of the pile after the final layer of soil has been applied by inserting a thermometer inside the soil. This will be your base temperature.
2. Check temperature daily. When the temperature has reached 50 degrees Celsius or above (this usually occurs on the third day), turn the compost heap.
3. To turn the compost heap start from the top, using a spade to place the materials into anther heap next to the original pile. Sprinkle with water and cover.
4. Once you have begun to turn your pile, it must be turned each day to keep the temperature below 70 degrees Celsius. Failure to turn the heap once a day can kill the fungi responsible for the decomposition of the organic materials in the mill mud or mud/ash mix.
5. After 24 hours a white woolly growth will be observed on the pile and will increase over the first week, slowly reducing until it fully disappears typically around the third week.
6. It usually takes another week before the temperature of the pile reduces to its base temperature (the temperature of the pile recorded in step 1). Once this happens the compost is ready to use.

How to Apply Mill Mud

Rested or composted mill mud can be applied in the following ways:

- If you have a limited amount try mixing it with soil in the area you plan to plant before you sow a seed or transplant a seedling. You might also like to try mixing mill mud with soil at the base of planting holes.
- If you have a larger quantity of mill mud you can spread it over the entire garden plot and mix it into the soil with a garden fork before planting.

TIP: It is better to mix mill mud with soil as pure mill mud lacks certain micro-elements which the soil can provide.

Manure

For healthy crop growth fertilization with nitrogen, phosphorus and potassium is necessary. Manure is a valuable source of these nutrients. Chicken, pig, cow, horse and goat manure are all fantastic organic fertilisers.

Similarly to mill mud, manure is best applied after it has been rested or composted. Applying fresh, raw or hot manure to your garden can cause problems such as:

- Highly soluble nitrogen compounds and ammonia released by fresh manure can burn plant roots and interfere with seed germination.
- Raw manure is full of undigested weed seeds which can lead to serious weed problems if applied directly to soils.
- Fresh manure may also contain pathogenic bacteria such as E.coli, Listeria, and Salmonella which can lead to severe sickness and even death if contaminated produce is consumed.

To learn how to compost manure refer to the start of this section. If you intend to rest your manure, it must be left for a minimum of 4 months without adding any new material. If new manure is added to the pile, you must wait another 4 months from its application before the manure can be used.

Applying manure

- When applying rested or composted manure shallow incorporation is favoured over deep digging or surface application.
- If you have a limited supply of manure you can also restrict its application to the bases of planting holes.
- It is recommended that manure is not applied after planting and sowing.
- Do not use raw manure in your garden.
- Do not use human, cat or dog faeces.

SECTION FOUR
Organic Pest and Disease Control

The creatures that we call pests and the organisms that cause disease are part of the natural environmental system and only become 'pests and diseases' when their activities start to damage crops and affect yields.

Organic gardening aims to control pests and diseases naturally by attempting to restore a balance between pest and predator, and by implementing practices that keep pests and diseases down to acceptable levels.

By managing pests and diseases naturally rather than chemically, organic gardeners save money, protect people from exposure to potentially harmful chemicals, and protect the environment and delicate ecosystems.

Methods of Pest and Disease Control

Healthy Soil

A healthy soil managed using organic methods and provided with a regular input of organic residues in the form of animal manures and plant remains will produce crops that will be healthier and more resistant to pests and diseases.

Whilst chemical fertilisers appear to improve plant growth, their use can also have negative effects. A plant may look healthy but, because of the high content of nitrogen given by the chemic fertiliser, causing fast sappy growth, it is attractive to pests. It has been observed that aphids lay double the number of eggs on a plant grown with chemical fertilisers compared to organically grown plants.

Resistant Varieties

Local crop varieties are typically more resilient to changes in weather and attack by insects and diseases. This is because they have been developed locally to suit local conditions, including climate and soil conditions, and have greater genetic diversity, meaning that growing local varieties of plants which are better adapted to local climate and soil conditions, and have greater genetic diversity and are therefore better able to resist attacks by pests and diseases.

Crop Rotation

Growing the same crops in the same site year after year can encourage a build-up of pests and diseases in the soil. These will transfer from one crop to the next. Crops should be moved to a different area of land each year and not returned to the original site for several years. For vegetables a 3 to 4 year rotation is usually recommended as a minimum. For further information on crop rotation refer to Section 2.

Good Hygiene

If infected plant material, live or dead, is left lying around, pests and diseases can be passed on to future crops. Debris should be cleared up and disposed of. This can be done by composting the debris. The composting process will kill some pests and diseases and produce compost which is a good soil improver and fertiliser. *Some diseases may survive being composted. If in doubt, the infected material should be burnt.*

Companion Planting

Companion planting means growing certain plants to protect other plants from pests or diseases. For further information on companion planting refer to Section 2.

Aromatic plants are often used in companion planting as they release a strong aroma or smell from their leaves, roots, seeds, stems and/or flowers that repel garden pests. These plants should be planted between crops or along garden fence lines or boundaries. In the case of short and/or vigorous growing plants such as mint, containers should be used to control their growth and stop them from spreading.

Some commonly grown aromatic plants include:

- Lemon Grass (Fiji grass or Coboi)
- Sacred Basil (Holy basil, Tulasi, Tamole or Domole)
- Marigold (French marigold, African marigold or Ghendha)
- Lemon Balm (Mint or Kapoor patthi)
- Sweet Basil (Basil, Tamole or Tutmalanga)
- Mint (Pudina)
- Coleus (Lata or Lau-lata)

Encouraging Pest Predators

There are many plants that can be grown to attract natural predators (beneficial or good insects) which will help keep down pests and diseases. The predators feed or lay eggs on crop pests, thus reducing the population.

Flowers such as marigolds, mint, and sunflower as well as local legumes are useful attractant plants.

Leaving areas of natural habitat (bushes and trees) around the edges of fields where crops are grown can also attract useful insects and birds by providing them with a home close to your crops.

Barriers

Barriers are physical structure put in place to prevent a pest from reaching a plant. They keep pests away from a plant but do not kill them. Here are some examples that you can adapt, depending on the resources available to you:

Crawling insects

Cut the bottom off a transparent plastic bottle and place it firmly into the ground over a young plant with the top off.

Climbing insects

To help protect trees from attack by insects, grease bands can be used. Wrap a piece of plastic or a long leaf around the trunk of the tree. Spread any kind of thick grease on top of this. Fold over the top of the foil or plastic to form an overhang to protect the grease from being washed away by the rain. Check the grease every week to ensure that the grease is intact. This prevents crawling insects such as ants, fruit fly larvae, slugs, snails, beetles or caterpillars from damaging trees, especially fruit trees, or grain stores.

Bait Traps

The use of baits and traps are traditional methods which have become neglected because of the increasing use of chemical pesticides. Here are some examples:

Cut worms

Method one

Mix equal quantities of hardwood sawdust, bran, molasses and enough water to make the solution sticky. Spread around the base of the plants in the evenings. The molasses attract the cutworms and as they try to pass through it they get stuck. The substance dries out in the sun and the pest dies.

Method two

Mix 100 grams (g) of bran, 10g of sugar, 200g of water, 5g of pyrethrum powder. Spread around the base of the plants. The cutworms eat the substance and die.

Source: Garden Organic 1998

Fruit fly

Traps need to be put in place before an attack is likely to start. For fruit fly, the traps should be baited 6 to 8 weeks before the fruit ripen.

Here are two examples of trap constructions which could be adapted:

Method one

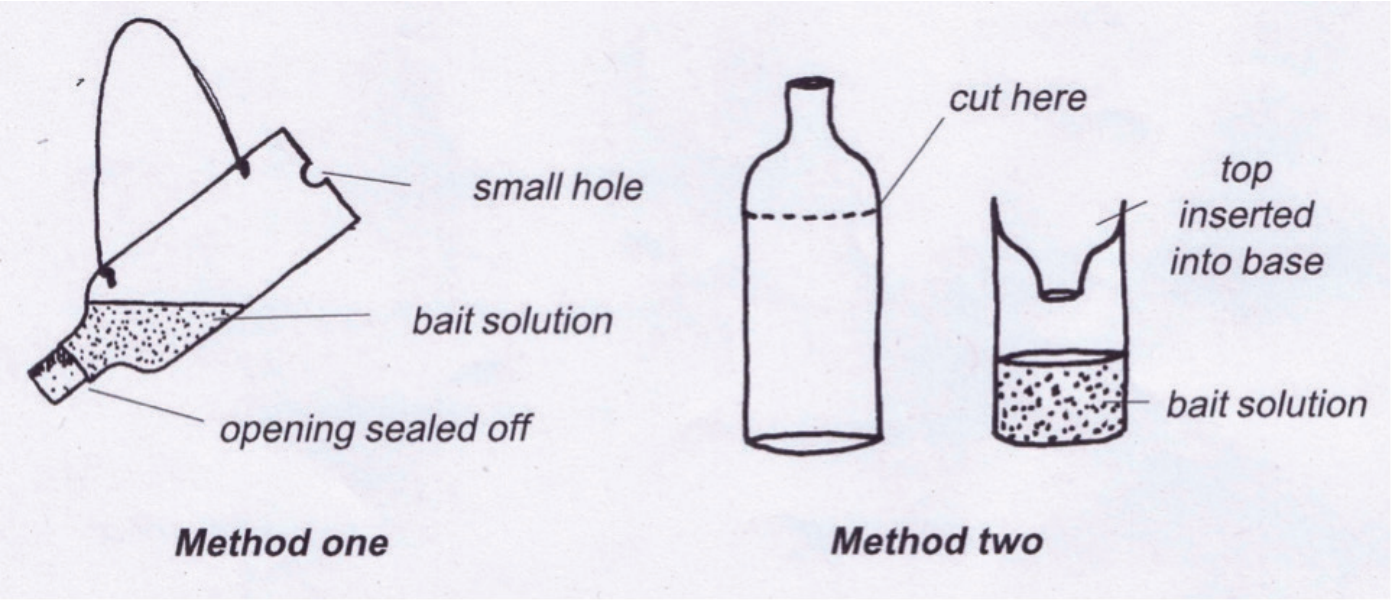
Make a small hole in the bottom of a plastic bottle or container. Seal the top of the bottle with a lid or stopper. Fill one quarter of the bottle with the bait. Hang the bottle upside down from trees around fields or gardens. The flies are attracted to the bait through the small hole. They are then trapped and drown in the bait.

Method two

Cut the top of a plastic bottle off. Pour some bait in the bottom half of the bottle. Turn the top half of the bottle upside down and place in the bottom half. Again the flies are attracted into the bottle and drown in the bait.

Here are two different baits for fruit fly that can be poured into the traps:

- Mix 1 litre of water, 250 millilitres (ml) of urine, a few drops of vanilla essence, 100g of sugar and 10g of pyrethrum powder.
- Miss 1 teaspoon of pyrethrum powder, 250g of honey, a few drops of vanilla essence, 250g of orange or cucumber peel or pulp and 10 litres of water.

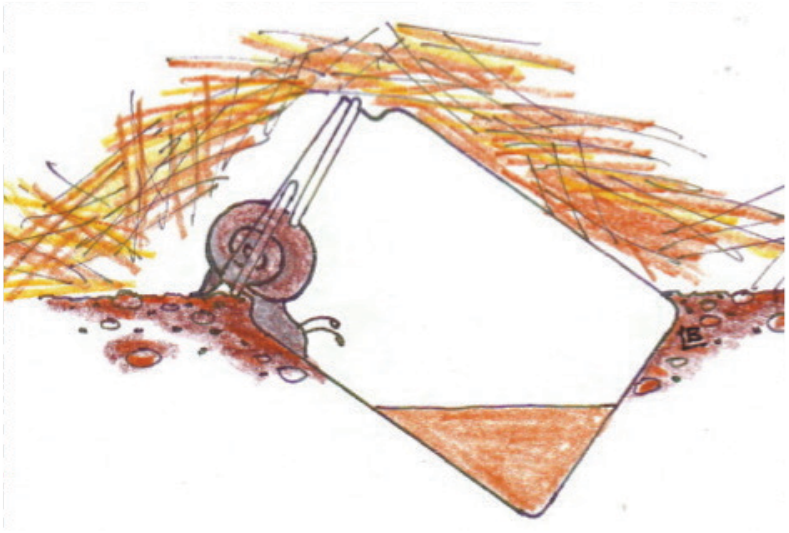


***Source:** Garden Organic 1998*

Snails and slugs

Snails and slugs are attracted to soft, sappy leaves. They like 'yeasty' smells too, and you can trap snails and slugs in a plastic jar that contains a spoonful of vegemite dissolved in half a cup of water. Dig a shallow hole in the bed and position the jar as shown in the drawing. Put some mulch over the top of the jar to keep it dark and stop it from getting hot.

Another way you can trap snails on slugs is using citrus halves that you have squeezed for juice. Cover the traps with mulch, and remove your catch the next morning.

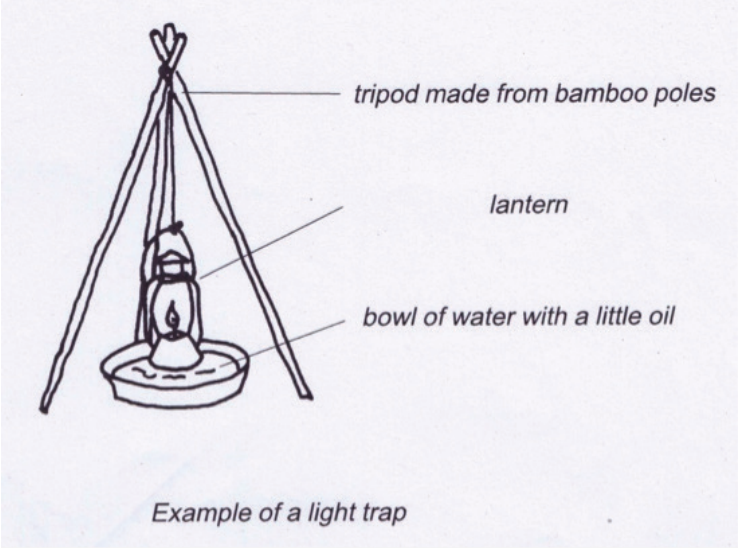


Source: Biological Farmers of Australia 2010

Light Traps

Light traps are set up at night and attract a variety of flying insects including moths, mosquitos, chafer beetles, American bollworms, army worms, cutworms, brown rice plant hopper, green rice leaf hopper, rice black bugs, rice gall midges, rice stem borers and tomato hornworms.

Make a tripod construction from wooden poles or bamboo. Press the poles down firmly into the ground to secure it so that it cannot be blown over or knocked down by animals. Suspend a lantern from the top of the construction over a bowl of water with a little oil in it.



Example of a light trap

Source: Garden Organic 1998

Fire risks must be kept in mind and the lamps must be hung so that the wood does not catch fire.

The best timing for placing light traps around a garden or field depends on the life cycle of the insect and the development stage of the crop. The best time is just after the moths emerge but before they lay eggs, so it is important to know the life cycle of the pests.

Fly Trap

Fly traps are large boards measuring about 30cm by 30cm which are painted bright yellow/orange and covered with an adhesive such as oil or glue. Different pests are attracted to different colours so you need to experiment. The flies are attracted to the bright colour of the board and fly onto it. They get stuck in the oil or glue and die.

For example, leaf minors are attracted to yellow, so place several yellow boards 60cm off the ground (on a table or hung from a tree). The board will attract a huge number of insects, which means a considerable reduction of pests.

Hand Picking and Squashing Natural Pesticides

In some cases it may be possible to pick pests directly off the crops. This can be done especially with caterpillars and other large insects in small plots of land. Smaller pests such as aphids can be squashed on the plant.

Parts of the plants that are diseased can be cut or broken off the plants to prevent the spread of disease.

Natural Pesticides

Natural pesticides are sprays made from plants such as garlic, chillies, marigolds and many others. These are inexpensive and have proved to be very effective. Here are some examples:

Chilli pesticide spray: To control aphids and other sucking insects. Slice a handful of dried chillies and some onion or garlic and mix together in a litre of water. Grate in a small handful of hard soap. Leave overnight, then strain through a cloth and add 5 more litres of water. Brush, sprinkle or spray on affected plants, but not in direct sunlight. Don't get it on your skin or in your eyes. If plant leaves burn, make the mixture weaker with more water. Repeat the treatment as often as necessary.

Simple soapy water spray: For sucking insects. Use one teaspoon to two tablespoons of normal liquid detergent soap for every four and a half litres of water. Spray as often as needed, especially under the leaves. Increase the amount of soap if necessary.

Flour or ash: Dust onto leafy vegetables to suffocate caterpillars. Flour is also a stomach poison for them.

Flour or ash: Dust onto leafy vegetables to suffocate caterpillars. Flour is also a stomach poison for them.

Tea or coffee spray: To deter insects. Soak coffee grounds or tea leaves in water and spray on the plants. Make sure the water is not hot when you spray it on the plants.

White oil or "summer oil" spray: To suffocate chewing and sucking insects. Make a concentrated mix with half a litre of vegetable oil (e.g., coconut oil) and half a cup of detergent or soap dissolved in water. To spray, mix 1 tablespoon of the mixture in a litre of water. If you store the mixture, shake well before using to mix up the ingredients.

Bug juice: Made with the bugs themselves is effective against caterpillars, slugs, larvae and bugs. Catch and kill a few of the pests which are attacking your crops, cover with water, grind to a paste and strain through a fine sieve or cloth. Dilute 50ml in 10 litres of water then spray their friends and relations.

Source: Food and Agriculture Organization of the United Nations, 2005

Tomato leaf juice: Useful in controlling aphids and caterpillars on many plants. Boil 500grams of tomato leaves in 5 litres of water. Strain and dissolve 30 grams of soap in the mix. For spraying use one part of the mixture to 4 parts of water. Please note, do not use this mixture on tomato plants or members of the tomato family (e.g., pepper or Irish potato).

Marigold leaf juice: Made the same way as tomato leaf juice, is a powerful, broad-spectrum pesticide (it even deters fleas on dogs!). Wild marigold, which comes up in fields, on roadsides or any patch of disturbed soil, is much more effective than the garden variety.

Source: Food and Agriculture Organization of the United Nations, 2005

TIP: Spray bottles are not always easy to come by. A large paintbrush, broom head or tied bundle of grass will work just as well. Dip this into a bucket of the pesticide and shake it to splash the mixture on the plants.

TIP: All sprays should be applied early in the day so that leaves can dry before dark.

A Good Plant Tonic

If your plants have a disease, a good general remedy is to spray the leaves with a solution of organic-allowed seaweed tea at the recommended strength. The chemical treatment for many plant diseases contains sulphur, copper, potassium or manganese. Seaweed contains all these minerals, and spraying the leaves helps plants to absorb them quickly, and improve their natural resistance to disease. After watering, give the soil around affected plants a drink of seaweed tea, too.

Spraying leaves with organic-allowed seaweed tea can also help by providing important minerals quickly where pest attack is caused by not enough plant food.

For instructions on how to make seaweed tea please refer to Section 3.

SECTION FIVE

Seed saving and growing new plants from planting materials

Saving seeds

If you have grown healthy plants from open-pollinated seeds in your garden (seeds from plants that have been pollinated by insects, birds, wind, or other natural mechanisms), you can save the seeds and sow them again. Seeds saved from plants that don't have any signs of disease and haven't been attacked by lots of pests will grow the best as they come from plants that have adapted well to your local climate and soil conditions. Saving seeds for next season will save money, too.

The time to decide if you want to save seed from your plants is when your crops are getting ready to harvest. The first rule of seed saving is "save the best and eat the rest". By following this rule, you will have a garden full of healthy plants.

Seeds from different plants

Each plant species produces seeds in distinct shapes and sizes, and are found in different parts of the plant. This section describes some of the main plant types and how to collect and dry their seeds.

Plants that hold seeds in pods

Perhaps one of the best examples of this kind of plant are beans of different varieties i.e., French bean, long bean, winged bean etc.

Choose only well-filled pods for saving seed. Small pods, or pods that are flat in parts, will tend to grow into plants that produce small, partly-filled pods. Loosely tie a scrap of brightly coloured cloth or wool around the stem of the fruit or pod you want to save so that someone else won't accidentally harvest it. If possible, save well-filled pods close to the base of the plants.

The pods may be left on the plant to dry, and harvested when the seeds rattle in the pods. However, if necessary, pods that are still green but are mature may be picked and dried separately. It is very important to handle legume seeds carefully, especially after they have been dried, as they can easily be damaged.

The seeds should be removed from the pods and then dried for about 5 days before storing. The amount of time they need to dry will depend on their size. In humid conditions, the seeds may be left in the pods and hung in the smoke above the cooking fire.

Plants that hold seeds in fleshy fruit

Plants that produce seeds inside fleshy fruits include tomatoes, cucumbers, peppers (i.e., capsicum), papaya, watermelon and passion fruit.

For seed collection, the fruit should be harvested when it is fully mature. The fruit should be stored for a few weeks so that the seeds can continue to mature. Alternatively, fruits can be allowed to further mature on the plant. After this time, the fruit can be cut open and the seeds removed. The flesh of the fruit can be removed from the seeds by hand or by the fermentation process. Fermentation is particularly useful for fleshy fruits whose seeds are surrounded by gel that is difficult to wash off.

To collect seeds using the fermentation process scrape the seeds and the surrounding gel from the fruits into a container (preferably transparent) and mix with a little water. Leave the jar in a warm place, out of direct sunlight for one to four days until foam appears on the surface of the mixture. As soon as foam forms, scoop it off with a spoon, and fill the container with clean water. Healthy seeds will sink to the bottom of the container. Carefully pour off any loose jelly floating at the top of the container, then tip the contents of the container into a sieve. Wash the seeds thoroughly in the sieve to remove all the jelly then tip the seeds out to dry.

Source: Biological Farmers of Australia 2010

Saving Watermelon Seeds

Watermelon seeds are the easiest to save because you can save them while eating the fruit. The seeds closest to the middle of the watermelon will be the strongest. Collect the seeds in a sieve or strainer and rinse them well to remove any sugary juice before laying them out to dry.

Seed Drying

Seeds must be dried before storing them to improve their storage life. This is because moisture in the seed may encourage mould, bacteria or other pests and diseases. However, seeds should not be dried too much or too rapidly as they may crack or lose their ability to germinate. Thy can be dried outside in the morning sun or half-shade, but should not be left in strong sunlight.

To dry seeds, spread them out thinly on paper, cloth, flat basket or plate in a warm place off the ground. They should not be dried on metal as this may become too hot. Turn them over several times a day to ensure that they dry evenly.

They should not be left outside at night as they may become damp or be eaten by rodents. The length of time that they take to dry will depend on the weather and the size of the seeds. Leave the seeds to dry for several days before storing them. When the seeds do not feel damp or stick together they are likely to be ready for storage.

Plants with seeds in hollow fruits

Seeds of hollow fruits, such as sweet peppers, chilli peppers and okra, can be removed by hand. The seeds do not need to be washed and should be laid out on a plate to dry out of direct sunlight.

Okra pods can be left on the plant until they are dry and brown and the seeds rattle, or may be picked when green and left to dry for a couple of weeks.

TIP: Care should be taken when removing seeds from chilli peppers and okra, as their juice can irritate the skin. Hands and utensils should be well washed after contact with chilli peppers and okra.

Plants with seed-bearing flower heads

Plants with seed heads include sunflower, onions, amaranth, carrot, and sorghum. The seed heads should be picked when they are dry, and can be left out of direct sunlight to finish drying if necessary. When completely dry, the seeds can be removed by rubbing or shaking the seed heads.

TIP: Corn bears seeds on a cob, which can be harvested in the same way as seed-bearing flower heads.

TIP: Care should be taken when removing seeds from chilli peppers and okra, as their juice can irritate the skin. Hands and utensils should be well washed after contact with chilli peppers and okra.

Preparing seeds for storage

Once seeds have been extracted and properly dried it is time to prepare them for storage.

Visual inspection

Any seeds that are immature, broken, diseased or infested with pests should be taken out. Stones, dirt and seeds from other plants should also be removed.

Winnowing

Winnowing can remove smaller contaminants such as dust and dry leaves. To winnow the seeds, place them in a large flat container and toss them into the air when there is a gentle wind, then catch them in the container. The light dust and leaves will be blown away by the wind.

Seed storage

Seeds must be stored in a way that prevents them from being attacked by pests or diseases, and that maintains their quality.

Good storage conditions for seeds are:

- **Low moisture**

Seeds should be sufficiently dried before being stored. To prevent seeds from getting damp keep seeds in an airtight container and try adding dry charcoal or toasted white rice in with the seeds. Seeds that are held in pods, hollow fruit such as chilli peppers and corn seeds on the cob, may be dried and hung near the smoke of a cooking fire. This technique also helps to keep away insect pests.

- **Low temperature and light**

High temperatures may encourage biological activity in the seeds and shorten their storage life, particularly if there is any moisture in the seeds. Bright light can also be damaging to stored seeds. Seed containers should be kept in a cool area and out of direct sunlight.

- **Protection against rodents**

To keep rodents such as rats and mice away from seeds, they should be stored in a clean hygienic area. The floor should be swept so there are no scraps of food that may attract rodents. Seed containers should be well sealed and if possible kept off the ground so rodents cannot get in.

- **Protection against insect pests and diseases**

Storage weevils, fungi and bacteria can infest seeds when in storage and damage them. Only seeds that are free of pests should be stored.

Weevils, fungi and bacteria start to multiply in warm and moist conditions. To prevent this from happening, the seeds should be kept dry and cool.

Some substances may be mixed with seeds to help prevent pests and diseases:

Sand: Mixing the seeds with clean, dry sand and filling the container will prevent weevils from moving around.

Aromatic plants: Some aromatic plants can prevent pests from multiplying and may kill them.

Hot peppers or chilli: Mix 4 to 6 teaspoons (20 to 30 grams) if dried and powdered chillies for every kilogram of seeds to be stored.

Black pepper: Mix 6 teaspoons (30 grams) of powdered peppercorns for ever kilogram of seeds to be stored.

Turmeric: Mix 4 teaspoons (20 grams) of powdered root of turmeric for every kilogram of seeds to be stored.

Propagating without seeds

Some plants can be reproduced or propagated without seeds. These plants are raised from different parts of plants including roots, stems, leaves, suckers, shoots, bulbs and tubers. These different parts of a plant are known as planting materials and are used in vegetative cultivation of certain crops. Plants cultivated in this way are genetically identical to the parent plant.

For example sweet potatoes can be propagated through cuttings from the vines or the tubers, and bananas put out 'suckers' (small shoots growing from the base of the parent plant) which may be planted to grow into a new plant.

Cassava and dalo are two staple crops grown in Fiji from planting materials. Below is more detailed information on what planting materials are used in their cultivation.

Cassava

Cassava is propagated from stem cuttings. Stem cuttings are obtained by cutting the stems from vigorous and disease free plants which are about 8 to 12 months old into stakes approximately 20cm long with 5 to 7 nodes on each.

The diameter of the stakes should be at least 3cm and the stakes should be soaked for 5 to 10 minutes in hot water to kill pests or disease-causing organisms that might be present. To get the right water temperature, simply mix equal amounts of boiling and cold water.

Dalo

There are essentially 4 types of planting material that can be used in taro production:

1. Side suckers produced as a result of lateral proliferation of the main plant of the previous crop.
2. Small corms resulting from the main plant of the previous crop.
3. Huli i.e., the top 1 to 2 cm of the corm with the bottom 15 to 20 cm of the petioles attached.
4. Corm pieces resulting when large corms are cut into smaller pieces.

SECTION SIX
Growing for health & nutrition

Over recent decades NCDs (diabetes, cardiovascular diseases, cancers, and respiratory diseases) have become Fiji's biggest killer, responsible for 77 per cent of all deaths in 2010. Poor nutrition is one of the key modifiable risk factors responsible for NCDs.

However, NCDs are not the only threat associated with poor nutrition. Micronutrient deficiencies and other nutrition related illnesses remain a significant issue in Fiji and are associated with poor health outcomes and even death.

All of these deficiencies could be avoided by eating a balanced diet. Fruits and vegetables are a significant part of a balanced diet and are important sources of essential nutrients.

School gardens can play an important role in addressing micronutrient deficiencies either through the provision of produce to students, or by teaching students how to grow nutrient rich fruits and vegetables in their backyard garden.

Growing "superfoods" in your school garden is highly recommended, as these nutrient rich fruits and vegetables not only prevent malnutrition and nutrient deficiencies, but can also help with some medical conditions. Many people around the world pay a high price for these foods, whilst in Fiji they can be grown virtually for free in the school garden.

This section provides information on the leading micronutrient deficiencies in Fiji, particularly among school aged children, and highlights how you can use the school garden to help prevent deficiencies from occurring or reoccurring.

NOTE: for all severe deficiencies medical intervention is required and supplements are often needed to reverse the deficiency.

Iron Deficiency

Prevalence in Fiji

According to the Fiji National Nutrition Survey 49.9 per cent of children between 6 months and 5 years, and 25.9 per cent of children aged between 5 and 11 years were found to be anaemic in 2004.

What is Iron?

Iron is an essential nutrient for the production of haemoglobin, a protein within your red blood cells that is responsible for carrying oxygen around your body. If we don't get enough iron in our diet we are at risk of developing the blood condition anaemia.

Signs of Anaemia

Many of the signs of anaemia are caused by decreased oxygen delivery to tissues and organs. Some signs which may indicate if an individual is suffering from anaemia include:

- Tiredness
- Lethargy (lack of energy)
- Irritability
- Pale coloured palms, eyelids and gums
- Hair loss
- Shortness of breath
- Behavioural problems
- Repeat infections
- Loss of appetite
- Increased sweating
- Failure to grow at the expected rate

TIP: Mild to moderate iron deficiency anaemia may have no signs or symptoms.

Why it's a risk?

It is important to treat anaemia as it can impair children's physical and mental health and increase their risk of illness and infection.

Where do we get iron from?

Meat is the best source of iron as it is more readily absorbed by our bodies. However, vegetables, lentils, and legumes also contain iron.

To help our bodies better absorb the iron from foods, we should mix iron rich foods with foods high in vitamin C such as guavas, tomatoes, chillis and pineapple. This is particularly important when eating non-meat sources of iron that are less easily absorbed by the body such as vegetables, lentils, and legumes.

In your garden

You can grow iron rich foods such as dark leafy greens (bele, watercress/karamua, tubua/chauraiya, rourou, kumala leaves, ota, and saijan/drumstick/boro ni idia/horse radish).

Pumpkin seeds are also an excellent source of iron so try saving seeds from pumpkins grown in your garden to dry and eat.

You can also grow fruits and vegetables rich in vitamin C to team with your iron sources. You might like to try growing guavas, tomatoes, chillis, capsicum, cumquats, limes, oranges, and pineapples.

TIP: Dalo, cassava, and tea can block iron absorption so try not to eat these foods in the same meal as iron rich foods.

Vitamin A Deficiency

Prevalence in Fiji

According to the National Food and Nutrition Centre's report on the micronutrient status of children from 6 months to under 5 years in Fiji, in 2008 a total of 8.6 per cent of children under 5 years of age were vitamin A deficient, and a further 34 per cent were at risk of deficiency. This same study found that vitamin A deficiency was much higher in Fijian children (11.2 per cent) in comparison to Indo-Fijian children (3.9 per cent).

The 2004 Fiji National Nutrition Survey suggested that this is due to a lower intake of beta-carotene (type of vitamin A) rich foods by Fijians.

Why is vitamin A important?

Vitamin A prevents eye problems, promotes a healthy immune system, is essential for the growth and development of cells, and keeps skin healthy.

Vitamin A is particularly important during childhood and adolescence as there are stages in our life typified by heightened growth and development. Without sufficient vitamin A, children may develop problems with their eyesight or suffer from frequent infections and illness for example.

Signs of vitamin A deficiency

- Night blindness
- Difficulty for the eyes to adjust to dim light
- Inability to distinguish images in low light such as at sunset or at night
- Frequent infections and illness due to low immunity
- Dry and scaly skin
- Dandruff and dry hair
- Mouth ulcers
- Acne

In your garden

You can grow plenty of Vitamin A rich foods in your garden including:

- Dark green vegetables (e.g. amaranthus/chauraiya/tubua, bele, drumstick/saijan/boro ni dia/horse radish, ota, kumala leaves, rourou, karamua/watercress, long beans, peas, okra, chinese cabbage)
- Orange fruits and vegetables (e.g. carrot, pumpkin, sweet potato/kumala, mangoes, paw paw)
- Avocado
- Tomato
- Pineapple
- Banana

TIP: Bele is a vitamin A superfood, containing 16083mg of vitamin A per cup, that's 14 times more than pumpkin.

TIP: Having a small amount of fat with your meal will help your body absorb vitamin A. Try adding some meat or a dash of coconut milk to your next meal.

Zinc Deficiency

Prevalence in Fiji

According to the National Food and Nutrition Centre's 2008 report on the micronutrient status of children from 6 months to under 5 years in Fiji, a total of 5.6 per cent Fijians under the ages of 5 are zinc deficient. This same study found that zinc deficiency was higher in Fijians (7.2 per cent) compared to Indo-Fijians (2.6 per cent), and it was also more common in boys (6.5 per cent) than girls (4.8 per cent).

Why is zinc important?

Zinc helps in muscle formation, wound healing and immune functioning. Rapid growth associated with childhood and adolescence means children need more zinc and are at a greater risk of deficiency.

Signs of zinc deficiency

- Delayed sexual maturation
- Stunted growth
- Hair loss
- Dermatitis (eczema)
- Impaired taste
- Diarrhoea
- Behavioural disturbances
- Sleep disturbances

In your garden

Sources of zinc include meat, chicken, fish and shellfish as well as eggs, cheese, milk, rolled oats and bran. Peanuts are also a source of zinc and can be grown in your garden. While vegetables don't provide zinc, it is important to have a good intake of vitamins A, E, B6, and calcium for your body to absorb zinc. All orange and green fruits and vegetables are good sources of these vitamins.

Protein Energy Malnutrition

Prevalence in Fiji

While Kwashiorkor and Marasmus are uncommon in Fiji, malnutrition remains an issue. According to the 2004 Fiji National Nutrition Survey, a total of 12.9 per cent of males and 12.7 per cent of females under 18 years were underweight for their age, and 4.1 per cent of males and 4.9 per cent of females under 15 years were underweight for their height. This same study found that 3.7 per cent of males and 3.1 per cent of females were short for their age. Indo-Fijian children were also consistently shown to have higher rates of underweight by weight for age and stunting.

Signs of malnutrition

- Stunted growth and development (both height and weight)
- Visible signs of wasting such as concaved (sunken) stomach, protruding bones and sunken cheeks
- Behavioural changes such as appearing unusually irritable, sluggish or anxious
- Problems concentrating
- Learning difficulties
- Greater susceptibility to infections and illness

In your garden

Malnourished children need food sources that are not only rich in calories and protein, but also rich in vitamins and minerals. You might like to try growing the following protein, calorie, and nutrient rich foods in your garden to address malnutrition.

Protein Rich:

The best sources of calories and protein are meat, chicken, fish, and dairy products (milk, cheese, yoghurt), but lentils and legumes (beans, dahl, chickpeas) can also be good sources of protein.

Calorie Rich:

Root crops such as dalo and cassava are excellent sources of calories, especially when mixed with coconut milk and coconut meat.

Nutrient Rich:

Fruits and vegetables of a variety of colours will be rich in vitamins and minerals needed for healthy growth and development.

Appendices

Appendix 1: Seed Spacing Table

Name of crop	Spacing within rows	Spacing between rows	Germination	Direct Seed or Transplant	Notes
Amaranthus (Amaranthus Viridis)	15cm	50cm	6 to 10 days after sowing		Seeds can also be broadcast into well made beds
Avocado Pear (Persia Americana)	9m	9m	Seeds are quick to germinate		
Banana (Musa Sapientum)	2m	3m			Healthy and disease free suckers should be selected for planting
Bele (Abelmoschus Manihot)	50cm	100 to 150cm	Sprouts 1 to 2 weeks after planting		Bele should be planted at an area that is well drained and is close to a water source
Breadfruit (Artocarpus Altilis)	12m	12m			
Capsicum (Capsicum Grossum)	50cm	1m	6 to 10 days after planting	Transplanting can be done during cloudy days or late in the afternoon. Irrigation is very important for healthy plant growth. If rainfall is not sufficient, irrigation should start immediately after transplanting and as needed afterwards.	
Cardamom (Ellettaria Cardamomum)	2m	2m			
Carrot (Daucus carota)	8cm	50cm			Sow thinly in rows and later thin to correct spacing 7 to 10cm

Appendix 1: Seed Spacing Table

Name of crop	Spacing within rows	Spacing between rows	Germination	Direct Seed or Transplant	Notes
Cassava (Manihot esculenta)	50cm	1m			Cutting 30 cm in length Mounds 0.5m in diameter and 1m apart
Cauliflower (Brassica oleracea botritis)	40cm	75cm	3 to 5 days after sowing	Transplant after 3 to 4 weeks	
Celery (Apium Graveolens)	15 to 25cm	60 to 90cm	Needs a well drained soil with sufficient moisture to germinate. Grows well under sarlon cloth and needs optimum temperature of 16 to 21 degrees celsius for germination.		
Chillies (Capsicum annuum)	30cm	1m	5 to 8 days after sowing		
Chinese cabbage (Brassica chinensis)	30cm	75cm	4 to 6 days after sowing		
Citrus (Citrofolia sinensis)					
For Meyer lemon and seedless lime	6m	7m			Grafted/Budded seedlings enhance early fruiting
Cocoa (Theobroma cacao)	2.5m	2.5m	2 weeks after sowing		
Corriander (Coriandrum sativum)	4 to 6 cm	22.5 to 30cm	6 to 10 days after sowing		

Appendix 1: Seed Spacing Table

Name of crop	Spacing within rows	Spacing between rows	Germination	Direct Seed or Transplant	Notes
Cowpea (Vigna uguiculata)	20cm (fertile soils) 10cm (poor soils)	65cm (fertile soils) 65cm (poor soils)	4 to 6 days after sowing		Crops should be irrigated after planting.
Curry Leaves (Murraya koenigli)	1m	1m	10 to 15 days after sowing.		
Cucumber (Cucumis sativas)	30cm	1m	5 to 7 days after sowing		
Dalo (Colocasia esculenta)	1m	1m			
Dalo-ni-Tana (Xanthosoma saggitifolium)	1m	1m			Planting depth of 30cm
Duruka (Saccharum edule)	0.3m	1.3m			
English Cabbage (Brassica oleracea var. capitata)	45 to 60cm	75cm	4 to 6 days after sowing.	Transplant 3 to 4 weeks after sowing.	Irrigate crop at 4 to 6 day intervals in dry weather.
Eggplant (Solanum melongena)	0.5m	1.5m	6 to 10 days after sowing.	Seedlings should be transplanted when they are at 3 leaf stage.	
French Bean (Phaseolus vulgaris)	15 to 20cm	50cm	3 to 6 days after sowing.		
Garlic (Allium sativum)	20cm	75cm			
Ginger (Zingiber officinale)	15 to 20cm	60 to 90cm			

Appendix 1: Seed Spacing Table

Name of crop	Spacing within rows	Spacing between rows	Germination	Direct Seed or Transplant	Notes
Kumala or Sweet Potato (Ipomoea batatas)	0.5m	0.8m			
Lettuce (Lactuca sativa)	30 to 40cm	75cm	5 to 8 days after sowing.	Raise seedlings in seed trays or seedbed and transplant at 3 to 4 leaf stage.	
Long Bean (Viga sesquipedalis)	30cm	1m	3 to 6 days after sowing.		Suitable for planting on stakes for better quality.
Maize (Zea mays. L)	30cm	75cm			
Mango (Mangifera indica)	9m	9m	Grafted seedlings enhance early flowering and fruited. Grafted plants can be procured from a reliable nursery a few days before transplanting.		
Mint (Mentha arvensis)	30cm	30cm	8 to 10 days after sowing.		
Mung (Vigna radiata)	20cm (fertile soils) 10 cm (poor soils)	45cm (fertile and poor soils)	4 to 6 days after sowing		Crops should be irrigated after planting.
Okra (Abelmoschus esculentus)	30cm	1m			
Onion (Allium cepa)	5 to 10 cm	50cm	7 to 14 days after sowing.		

Appendix 1: Seed Spacing Table

Name of crop	Spacing within rows	Spacing between rows	Germination	Direct Seed or Transplant	Notes
Parsely (Petrosellinum crispum)	30cm	45cm	10 to 12 weeks after sowing.		
Passionfruit (Passiflora edulis)	5m	3m	Seeds germinate 10 days after sowing.	Plants are ready for transplanting within 6 to 8 weeks.	Vines to be trained on the trellis.
Papaya (Carica papaya)	2m	3m	Seeds germinate in 10 to 12 days after sowing. In cooler seasons it takes 18 to 21 days.	Seedlings are grown in plastic pots for 6 to 7 weeks after sowing before transplanted in field.	
Pigeon Pea (Cajanus cajan)	20cm (fertile soils) 10cm (poor soil)	65cm (fertile and poor soil)	5 to 7 days after sowing.		Crops should be irrigated after planting.
Pineapple (Ananas comosus)	Slopy land: 0.3m between plants. Flat land: 0.3m between plants (double rows).	Slopy land: 1.2m between ridges, 0.6m between rows per ridge. Flat land: 1m between ridges, 0.4m between rows per ridge.			Best planting material are suckers weighing 250 to 300g or 25 to 30 cm high. Contour planting should be practiced on slope land to avoid soil erosion.
Plantain (Musa balbisiana)	2m	3m			Healthy and disease free suckers should be selected for planting.
Potato (Solanum tuberosum)	30cm	75cm	10 days after sowing.		

Appendix 1: Seed Spacing Table

Name of crop	Spacing within rows	Spacing between rows	Germination	Direct Seed or Transplant	Notes
Pumpkin (Cucurbita maxima)	1.8m		6 to 12 days after sowing		
Radish (Raphanus sativus)	5cm	50cm			Seeds can be broadcast and then thinned out to 5cm apart 2 weeks after germination.
Rockmelon (Cucumis melon)	1m	2m	6 to 10 days after sowing.		
Sorghum (Sorghum vulgare)	15cm	46cm			
Soursop (Annona muricata)	4.5m	4.5m		Seedlings are grown in nursery and transplanted in to the field at 8 to 10 leaf stage.	
Soybean (Glycine L. max)	20cm (fertile soils) 15cm (poor soils)	45cm (fertile and poor soils)	Plant seeds 2 to 4 cm deep. Germination 4 to 6 days after sowing.		Crops should be irrigated after planting.
Spring Onion (Allium cepa)	8cm	50cm	6 to 10 days after sowing.		
Tomato (Lycopersicon esculentum)	30 to 40cm for staked varieties	0.75m to 1.0m or 1.5m for indeterminate varieties grown in open fields.			
Watercress (Rorippa nasturium aquaticum	30cm	50cm	2 weeks after planting.		

Appendix 1: Seed Spacing Table

Name of crop	Spacing within rows	Spacing between rows	Germination	Direct Seed or Transplant	Notes
Watermelon (Cirtullus lanatus)	1m	3m	6 to 10 days after sowing.		
Winged Bean (Psophocarpus tetragonolobus)	2m	3m	10 to 12 days after sowing.		Suitable for planting on trellis.
Yam (Dioscorea alata)	Ridge: 60cm Mounds: 80cm	Ridge: 1m Mound: 1m			
Zucchini (Cucurbita pepo) Recommended Varieties: • Marrow • Black Jack	30cm	1m	5 to 10 days after sowing.		

Source: Ministry of Agriculture n.d

Appendix 2: Crop Calendar

Vegetable	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Asparagus	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Beetroot				✔	✔	✔	✔	✔				
Bele	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Broccoli				✔	✔	✔	✔					
Eng. Cabbage				✔	✔	✔	✔					
*Ch. Cabbage	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
*Capsicum	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Carrot			✔	✔	✔	✔	✔	✔	✔			
Cardamon	✔	✔	✔	✔	✔					✔	✔	✔
Cassava	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Cauliflower			✔	✔	✔	✔	✔	✔				
Celery				✔	✔	✔	✔	✔				
Chicory			✔	✔	✔	✔	✔	✔	✔			
**Chilli	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Choko	✔	✔							✔	✔	✔	✔
*Coriander (dhania)	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Cow Pea	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
*Cucumber	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Dalo	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Duruka	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
**Eggplant	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Fennel				✔	✔	✔	✔					
French Beans			✔	✔	✔	✔	✔	✔	✔	✔		
Garlic				✔	✔	✔	✔	✔				
Ginger									✔			
Gourd	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Green Peas (matar)				✔	✔	✔	✔	✔	✔			
Karamua	✔	✔	✔							✔	✔	✔
Kawai							✔	✔	✔			
Kohlrabi				✔	✔	✔	✔	✔	✔			
Kumara	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Leeks				✔	✔	✔	✔					
Lettuce	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
**Long Bean	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Mung Bean			✔	✔	✔	✔	✔	✔	✔	✔		
Okra	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Onion				✔	✔	✔	✔	✔	✔			
Parsley				✔	✔	✔	✔	✔	✔			
Peanuts		✔	✔	✔	✔	✔	✔	✔	✔	✔		
Pigeon Pea		✔	✔	✔	✔	✔	✔	✔	✔	✔		
Potatoes				✔	✔	✔						
Pumpkin	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
Radish	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

Appendix 2: Crop Calendar

Rockmelon				✔	✔	✔	✔	✔				
Soybean	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Spring Onion				✔	✔	✔						
Squash		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
Sweet Corn	✔	✔	✔	✔								✔
Tabua	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
*Tomatoes	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Turnips					✔	✔	✔					
Urd		✔	✔	✔	✔	✔	✔	✔	✔	✔		
*Watermelon	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Watercress	✔	✔	✔	✔						✔	✔	✔
*Winged Bean	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Yam						✔	✔	✔	✔			
*Zucchini	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

Tree Crop	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Avocado	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Banana	✔	✔	✔							✔	✔	✔
Breadfruit	✔	✔	✔								✔	✔
Citrus	✔	✔	✔							✔	✔	✔
Cocoa	✔	✔	✔	✔						✔	✔	✔
Coconut	✔	✔	✔	✔						✔	✔	✔
Coffee								✔	✔	✔	✔	✔
Curry Leaves	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Noni (Kura)	✔	✔	✔							✔	✔	✔
Macadamia Nut	✔	✔	✔	✔						✔	✔	✔
Mango	✔	✔	✔								✔	✔
Passionfruit				✔	✔	✔	✔	✔	✔			
**Papaya	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Pineapple				✔	✔	✔	✔					
Plantain	✔	✔	✔							✔	✔	✔
Saijan	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
**Soursop	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
*Sugarcane	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Vanilla Bean	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Yaqona	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

*= grows best in cool months

**=grows best in wet months

TEI TEI TAVEUNI
Sustainable Agriculture

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In 2013 the Biological Farmers of Australia re-launched as Australian Organic. All resources referenced in this handbook as "Organic School Gardens" are no longer available but have been replaced by new resources from Australian Organic Schools at www.organicschools.com.au

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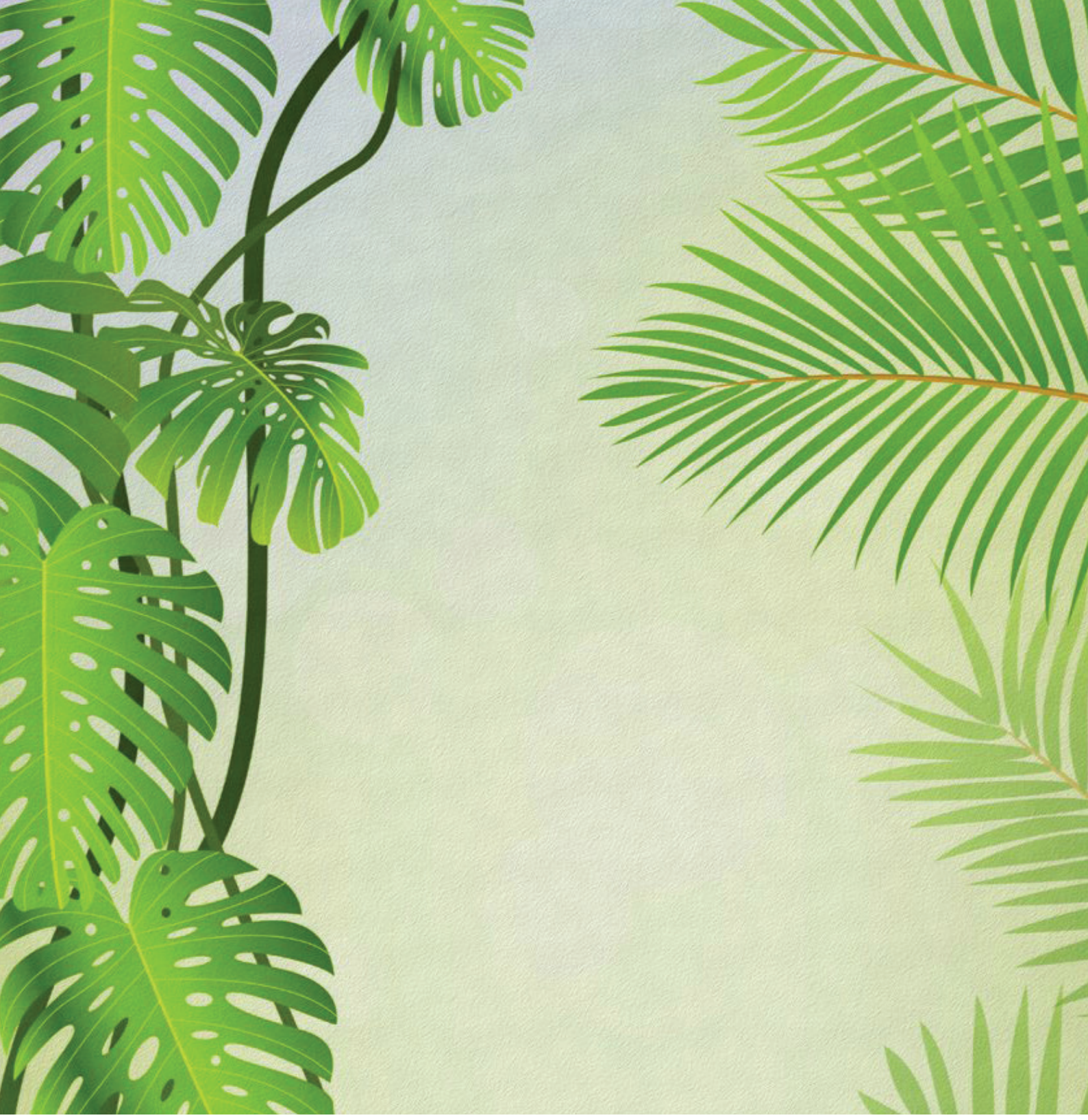

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