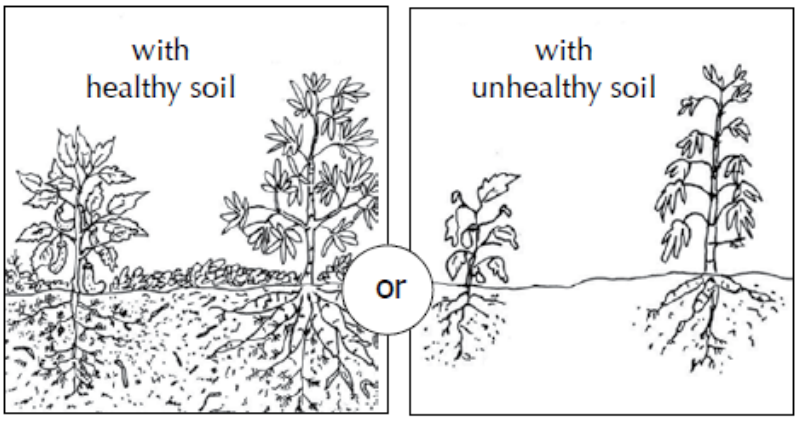
Healthy Soil

1.1 About Soil

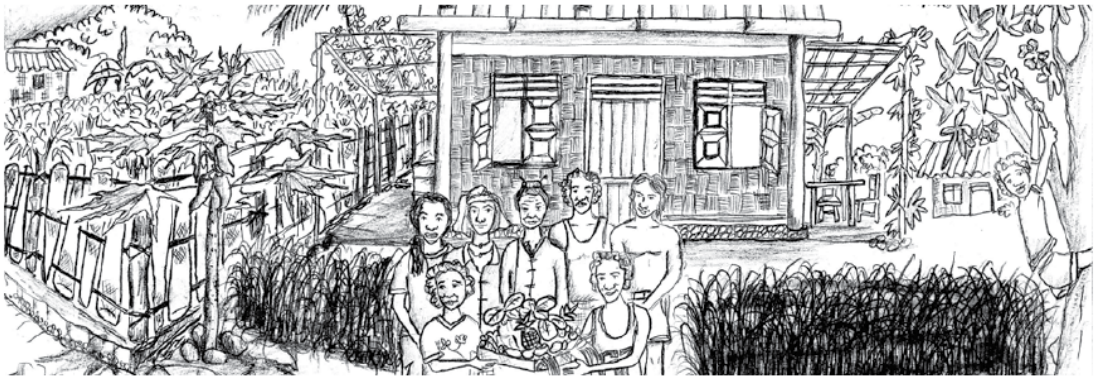
Healthy living soil is the foundation of any farming activity. Soil is the most important factor in producing healthy and productive vegetables and fruits. Soil must contain all the nutrients that are important for plant growth. The soil must be protected from erosion to keep a good top soil, and protected from the sun and wind to conserve its moisture. Creatures / biota in the soil must be protected because they are essential for creating healthy, living soil.



Good quality soil is very important in all gardens, small and large. The whole family, especially women who do most of the home gardening to supply nutrition for the family, should learn and understand about soil quality and techniques for improving soil quality. Most of these techniques are simple, do not require heavy work, and use local, inexpensive materials.

Better quality soil will give better quality produce, with better nutrient supply and better taste. **Healthy soil directly improves family health!**

Better health reduces the chances of becoming sick, increases thought and concentration, gives strength, energy and a longer life. Good quality vegetables make people feel full when they eat them, and keep them full for longer.



1.2 What is Healthy Living Soil?

- Healthy soil contains humus. Humus is partly broken down organic matter: compost, mulch, manure, plant roots and plant material. Humus provides food for soil biota, which then become food for plants. Humus also stores plant nutrients, helps to bind soil particles together, improves soil structure, and soaks and stores water in the soil

- Healthy soil means that the soil is alive! It contains millions of soil biota which turn organic matter and nutrients into plant food. Soil biota includes bacteria, microorganisms, ants, worms, and many other very small organisms

- It contains a balanced combination of clay and sand particles. The clay holds the minerals and the sand allows drainage / water channels

- It is composed of 50% clay, sand, humus and organic materials and 50% air pockets. The texture should be loose when pressed, not crumbly like sand or sticky like clay

Air pockets are very important because:

- They provide space for the soil to hold a lot of water
- The air provides the oxygen that is needed by plant roots to process nutrients
- They allow easy, fast and deep root growth, so that the plants can soak up more water and nutrients, and the plants will become bigger and healthier

So, DON'T compact your soil! Avoid walking on your garden beds.

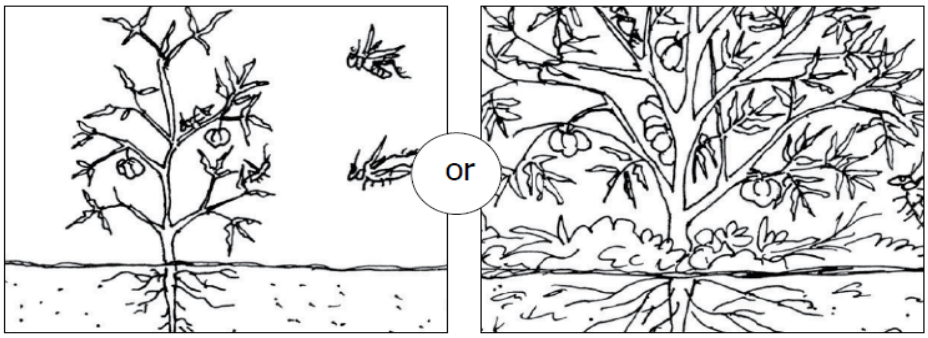
1.3 Benefits of Healthy Living Soil

- Plants are more drought resistant because the soil can store much more water and plants can send their roots much deeper into the soil to receive water and nutrients

- Plants are more disease and pest resistant because they are healthier. An unhealthy person will become sick more often, the same is true for plants

- The plants produced will contain more vitamins and minerals, which if consumed will improve the health of the whole family, especially children

- Reduces evaporation from the soil, so that the soil will hold and store much more water. This will reduce the need to water plants



- The soil becomes easier to dig and work with because it has a loose texture. This is very important because it will save a lot of time and human energy

- It can save a lot of money if most of the land management is organic. Soil needs very little expense if good techniques are used. Remember to collect and reuse all plant and animal wastes

- Water will not collect in the soil during the wet season. Even though healthy soil can store more water, the good soil structure will also allow for drainage if there is too much heavy rain. Too much water can slow down plant growth, and even kill plants if their roots become drowned in water. In areas where the soil contains too much clay, stagnant water can become a big problem. Making raised garden plots will also greatly reduce this problem.

To improve soil, do:

- **Use organic compost, mulch and liquid fertilizers regularly**. This will provide a lot of nutrients, increase the amount soil biota, improve soil structure and they are inexpensive to make

- **Use mulch** to protect the soil from direct sunlight, conserve water and increase the amount of humus in the soil

- **Recycle nutrients**, such as left over plant and animal material, to return nutrients into the soil

- **Use legumes**. There are many different types of legumes that can be planted, from annual to perennial. Legume plants provide nitrogen for the soil, can be used for mulch, animal feed, food for people, serve as windbreaks, help to prevent erosion, and more.

- **Rotate crop production**. Different types of plants need different types of nutrients. Crop rotation is useful for balancing nutrients in the soil. Crop integration will also help.

To protect soil quality, don't:

- Compact the soil. Soil compaction reduces root growth, water storage and water drainage, as well as damages soil structure. It also means that a lot of energy is needed to dig the hard soil

- Leave the soil open, exposed to the sun. This will make the soil dry and more difficult to dig

- Use anything that will kill soil biota. Soil biota are your friends and helpers for building healthy and balanced soil. Using pesticides and herbicides will kill them

- Waste water. Water is a precious resource and should be stored in the ground. Water that is continually flowing can create erosion. Good water usage will reduce the risk of drought. The amount soil biota will also reduce if the soil is very dry, these biota need water too

BEWARE!

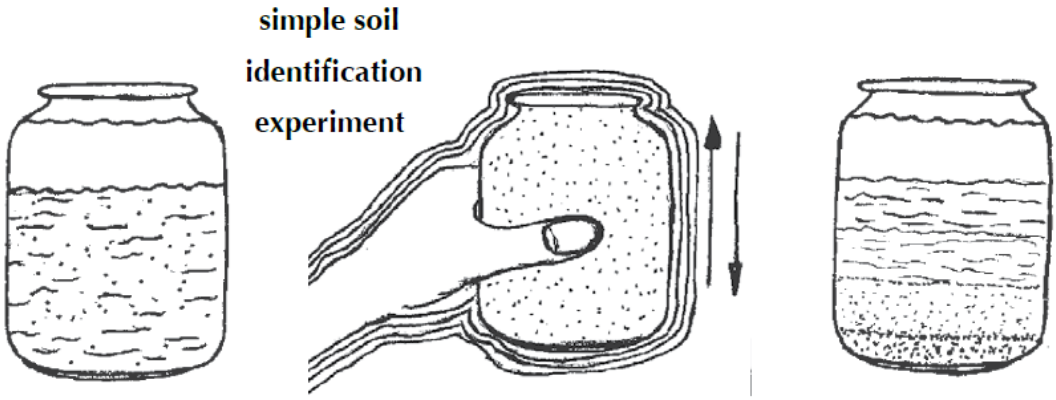
Stop burning…

- Burning destroys valuable materials, that can be made into compost, mulch, and nutrients for the soil
- Burning reduces the amount of soil biota
- Burning dries out the soil and reduces water volume
- Burning creates erosion and pollution

1.4 Different Types of Soil

By doing a simple experiment, you can identify the types of soil that you have. This knowledge will help you in choosing the best method for improving your soil.

1. First, take three or more soil samples and place them in clear jars or bottles
2. Fill the container 2/3 with soil, then add water until full
3. Close the containers and shake them evenly
4. Then, let the soil settle and you can see what type of soil you have



Clay will always be at the top, with sand underneath, and very course sand at the bottom. This is a very simple experiment, so even kids can do it.

Clay soil holds nutrients well, but does not contain much air, so when heavy rains come the water can become stuck in the soil.

While sandy soil will soak up water quickly and contains a lot of air, it easily releases nutrients and can quickly become dry.

1.5 Improving Soil Quality

For All Types of Soil

For all types of soil the best solution is to regularly use mulch, dry compost and liquid fertilizer compost. This will:

- Improve soil structure and the amount of air in the soil
- Increase the number of soil biota
- Increase the amount of available nutrients
- Increase water storage capacity

For Clay Soils

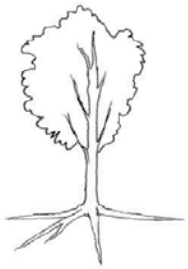
The following steps are useful for improving clay soils:

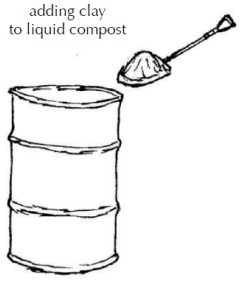
- Reduce compaction because once the soil becomes compacted it sticks together. This makes root growth difficult, as well as making it difficult for people to dig
- Add sand to improve soil structure
- Use green manure crops and crop rotation to help improve soil structure over time. See the section on green manures in this module for more information on techniques.
- Planting trees will also help to improve the structure of clay soils. Trees provide mulch material and their roots will help to break up the clay soil. Trees can also be combined with other types of plants

For Sandy Soils

The following steps are useful for improving sandy soils:

- Add 3 shovels of clay into liquid fertilizer. The clay will bind nutrients, and when this mixture is used, the clay will stay in the sandy soil and hold nutrients within the soil
- Add 1/2 a shovel of clay to a large bucket of water, spray this mixture over the sandy soil. Using the liquid fertilizer technique above is much better, but this method still adds valuable clay particles to the sandy soil
- Use green manure crops to add humus to the soil, this will improve the sandy soils structure
- Plant trees. In very dry sandy areas, it is better to plant trees than to plant annual vegetable crops





1.5 Soil pH

The soils pH level is a measure of the acidity or alkalinity of the soil. For example, we can compare a soil's pH level with your stomach. If your stomach is too acidic it will not work well. This will then cause problems for you stomach and the rest of your body.

The same is true with soil. In good conditions, the soil's pH level will be neutral, this will greatly improve the productivity of everything that is being grown in that soil.

- If the soil is acidic, nutrients will easy leach out of the soil. Productivity will reduce and if the soil is very acidic, only a few types of plants can be grown.

- If the soil is alkaline, there are many nutrients in the soil, but they are bound and not easily available for plants to use. Productivity will reduce and only a few types of plant can be grown.

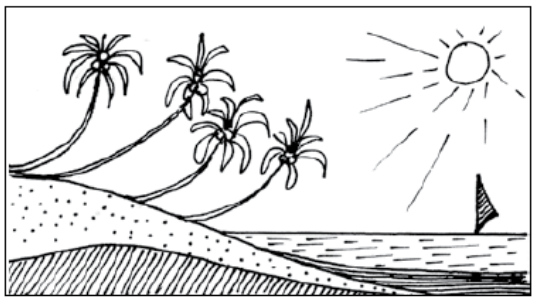
Identification of Soil pH

Acid soils:
Are generally found in wetland, higher rain fall, and in the

areas with mountains

Taste sour, like vinegar

Alkaline soils:
Are generally found in dry land, and areas with lots of limestone



coastal areas,

Taste sweet

Balancing the soil pH

This can be done by regularly using mulch, compost, liquid fertilizer and other organic materials.

Increasing the humus content in the soil will make the soil pH neutral, allowing more nutrients to stay in the soil and be available for plant use.

1.6 Nutrient Cycles

All plants need nutrients to grow. Different nutrients are needed during the growing process and are stored in the plant's leaves, fruit, stems, trunk and roots as the plant grows.

These nutrients can become lost from the system (the soil), and need to constantly be replaced. A lot of nutrients can be recycled back into the soil through humans, animals, compost and mulch. Some nutrients that do become lost can be replaced by using some soil improvement techniques, such as:

- Planting green manure or legume crops
- Implement crop rotation
- Using compost and liquid fertilizer
- Recycling plant and animal materials back into the soil
- Applying mulch regularly

DON'T burn!
Burning land is a very serious problem, because it reduces soil fertility and removes valuable nutrients from the soil. Each time the land, leaves, grass and other plant materials are burned, nutrients which are stored in plants become lost. After burning, the ash does provide a small amount of potassium and minerals, but the nutrients that have been removed are much more than what is contained in this ash.

Remember! The more nutrients that are recycled back into the system, the less outside inputs are needed!

1.7 Organic Soil Improvement Strategies

If land is under cultivation, then nutrients are being used and must be replaced. To improve the nutrient condition, it is not enough to just replace the missing nutrients, but also with time there should be soil texture improvement so that the soil can store more nutrients and water.

Natural organic fertilizers can be used regularly and can be applied before, during and after planting. The nutrients that are not used will be stored in the soil to be used later. Both for short term and long term, organic fertilizers will help to improve the soil's condition.

Notice!
It is always better to compost manures before using them as fertilizers. If the manure is fresh, especially chicken manure, it can burn plants, especially small plants and young vegetables. The nutrients are also not yet available for the plant to use. This is the same as humans trying to eat rice, corn or meat before it is cooked!

Composting organic materials will concentrate the nutrients, making them easily available for the plant to use. There are many different composting methods, some of which will be explained later on. Over time, by experimenting, you will find out what works best for your land, climate and needs. This could be new techniques, traditional techniques, or a combination of both.

Some sources of new nutrients:

- Seaweed is very beneficial and contains many nutrients to help to replace missing nutrients
- Manure is good because it has lots of nutrients. Chicken and duck manure are concentrated manures (should be composted first). Cow and horse manure are good too and can be used without composting.
- Animal bones, carcasses and innards are a high concentrated source of nutrients and can provide a lot of micro nutrients. These materials must be composted first, or buried under new fruit trees
- Leaves and grass clippings can be used as mulch to protect and enrich the soil
- Legumes to add nitrogen to the soil
- Wood ash from kitchen cooking fires can supply potassium
- The soil from the bottom of a well managed fish pond contains lots of nutrients
- Tree leaves provide a variety of nutrients, because trees soak up minerals from deep in the soil

Mulch: Organic weed control and soil improvement

Healthy soil, Healthy garden, Healthy YOU!

What is Mulch?

In natural forests, leaves, rotting materials, animal manure and even dead animals, all make up mulch which covers the ground, like a skin. This skin is continuously being added to and also is continuously decomposing. This 'skin' or mulch provides nutrients and humus to the soil as it decomposes, which are then used by plants and trees as food. Besides that, it also continuously provides food for soil biota.

We can copy nature by using mulch to make a skin for the soil. This skin is an important natural protection against drying from the sun and erosion because of rain. This skin also provides food for the soil biota in your garden.

Benefits of Using Mulch

- Keeps soil temperatures stable, which means that the soil temperature is cooler in hot temperatures and is warmer in cool temperatures. This moderate temperature is good for plant growth.
- Reduces weeds. Weeds can only grow if there is light, so without light the seeds of weed plants will die. A layer of mulch will prevent sunlight from entering
- Provides organic matter, and valuable nutrients for the soil and improves structure
- Increases the soil's water storage capacity
- Helps to neutralize the soil's pH levels
- The soil will become easier to dig and manage
- Reduces erosion
- And of course, all of the points above will help to increase production!

What to use

You can use a variety of organic materials for mulch:

- Leaves (tree and plant)
- Grass clippings
- Weeds (no seeds)
- Compost
- Animal manure (cow or horse)
- Old paper

BEWARE!
Make sure there is no plastic rubbish, used batteries, glass bottles, or any other non-organic materials in your mulch. This will contaminate your garden and your vegetables!

How to Use Mulch

Before mulching:
Use rocks, thick branches etc. to make garden borders. This will help to hold the mulch, give room for soil to build up and prevent erosion

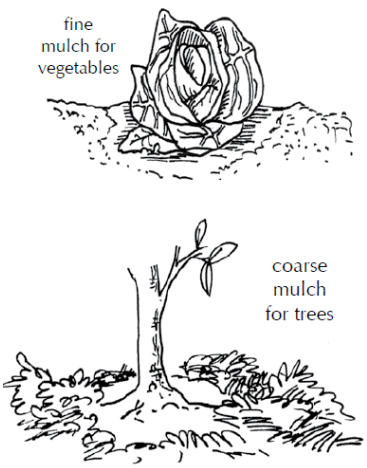
If you put compost under mulch it will maximize the benefit of the compost

When / where to use mulch:

- For seeds and seedlings, apply mulch to the soil before planting
- For trees, underneath the outside leaves is the most important area to mulch (this is where the tree roots feed)- continuous mulching will improve tree health and productivity
- For vegetables, plants and trees, DO NOT let mulch touch the stem or trunk- this is very important in the wet season to prevent rot and mould

How much mulch to use:

- Apply mulch regularly and as thick as possible. 5-10 cm is generally the ideal thickness, but for fruit trees up to 20 cm thick is better
- Apply mulch to the whole plot, not just around the vegetables and plants



What kind of mulch to use:

- Use fine textured mulch for vegetable plots, and a coarser textured mulch for mature plants and trees
- If you are using weeds as mulch, separate the weed seeds first and give them to animals or use in liquid fertilizer. This will reduce future weed growth
- Legumes, grasses and other trees and plants can be grown to produce mulch
- Plant plants that can be used for mulch, like legumes (See legume section).

Remember to always think of the most multifunctional plants, for example, plants that can produce mulch material but also provide food for humans or animal fodder, function as a windbreak, fence, or help to reduce erosion, improve soil, produce fire wood, building materials, and so on

Legumes and Green manure: Organic soil improvement and weed control

Healthy soil, Healthy garden, Healthy YOU!

Legumes are a type of plant that gives nitrogen to the soil.

Nitrogen is one of the most essential elements of healthy stem, cells and leaf growth.

There are many different types of legumes in Tonga, some are annuals (complete lifecycle in 1 year) and others are perennials (complete life cycle more than 2 years). These plants are a very important part of any system, and can be used in many different ways.

How do they work?
Legume plants bind nitrogen from the air in soil to nodules, which are attached to the plant roots. These nodules are very small, about the size of a match head or smaller. The nodules provide nitrogen for the legume plant. Excess nitrogen which the plant cannot use is let out into the soil, and is available for other plants to use.

Types of Legume Plants

Annual legumes: All beans, all peas, clovers.
Perennial legumes: All types of acacias, leuceana, casurina, sesbania, moringa, gliricidia, tamarind.

Legumes provide many benefits. Some legume products include: food, animal fodder, mulch and compost material, timber, fire wood, and medicines. While legumes can also function as: windbreaks, living fences, trees for shade, and trellises. Legumes can be planted together with other plants / crops.

Legumes as green manure

Different crops use different amounts of nutrients to grow. If you grow the same type of crop over and over again on the same plot of land, some nutrients will become depleted and pests and diseases will spread. The soil and its nutrients will then become imbalanced. It is good to rotate plants from plot to plot each season. Crop rotation will also help to reduce pest and disease problems.

It is important to let one part of the garden have a rest during a crop rotation cycle so nothing is grown in that bed for a period of time. This allows the soil to 'recover' and to be improved, which prevents the spread of pests and disease.

We can improve the soil by planting green manure crops. This green manure crop should be planted thickly and should cover the whole land area. Green manure crops, such as mucuna bean, are perfect for this job.

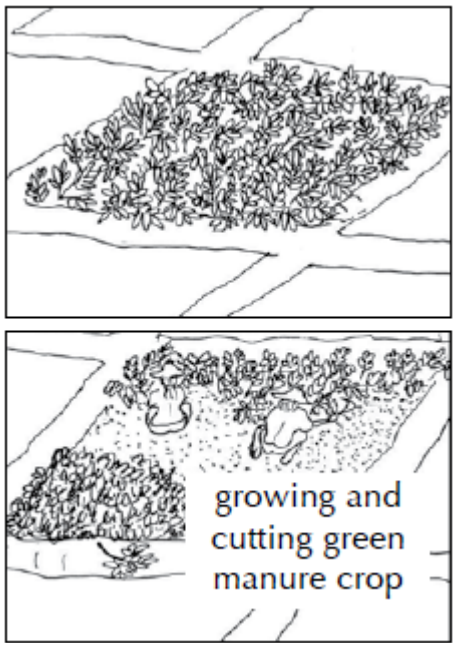
Green manure crops are not really grown as food for humans, but only for the soil's benefit.

How to use Green Manure

A green manure crop is one that can be grown over a season when the bed is not in use and it is tilled into the soil to improve the fertility. A green manure crop also prevents the soil from eroding and compaction when not in use.

Mucuna Bean *Mucuna pruriens* var. *utilis*

1. Before planting, clean up the garden area and remove all crop debris. Rake the soil to remove clumps, and sow the seeds when rain is expected.
2. Now scatter the seeds over the surface of the soil. Ensure that the seeds make firm contact with the soil by gently tapping the upper surface with the back of spade.
3. The plants will germinate and grow for about 8-10 weeks.
4. Cut when young - before they become woody and before flowering or just as the first flowers appear. At this stage the nitrogen content is relatively high.
5. After cutting, leave it on the soil as mulch and allow the green manure to decompose into the soil for up to 4 weeks.



This technique does take time and labour, but there are many benefits, such as:

- Nitrogen from legume roots is left in the soil to be used by the next crop that is planted
- Mulch and compost material
- An increase in humus and soil biota

These benefits all help improve soil structure and will increase production of the next crop. So, the increased productivity of the next crop pays back the time and work that you have spent on the green manure crop.