



MODULE No 4.

Healthy Soil





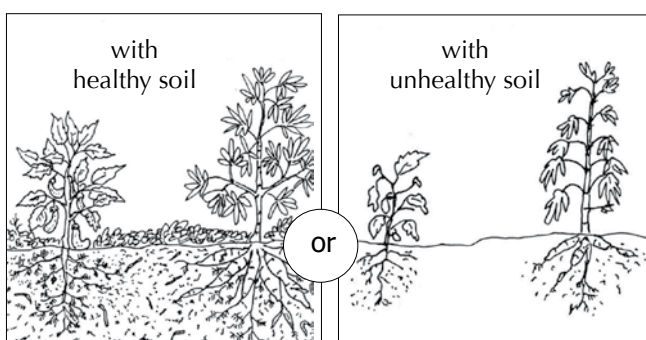
Notes...

About Soil

Healthy living soil is the foundation of any farming activity. Soil is the most important factor in producing healthy and productive vegetables, fruits and grains.

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. **This is a good way to directly improve 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.



In some places, the earth's top soil and nutrients are slowly disappearing because of regular burning and deforestation of farming land and forests. This causes erosion and landslides. These practices must be stopped! Farmers must protect their soil. The soil should be viewed as a very valuable asset.

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
- The soil can function as a 'nutrient bank', it stores nutrients that are ready for plant use, and those nutrients are then not lost from the soil
- The soil will have a balanced pH level. This means that the soil is not too acidic and not too alkaline



The Importance of Worms in the Soil

Worms are your best friends in the soil!

These worms are earthworms. This is a different type of worm than the ones that make animals and people sick. Many worms in your soil show that the soil is healthy. Earthworms eat the humus in the soil, and then change that humus into nutrients, this is very good for the soil.

Earthworms will continuously:

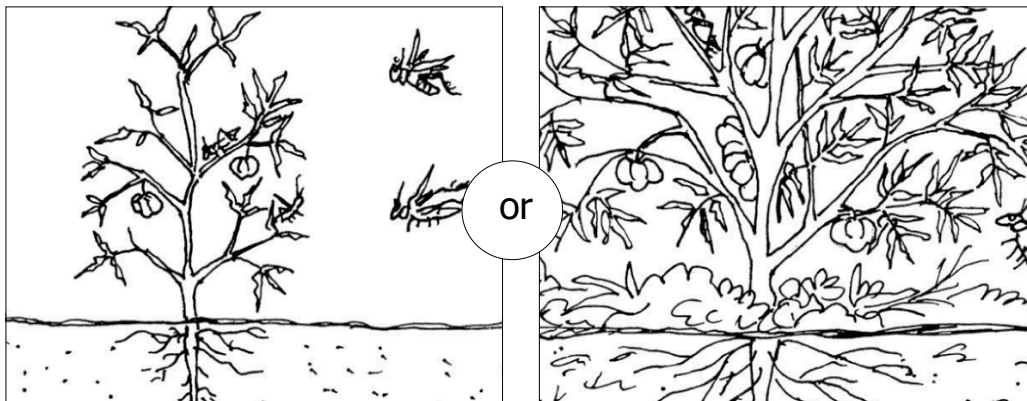
- Change humus into nutrients that plants can use
- Dig the soil so that air can enter the soil
- Improve soil structure and water drainage
- Bring nutrients up from deep in the soil to supply food for plant roots



All the worms need is mulch and compost! However, be careful with chemical pesticides, herbicides and some fertilizers, because they will kill the worms in the soil.

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

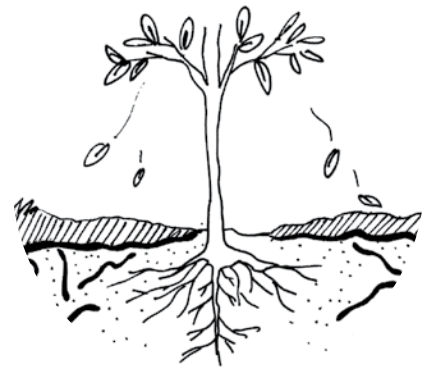


- You have millions of workers in the soil that manage nutrient availability, store those nutrients, and increase the amount of air in the soil. Worms are hard workers!
- The soil becomes easier to dig and work with because it has a loose texture. This is very important because it will save a lot of 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 compile and reuse all plant and animal wastes
- Water will not be stagnant 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 EM (Effective Microorganisms) 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 organic materials, 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 seasonal 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 erosion...

The first soil that is eroded is the topsoil. This is the most valuable layer of soil! The topsoil contains a lot of nutrients that could take years to replace. The soil will not be able to hold water, and plant roots will become exposed to the soil surface, the plants will then grow very slowly or even die.

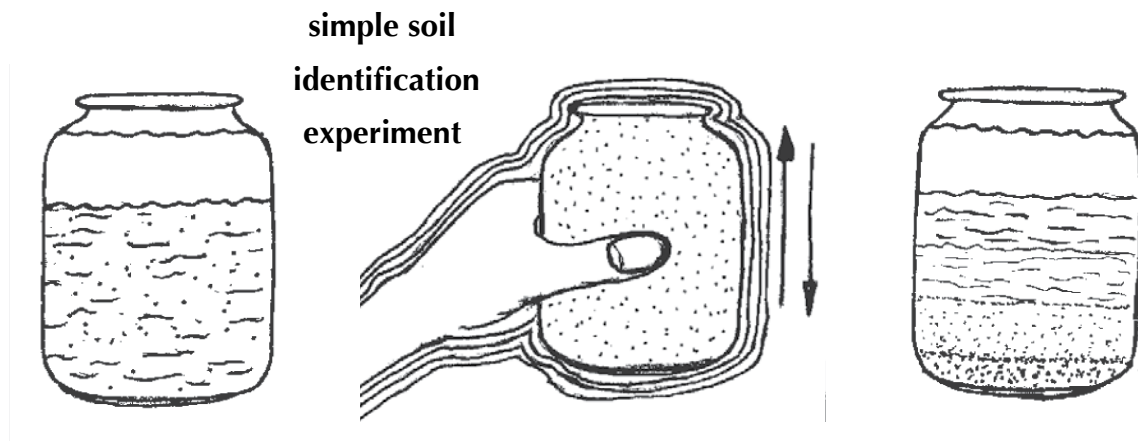
Stop burning...

- 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

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.

- First, take three or more soil samples and place them in clear jars or bottles
- Fill the container 2/3 with soil, then add water until full
- Close the containers and shake them evenly
- 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 coarse 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.

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 compost. This will:

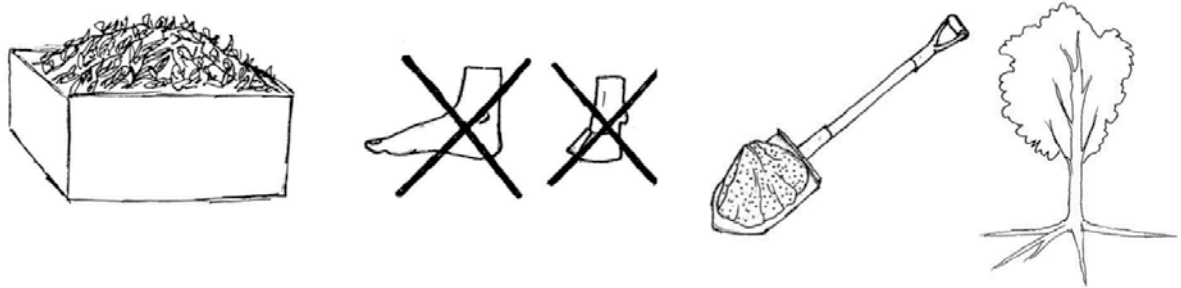


- Improve soil structure and the amount of air in the soil
- Increase the number of soil biota
- Increase the amount of available nutrients
- Increase water storage capacity

For Clay Soils

The following steps are useful for improving clay soils:

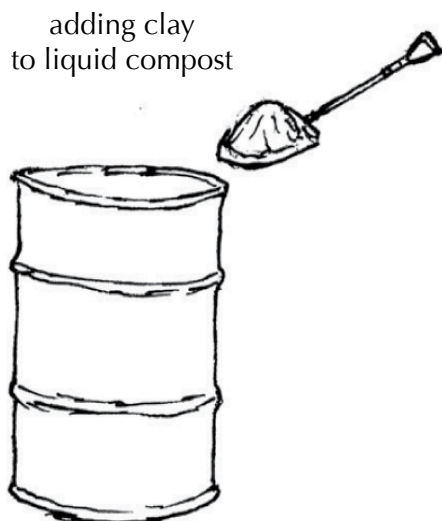
- Reduce compaction, because once the soil becomes compacted it sticks together. This makes root growth difficult, as well as making it difficult for people to dig
- Add sand to improve soil structure
- Use green manure crops and crop rotation to help improve soil structure over time. See the section on legumes 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
- Gypsum can help to improve the drainage and structure of soil. This technique will improve clay soil structure quickly, but is expensive. This technique will not work well if the soil's pH is too alkaline



For Sandy Soils

The following steps are useful for improving sandy soils:

- Add 3 shovels of clay into liquid compost. 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 compost 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 dry sandy areas, it is better to plant trees than to plant annual vegetable crops

Soil pH

The soil's 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 your 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.

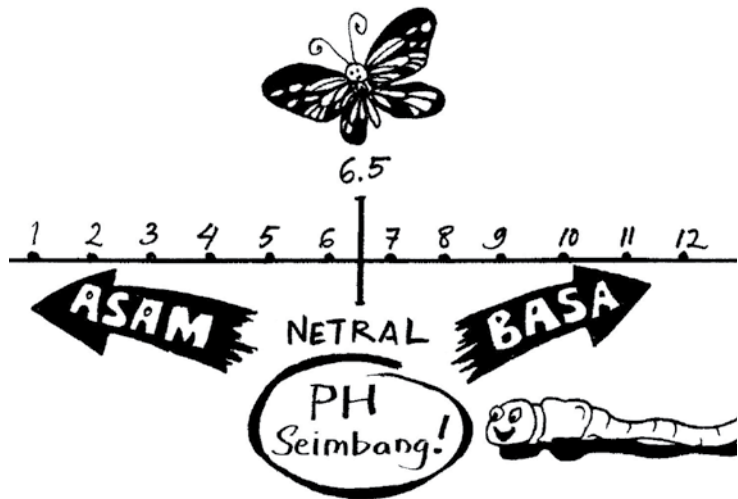
pH Chart

If the soil is acidic, nutrients will easily 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.

By adding enough mulch, compost and other organic materials, the soil will contain more humus which will then neutralize the soil's pH levels, as well as increasing the amount of nutrients in the soil.

Using chemical fertilizers when the soil is in acidic or alkaline condition will only be wasting money, because a lot of nutrients will be bound in the soil or leach out of the soil. Besides that, it will also create many more problems in the future.



Identification of Soil pH

Acid soils:

- Are generally found in wetland, areas with higher rain fall, and in the mountains
- Taste sour, like vinegar

Alkaline soils:

- Are generally found in dry land, coastal areas, and areas with lots of limestone
- Taste sweet

Testing Soil pH

Soil pH can be accurately identified using a pH tester. A pH tester shows a series of numbers, ranging from 1 to 12. Number 1 shows that the soil is most acidic, and number 12 shows that the soil is most alkaline. The ideal soil condition will have a pH of 6.5 or neutral; in this condition, the soil is neither acidic nor alkaline.

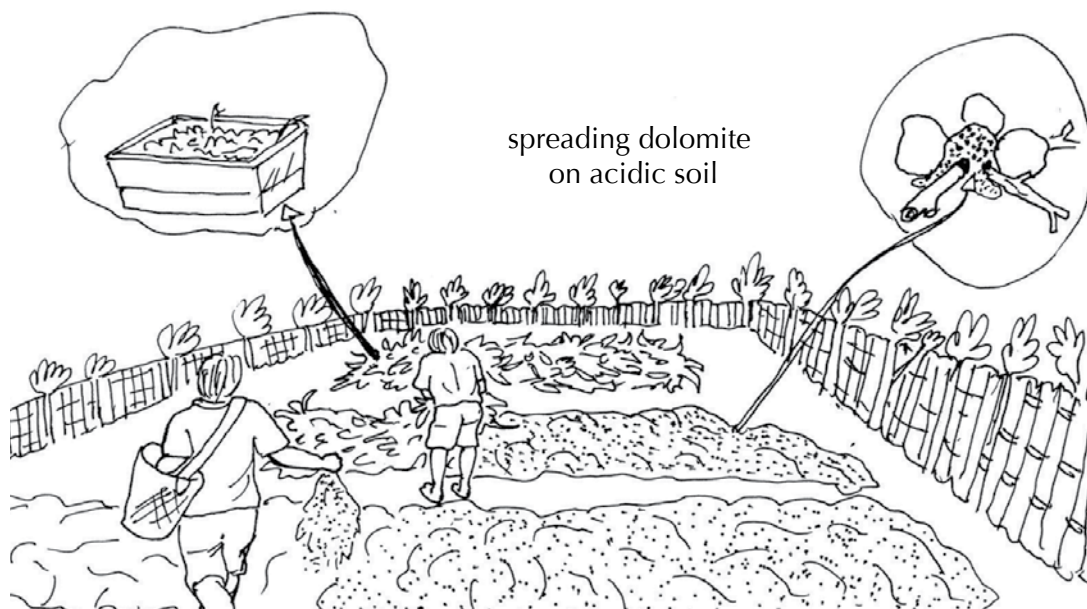
There are a few types of pH testers. Some agriculture workers and NGOs may have this type of tester. However, by identifying landforms (for example, swamps), rocks, and common tree types, you can identify the soil pH without needing this equipment.

Solutions for Balancing Soil pH

The best solution for acidic or alkaline soils is to increase the amount of humus in the soil. 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.

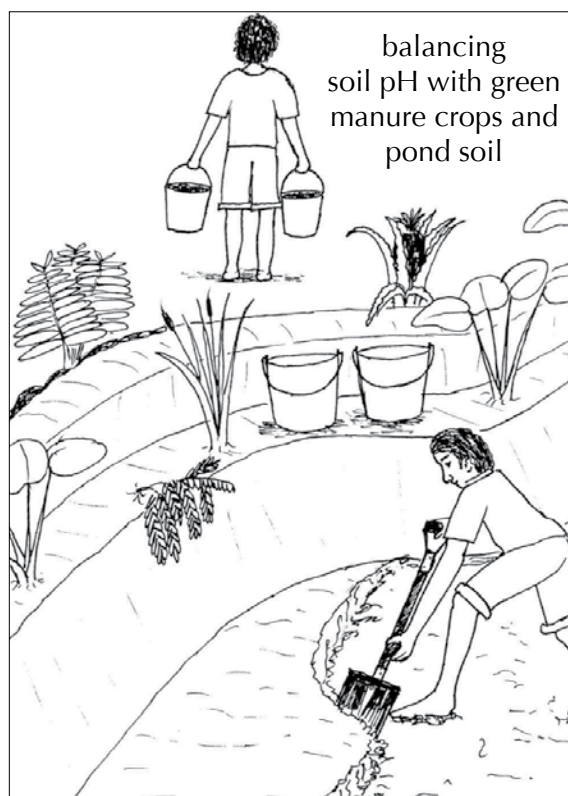
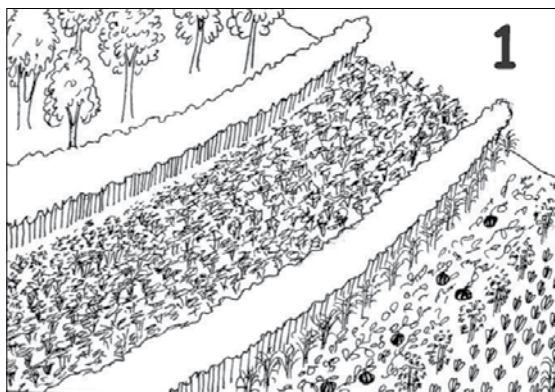
Other Solutions for Acidic Soils

- Ash from wood fires (there must be no plastic content in the ash) can be spread over soil that is acidic. Don't use more than 1 kg for every 30 square meters each year. Don't burn grass and plant materials to make the ash; grass and plant materials are also very important for balancing soil pH
- For acidic soil in small areas, crushed seashells will provide lime to help balance soil pH
- For larger areas, dolomite can be used. Lime can also be used, but dolomite is better because it contains magnesium, and is safer for plant roots. These materials are expensive, and should only be used after the soil pH has been tested



Amount (kg) of dolomite needed to raise soil pH levels to 6.5, per 30 square meters:

Soil pH	Sandy Soil	Loam Soil	Clay Soil
6.0	1 kg	1.5 kg	2 kg
5.5	2 kg	3 kg	4 kg
5.0	3 kg	4 kg	6.5 kg
4.5	3.5 kg	6.5 kg	9 kg
4.0	4 kg	8 kg	10.5 kg



Other Solutions for Alkaline Soils

- Use 6 kg of compost per square meter to lower soil pH by 1 point (for example, 8.5 pH to 7.5 pH). This does not need to be applied all at one time
- Use 2 kg of manure per square meter to lower soil pH by 1 point
- Iron sulfate (FeSO_4) or other materials that contain sulfur can be used, but they are expensive. It is best to test the soil pH before using these materials

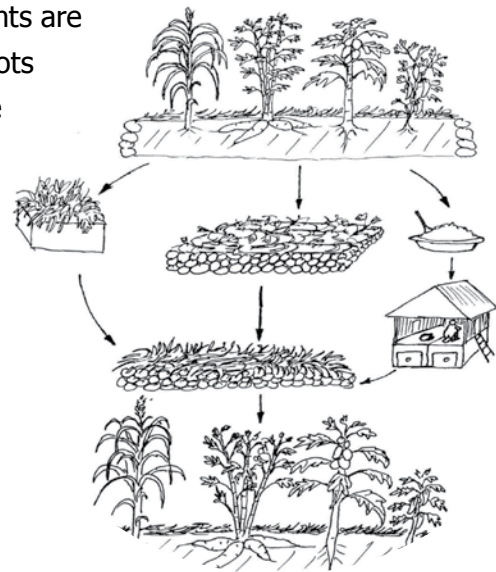
Amount (kg) of iron sulfate, or other materials that contain sulfur, needed to lower soil pH by one point per square meter:

Material	Sandy / Loam Soil	Clay Soil
Iron sulfate	2 kg	8 kg
Material that contains sulfur	300 g (1/3 kg)	1 kg

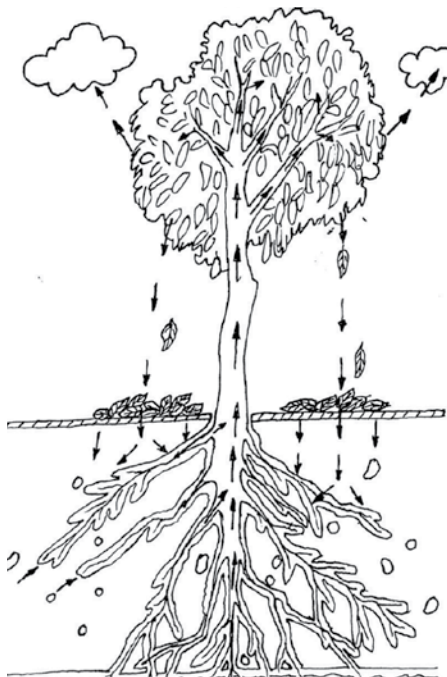
Nutrient Cycles

All plants need nutrients to grow. Some of these nutrients are stored in the plant's leaves, fruit, stems, trunk and roots as the plant grows. Trees and deep rooted plants are able to soak up minerals from deep down in the soil through their roots, but these minerals are sometimes not available in the soil. Trees will also soak up water from deep in the soil, like a big water pump.

Some nutrients are used for the process of the plant's growth, others are used by the plant to form fruits or seeds, or are stored within these fruits or seeds. This is the same for vegetables and other smaller plants.



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 seasonal and perennial legume trees
- Implement crop rotation and allowing the land lie fallow (not planting for a period of time)
- Using compost or liquid compost
- Using seaweed, manure, animal bones and carcasses, and other organic materials
- Applying mulch regularly
- Implementing a variety of systems, for example planting many trees, which besides functioning as a wind break will also attract birds and other wild animals, which will then naturally give manure to the land. You can also keep pigeons, their manure is easier to collect. Bird manure contains high concentrations of nutrients and is a very beneficial high quality natural fertilizer when dry

In tropical climates a lot of nutrients are stored in trees, and only a small amount are stored in the soil. Therefore, cutting down forest means removing nutrients from this system. The soil will only last for one or two years, after which it becomes poor in nutrients and not very good for growing crops.

In Indonesia, the amount of forest is continually reducing, mainly caused by clear cutting and burning. Forests are being cut down primarily for commercial purposes, and forest burning happens almost every dry season. Besides this, forests are being used for many other needs, such as agricultural land, new residential settlements, farm land, animal grazing land, and a source of fire wood.

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. This occurs both on agricultural land as well as animal grazing land. 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. To get potassium, using ash just from kitchen cooking fires is enough.

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

Nutrient Deficiencies

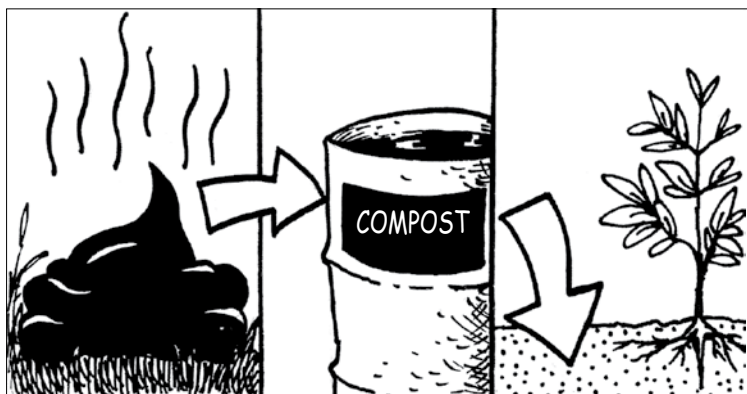
In some places, a lot of soil is nutrient deficient. Some areas are very deficient, and others only lack one or two types of nutrients. Just like people, plants also need a range of vitamins and minerals to grow well. If nutrients are not available, plants will be smaller, and more susceptible to drought, pests and disease. Plants show specific signs when they are missing a nutrients, for example:

Missing nutrient	Plant Characteristics
Nitrogen	<ul style="list-style-type: none">• All leaves and new growths are yellow and pale• Early maturing, fruit and flower size is smaller
Potassium	<ul style="list-style-type: none">• Leaves are small and darker in color• Older leaves are blue / purple with yellow edges• Plant growth is slow
Phosphorus	<ul style="list-style-type: none">• Fruit size is small and poorly colored• Burnt leaf edges and yellowing of older leaves
Magnesium	<ul style="list-style-type: none">• Yellowing leaf edges, yellow spots but the leaf veins stay green• Often there are brown spots on the leaves• Old leaves drop off faster
Sulphur	<ul style="list-style-type: none">• All leaves have a dull color
Calcium	<ul style="list-style-type: none">• New leaves and shoots grow and develop poorly• Unusual fruit growth
Micro nutrients	<ul style="list-style-type: none">• Symptoms vary

If plants are sick or not producing well, it is not enough to just add a basic fertilizer. In fact, this approach can even cause more problems. It is better to first try and identify the problem, and then to figure out what the exact deficiency is. In this way, problem solving will be more effective and inexpensive.

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.

It is always better to compost manures before using them as fertilizers. If the manure is fresh, especially bird 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.

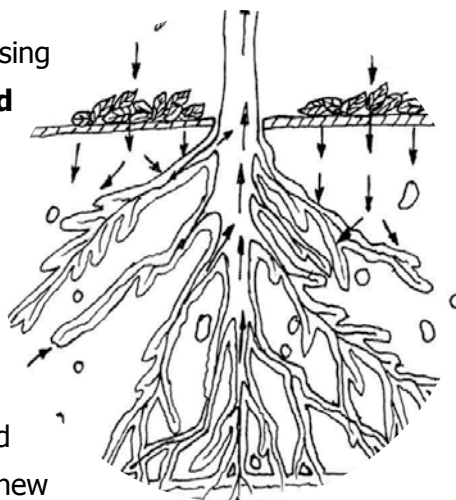
There are many different composting methods, some of which will be explained later on. Over time, by experimenting, you will find out what works best for your land, climate and needs. This could be new techniques, traditional techniques, or a combination of both.

Natural Nutrient Sources

Almost all nutrient deficiencies can be handled by using compost, liquid compost, and mulch. **This is the best and most balanced method.**

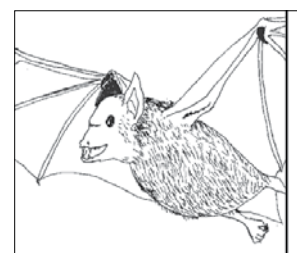
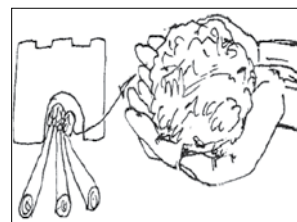
Sometimes, a specific nutrient or nutrients are not available in the soil or plants, because of erosion, deforestation or poor soil.

This nutrient needs to be reintroduced into the soil, and for best results, added again once or twice a year. This new nutrient should be recycled within the system as much as possible to reduce the need for more outside inputs.



Some sources of new nutrients:

- Seaweed contains many nutrients. Many nutrients are washed out to sea with water because of land erosion or landslides. Seaweed is very beneficial and contains many nutrients to help to replace missing nutrients
- Bat, pigeon, chicken and duck manure are concentrated manures. Bat and pigeon manure are the best, but all manure is good because it comes from organic sources
- 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
- Mulch or manure from other areas
- 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
- Mulch from water plants. Water plants are very good at taking and storing excess nutrients from water. Pond water also contains nutrients
- Tree leaves provide a variety of nutrients, because trees soak up minerals from deep in the soil
- Micro-nutrient fertilizers (best if made from seaweed or rock dust) can be used to replace nutrients. This is not a normal fertilizer, such as urea fertilizer which does not replace certain lost nutrients



EM (Effective Microorganisms)

All organic composts provide microorganisms, bacteria, soil biota and fungus. All these components or elements are important for improving soil structure and quality. EM is a liquid that can be added to compost, liquid compost or directly into the soil. EM contains microorganisms which the soil needs.

EM is used to:

- Speed up the composting process
- Improve the quality of natural fertilizers
- Make nutrients more available to the plants
- Improve all aspects of soil quality

EM can be bought from agricultural stores. The bottle of EM that you buy can then be used to make more EM, because bacteria and microorganisms easily multiply. Only one bottle of EM is needed to have a continuous supply.

How to Multiply EM

Materials: Used water / aqua bottles, water, palm sugar, 1 bottle of EM

Method:

1. Fill the empty bottles with water. Add a slice of palm sugar and shake well, until the sugar dissolves. Add one full capful of EM
2. Gently mix and stir in
2. Leave this mixture in a dark place for 2 weeks. Avoid direct sunlight

Microorganisms and bacteria will multiply quickly because they will feed on the sugar. This new EM is now ready to be used, and can be used to make new bottles of EM.



How to Use EM

Liquid compost: Add about 1 bottle of EM to one drum of liquid compost.

Compost: Add about 1 bottle of EM to a small amount of compost or 2 bottles of EM to larger amounts of compost.

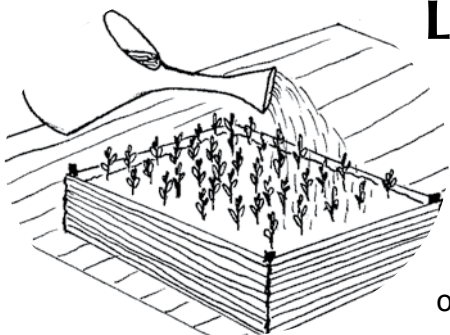
Soil: Spray EM liquid to agricultural land and around plants. Only a little EM is needed because these microorganisms will multiply on their own. It is more effective to use EM at the same time as when mulch and compost is added.

Rice paddies: Add a few bottles of EM into the irrigation water. This will be much more effective if combined with SRI (System of Rice Intensification) techniques.



BEWARE!

Microorganisms in EM, pesticides, fungicides and some types of non-organic fertilizers can damage or destroy plants by burning them.



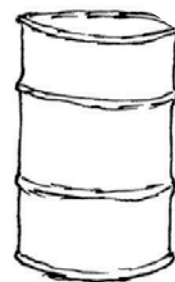
Liquid Fertilizer

Liquid fertilizer can be easily prepared and is very useful in many ways, including for nurseries, small gardens, fruit trees and other large crops. This is a good way to make nutrient rich fertilizer from small amounts of manure and other organic materials. Liquid fertilizer can easily be sprayed over large areas of land.

Liquid fertilizer is made in very strong concentration, so it needs to be mixed with water before being used. Liquid fertilizer can be stored and it lasts a long time, and can be used on larger areas of land. Liquid fertilizer can be made in a container of any size, from a bucket to a large drum. The more you make, the better. This fertilizer can be made from any organic material, and can be stored anywhere, as long as it is protected from hot sun and hard rain.

How to Make Liquid Fertilizer

Step 1: Prepare a container, for example a drum. Make sure the drum does not leak, cut off the lid by cutting around its edges and then hit down any sharp areas along this edge.



Step 2: Clean the inside of the drum using detergent, lemon, and water, then dry the drum in the sun for 2-3 days. Make sure that all oil, petrol or other poisonous materials are gone, because when the liquid fertilizer is made bacteria will live in it; poisonous materials can kill this bacteria.



Step 3: Fill 1/3 of the drum with green grass (weeds), green leaves (legume cuttings), or seaweed (if you live near the ocean). Using weeds in liquid fertilizer will give multiple benefits, because besides the weeds providing many useful minerals, this also reduces weed problems.



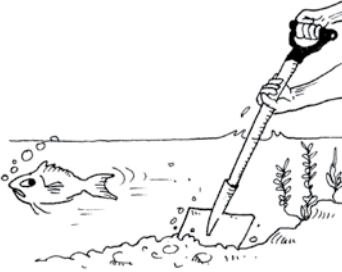
If using legumes, don't put branches in the liquid fertilizer, because these branches take a long time to rot and make it difficult to stir the fertilizer. Seaweed contains nutrients and minerals that are useful and important for plants. Sometimes these nutrients are lacking from the soil, manure, and plants. Seaweed must be washed first to remove the salt, because salt can have a bad effect on soil quality and plant growth. When collecting seaweed, only collect the fresh seaweed, as dry seaweed contains much more salt.



Step 4: Fill the next 1/3 of the drum with manure. Fresh animal manure contains more nutrients than dry manure.

Combine different types of animal manure (if available) to achieve the best result, as different manures contain different types of nutrients. Bird manure is best, and then pig, goat, cow and horse manure.

The smaller the animal, the stronger the manure (mouse manure is really great, if you can collect it). Therefore, less bird manure is needed than cow or horse manure.



Step 5: Add 2-3 shovels of healthy, living soil. Healthy soil contains many biota, which will speed up the process of turning organic materials into fertilizer and help prepare the nutrients for plant use.

When soil biota / bacteria eats the organic materials in liquid fertilizer, this bacteria will continue to multiply. Putting bacteria into the soil is just as important as providing nutrients for plants.



Step 6: Fill the container with water.

Step 7: Other materials that can be added include: 1/2–1 shovel of kitchen cooking ash, to add minerals and potassium, and 1 shovel of fishpond soil.



Step 8: If easily available, animal carcasses are also useful, like: Rat carcass, fish heads and bones, chicken carcasses, and smaller animal innards can all be added to the liquid fertilizer. This will add nutrients and minerals to the fertilizer. Remember, the most important thing is to provide more bacteria which will speed up the rotting of organic materials in the fertilizer.



Step 9: Cover the drum to prevent animals, like mosquitoes and flies, from entering, to avoid direct sunlight which could kill bacteria, and to avoid rain entering the drum.



Step 10: Stir the liquid fertilizer using a long stick for 5-10 minutes every day, for 2 weeks. This must be done to add oxygen to the fertilizer. In this fertilizer there are two types of bacteria, aerobic and non-aerobic. Aerobic bacteria needs oxygen, while non-aerobic bacteria does not need oxygen. Both bacteria work in the same way, but aerobic bacteria works better to create quality fertilizer, because its decomposing process is even and it reduces bad smells. So, the more often you stir, the faster the decomposing process and better the fertilizer quality.



Using Liquid Fertilizer

To use liquid fertilizer, it must first be mixed with water. Combine 1 part liquid fertilizer with 20 parts water (1 : 20). If this fertilizer is not first diluted with water, and directly applied to plants, especially in large amount, it will burn the plants leaves and roots because the fertilizer concentration is still too strong. Young plants are generally more sensitive than older plants.



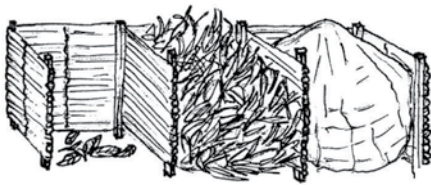
Use liquid fertilizer once or twice a week for vegetables and small trees, on other days it is enough to just give water. For fruit trees that are already established, use liquid fertilizer once or twice a month. When watering, you can use a container, like a can, with holes punched into the bottom.



For vegetables, first apply mulch around the plant, and then spray with fertilizer. If possible, avoid spraying the leaves directly, don't let the still concentrated liquid fertilizer burn the plant. This is also important with trees.

If the liquid fertilizer is almost finished, you can add more organic materials. Don't forget to continue stirring this liquid fertilizer, and wait two weeks before use. Don't wait until the fertilizer is completely finished, because then you will have to repeat the entire process from the beginning.





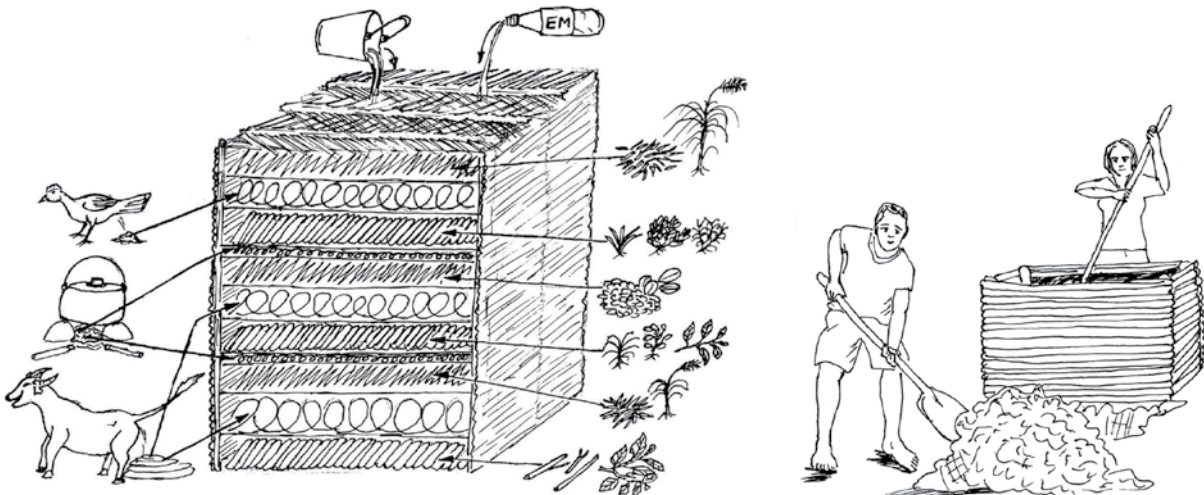
Compost

Compost is made up of decomposed organic matter, which is a concentrated rich nutrient source. The main ingredient is carbon and a small amount of nitrogen, as well as other nutrients, minerals and soil biota.

Compost doesn't just provide nutrients for vegetable and fruit plants, but it also improves the soil quality. There are many ways to make compost, from simple mixtures of rice husks and cow manure, to ones that are made from a variety of materials. Use available materials, and experiment for yourself.

Making Quick Compost Heaps

- A compost heap will work well if it is made all at once. This means all the materials are collected, and then the compost heap is made layer by layer
- A compost heap should be about 1 m wide, 1 m long, and 1 m high to create enough heat to decompose well
- You can use many different materials, such as: Animal manures, grass, weeds, water plants, leaves, seaweed, soil, rice and coffee husks, sawdust, animal carcasses (mice, fish, chickens and so on), urine, small bits of paper which can be broken down, and other natural materials which can be easily found
- Try to combine about 1/3 manure, 1/3 dry leaves, 1/3 coffee husks, rice husks or sawdust. These amounts do not have to be exact, just estimate
- Use a small amount of bird manure (pigeon, chicken or duck), or a larger amount of animal manure
- These materials should be in layers, 5-10 cm thick. The first layer of organic plant material (dry leaves, husks and other dry materials) is 10 cm thick. The second layer is of decomposed animal manure. The third layer is a little kitchen ash and healthy soil. Then add some water. Repeat these steps until the heap is 1 m high, 1 m wide, and 1 m long
- Add water twice during the process of making compost. First, add about 2-3 buckets of water during the beginning process, then add 2-3 buckets more when the compost heap is already finished. Water is very important for the composting process, but not too much. The compost should be moist, but not wet



- Cover the compost to protect it from rain and direct sunlight, and keep it somewhere safe from animals, this will also help to keep the heat in the compost. This cover can be made of palm fronds, an old tarpaulin, banana skins or leaves, or a thick layer of leaves. If possible, have this cover ready for the wet season to prevent rain from entering
- If all these steps are followed, the compost will become very hot (around 65°-68° C), because of bacteria activity in decomposing. This temperature will cool down again to around 45° C after 2-3 weeks
- The compost now needs to be turned inside out, because the outer layer is not receiving enough heat and will not be as composted as the inner layer. After the compost is turned, add 2 more buckets of water, but only if needed, then return the compost cover. The compost heap will then reheat and be ready for use in 2 weeks
- Now the compost is ready to be used in the garden. Use 2 handfuls for every seedling, and 4 handfuls for every mature plant. It is even better to cover the entire garden area with a layer of compost, about 3-5 cm thick will work well

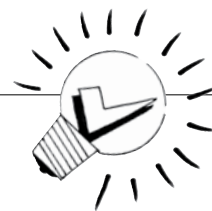


Making Slow Compost Heaps

Slow compost can be made from only 2 or 3 types of material, but you need the balance the amount of manure with plant materials. A good mixture is about 1/3 manure with 2/3 plant materials. Slow compost will take about 2-3 months before it is ready to be used. This type of compost is not as nutrient rich, but it is still good enough to improve soil condition.

How to Use Compost

- Start to make a new compost heap when the old compost heap is already half used up. This will ensure a continuous supply of compost
- Use compost on plots 2 weeks before planting vegetable seedlings or directly planting seeds, such as corn, beans, eggplant and so on, to allow the nutrients and compost soak into the soil. Wait 2 weeks after planting before adding more compost
- The best place to use compost for trees is directly under the outer layer of leaves (on the ground of the tree's outer crown, not around the tree trunk). This place is around the bottom of the tree's outside leaves, and it is where the tree's roots feed from most. Don't compost around the tree trunk, because this could cause the trunk to rot. This is true for all types of fertilizers



SMART IDEAS!

If the compost doesn't smell good or smells very sour, this means that too much manure was used. If the plant materials are not decomposed enough, this means that too little manure was used.

Making Compost Baskets and Trenches

Information taken from *Faith Garden Manual*, written by *Mindanao Baptist Rural Life Center*, Bansalan, Philippines.

Step 1: Dig holes in the middle of the garden plot, about 1 hand length deep (15-20 cm), and 3 hand lengths wide, leave 1 meter in between each hole (about 1 large step). Otherwise, the trench can be dug lengthwise in the middle of the garden plot, about 1 hand length deep, and 2 hand lengths wide.

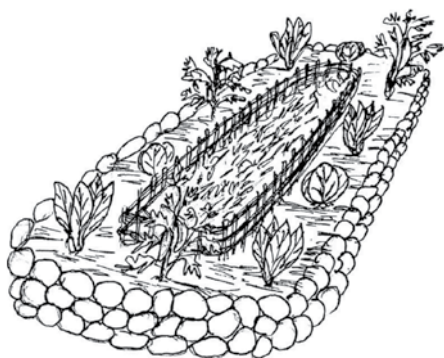


Step 2: Place bamboo sticks around the edges of the holes or trench. These sticks should be about 1 hand length apart and 2 hand lengths above ground.

Step 3: Make a fence of woven bamboo / leaves through the sticks.

Step 4: Put into the holes or trench in order:

1. A thin layer (about 5 cm) of small branches or dry grass to provide air
2. Different types of manure
3. Grasses, weeds, leaves, and washed seaweed
4. Add 1 handful of kitchen ash to each hole, or per meter of the trench

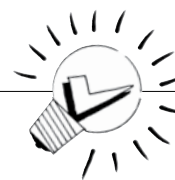


Step 5: As the old compost materials decompose, add new materials, in the same layers as before. The compost does not need to be turned.

Step 6: Plant seeds when the compost at the very bottom begins to decompose. Leave about 1 hands length in between the seed and the compost basket or trench.

Step 7: Water the plants regularly for 2 weeks after planting. Then you can water the compost basket or trench directly, not the plants. The plant roots will grow into the hole or trench. This will improve plant growth and save water.

Step 8: When the plants are harvested, the compost from the baskets and trench can be shoveled out and used on the garden plots to add humus to the soil. After this, new compost materials can be added to the basket hole or trench in preparation for the next planting.



SMART IDEAS!

- This technique can also be used for young fruit trees
- Make the compost baskets or trench one month before planting
- Swales can be used as compost trenches for sloped land
- To allow continuous cropping, fill the baskets or trenches at different times, each plot can be filled 2 weeks to 1 month apart
- The basket or trench sticks can be made higher to be used for growing vine plants, such as beans, cucumbers and other climbing vegetables

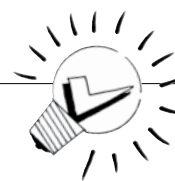
Compost Pits

A compost pit is a great way to supply plants with nutrients. Examples of plants that work well with this system are bananas and papayas. Materials for this compost uses anything available, such as: Leaves, weeds, manure, rice / coffee husks, and paper can all be added. Urine is also recommended. The compost that collects at the bottom of the pit can be dug up each year and used for plants.



Benefits of using compost pits:

- Deals with weed problems
- Uses excess water and organic wastes
- Stores more water in the soil and in the compost materials, so that less water use is needed for plants, especially in the dry season



SMART IDEAS!

To deal with mosquito and insect problems inside the pit, soak a handful of neem leaves in a bucket of water for 2 days, then pour this liquid with the leaves into the compost pit. Repeat this method every 3 months.

Direct Composting

Compost can also be placed directly on top of the garden plots or land where the garden plots will be made. The soil underneath will receive the benefits of nutrients that are released, and this will increase the amount of soil biota.



Diluted Urine

Human urine is an easily available, free and continuous source of nutrients. Urine contains quite high amounts of nitrogen. If urine is diluted with water (10-20% urine, with 80-90% water), it becomes a great fertilizer for fruit trees, citrus trees respond especially well. Urine can also be added to compost pits and other types of compost heaps.

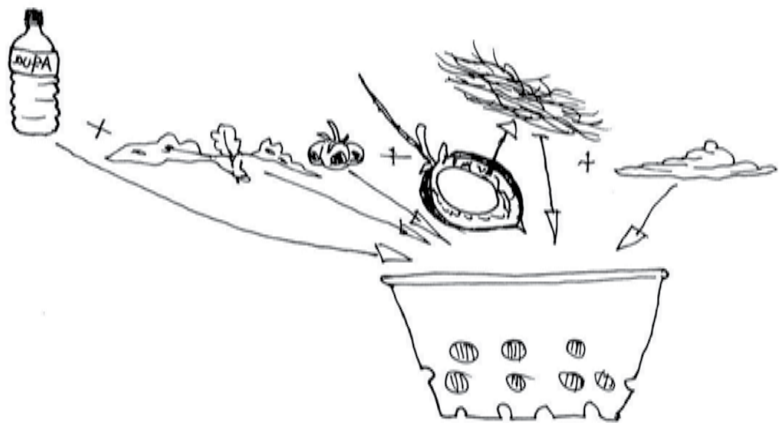
Urine is not recommended for use in vegetable gardens. Also, mature fruit trees will receive benefits from direct urination, but not continuously on the same place.

Earthworm Farms

At the beginning of this module the benefits of worms were explained; more worms in the soil means better soil. Farming earthworms is a simple way to quickly increase the number of earthworms in your soil.

Materials needed:

- One old bucket
- Coconut husk fiber
- Cow or horse manure that has been soaked in water
- Left over kitchen vegetables
- A flat piece of wood or metal
- A large rock

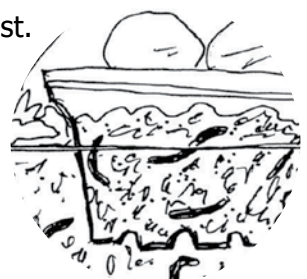


How to Make an Earthworm Farm

1. Make 10 coin sized holes at the bottom and on the sides of the bucket
2. Dig a hole in the garden, large enough for the bucket to fit inside of. The top of the bucket should be about 1 hands length above soil
3. Fill the bucket with coconut husk fiber, left over vegetables, and lastly with animal manure. Use about the same amount of each material
4. Cover the bucket with a piece of wood or metal so that animals cannot enter, and then place the large rock on top to hold it in place

Make sure that the materials in the bucket are moist, especially during the dry season. Add more materials to the bucket if needed. Every few months, clean out the bucket, the materials in the bucket can be used as they have become a rich nutrient compost.

After, add new materials to the bucket. Earthworms will come and eat the materials in the bucket, and then return to the soil. Earthworms are useful for small and large gardens, and even for rice paddies. With more earthworms, the soil becomes better and plants will be healthier!



Mulch

What is Mulch?



In natural forests, leaves, rotting materials, animal manure and even dead animals, all make up a mulch which covers the ground, like a skin. This skin is continuously being added to and also is continuously decomposing. Mulch (or skin) 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.

Mulch that is used on gardens, agricultural land, crop land and reforestation areas can be grass cuttings, tree prunings, leaves, compost, decomposed manure, rice / coffee husks, used paper, rocks, animal bones, or any material, so long as it is organic. Make sure there is no plastic rubbish, used batteries, glass bottles, or any other non-organic materials.

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. Remember, this is the same as with people!
- 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
- Mulch will become humus, which will improve soil structure and increase the number of soil biota
- 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!



How to Use Mulch



- 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 soil before planting
- Apply mulch to the whole plot, not just around the vegetables and plants
- Use fine textured mulch for vegetable plots, and a coarser textured mulch for mature plants and trees
- For trees, apply mulch underneath the outside leaves, because this is where the trees roots will feed. Regularly applying mulch will improve the tree's health, and the size and amount of fruits
- Don't let the mulch touch the plants stem or trunk. This is very important to avoid rotting, especially in the wet season
- Use rocks, branches, or whatever material that can be used to border the garden. This will help hold the mulch in place and prevent erosion
- If you are using mulch and compost at the same time, apply the compost underneath the mulch to maximize the benefits of the compost
- If you are using weeds as mulch, separate the weed seeds first and give them to animals or use in liquid compost. This will reduce future weed growth

- Plant plants that can be used for mulch, like legumes.

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

fine
mulch for
vegetables



coarse
mulch
for trees



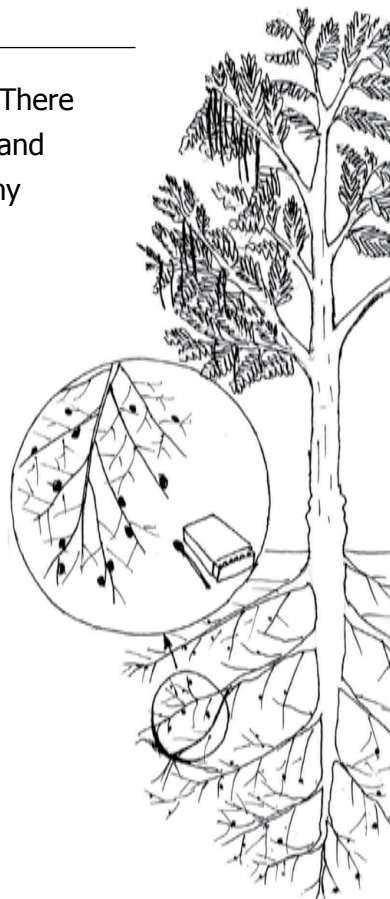
- Leftover farming materials, like rice / coffee husks, can be composted or dried before being used as mulch. These materials should be put in a pile for 1 month or more before being combined with manure to make compost, then use this compost as mulch

Legumes

Legumes are a type of plant that gives nitrogen to the soil. There are many different types of legumes, some are annuals and others are perennials. This plant is a very important part of any land or 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. Bacteria called rhizobium attach themselves to the roots of the legume plant and live there. This bacteria is only released into the soil after the roots die.



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.



SMART IDEAS!

Perennial legumes

Prune 3 or 4 times a year. If a legume trees branches are pruned, the roots will also die back to the same amount that is pruned. Therefore, the dead roots with nodules will release all of their nitrogen into the soil. Other plants can then use the nitrogen that is released. The prunings can also be used as mulch, animal fodder or compost material. As the legume grows back, its roots will also grow back, and new nodules will grow on them. This is a sustainable cycle. If a legume tree dies, it will still provide nitrogen from its roots for a few years afterwards.

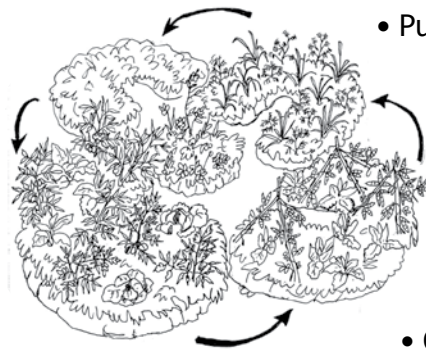
Annual legumes

Prune back after the first flowers grow, this is because these plants need a lot of nitrogen when producing seeds, so there won't be much nitrogen left in the soil for other plants.

Techniques for Using Annual Legumes

1. Crop Rotation

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. The soil and its nutrients will then become imbalanced. **Some examples of plants and the nutrients they use to grow:**

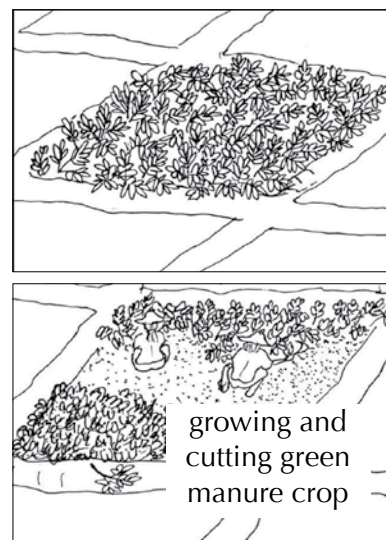


- Pumpkins and melons like as much nutrients as they can get
- Corn and tomatoes use a lot of nitrogen and some other nutrients
- Vegetables use less nutrients
- Beans and peas use nitrogen and other nutrients, but they also produce nitrogen
- Carrots and radishes use less nutrients

It is good to rotate plants from plot to plot each season, or even better, to grow different types of crops together. Crop rotation will also help to reduce pest and disease problems. It is important to let the land lie fallow during a crop rotation cycle. Fallow time or 'rest time' means that nothing is grown for a period of time. During this fallow time, mulch, manure and compost can be applied and left on top of the soil or turned into the soil. Animals can also be used during a fallow period to add manure, improve the soil, and reduce weed problems. Fallow time allows the soil to 'recover'.

2. Green Manure Crops

During the fallow period, the soil can be improved and prepared for the next crop to be planted by planting green manure crops. This green manure crop should be planted thickly and should cover the whole land area. Green manure crops can be a mix of legumes, annual grasses and other annual plants. Green manure crops are not grown as food for humans, but only for the soil's benefit. As soon as the first flowers appear, cut down the green manure crop and leave it on the land as mulch. This technique does take time and labour, and maybe even a little bit of money, 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.

SMART IDEAS!



Green manure crops can also be used on land that has not yet been used for crops. This technique will help to prepare the soil for future production.

3. Annual Crop Integration

Legumes can also be integrated with vegetable crops or other crops at the same time. This technique will increase diversity in crops harvested from one plot of land. The other crops growing will benefit from the excess nitrogen which is produced by beans and peas. Crop integration can follow any pattern, as long as it suits the plants and shape of the land.

Techniques for Using Perennial Legumes



1. Living Fences

Legumes are easily grown from seeds or cuttings, if the plant is continuously pruned it will become a thick living fence. Living fences can also function as windbreaks for vegetable plots, chicken and animal systems, aquaculture, and nurseries. This plant grows quickly and the material from pruning is very useful as animal fodder and material for mulch and compost. Living fences will also protect crops from animals.

2. Legume Swales and Terraces

On sloped land, legumes can be used to prevent erosion. Plant legumes to create living swales or terraces:

- Plant the seeds following the contour of the land
- Plant them very close together (3-5 cm)

For more information about tree swales and terraces, see Module 8 – Forests, Tree Crops and Bamboo.

3. Perennial Crop Integration

Legume trees can be integrated with fruit trees, coconut trees, coffee plants, vegetables and other crops. Legumes will provide nitrogen, mulch, as well as protection from winds and erosion. All of these plants can be integrated in rows, plots, or combined in other ways. It is all up to you.

Taller legume trees, like Casuarinas, provide shade for coffee, vanilla, and other plants that like shade. Animals also need shade, and legume trees can provide this function.

4. Pioneer Trees

Pioneer trees are trees that are planted first in a system. They are used to prevent erosion, provide protection for future crops, improve the soil and provide mulch. Pioneer trees often grow in hard soil conditions. Because of this, use trees that don't need a lot of water, and are most enduring in hard conditions. Legume trees can be pioneer trees, because they:

- Easily grow from seeds or cuttings
- Grow quickly
- Provide nitrogen for other crops



SMART IDEAS!

- Almost all types of legume trees have short life spans. Use short life legume trees as pioneer trees, and longer life legume trees for windbreaks, shade and living fences
- Plant many more legume trees as pioneer trees, and then after a year or two, cut down the weaker or smaller trees to be used as mulch and to provide space for new trees
- If legume trees are planted on sloped land, when their nitrogen is released into the soil, it will slowly move down to lower areas, so lower areas will receive enough nutrient supply
- Remember, legumes are multifunctional. They provide many benefits. Use as many of these benefits as possible



Fertile Soil

If we have fertile, healthy soil, this will be a strong foundation for continually producing productive sustainable crops, whether for a small home garden or a large agricultural farm. If the soil is well managed in a healthy farm system, the soil will become more fertile over time and continually produce healthy food and crops.

Non-organic Fertilizers

In the last few decades, the use of non-organic fertilizers has increased dramatically all over the world. In Indonesia, the practice of using non-organic fertilizer is supported by a government program to increase farming produce. So, almost all Village Cooperations (KUDs) and some farming stores sell non-organic fertilizers directly to farmers. However, besides the high prices of non-organic fertilizers, even if used correctly by farmers, they only provide short term benefits, which will not last in the long run.

The information above is only the writers opinion, and an attempt to analyze and suggest to farmers that if we do use chemical materials or non-organic fertilizers, we should truly understand the negative effects of the materials on our environment. Farmers in Indonesia often have difficulty accessing information about these topics, in part because there are not a lot of field workers that really understand such topics.

Once we damage the land, it will take a long time for the land to recover to its normal condition, when of course food production for community needs must still be met. If non-organic fertilizers are being used, water irrigation must be good enough to supply even more water for crops, because non-organic fertilizers stimulate plants to soak up more nutrients and water from the soil than what they normally need for growth. Non-organic fertilizers are similar to stimulating medicines.


If the practice of using non-organic fertilizers continues, in time the nutrients in the soil will be used up, the amount of acidity in soils will increase, bacteria / microorganisms in the soil will die, soil structure will deteriorate, and in the end farmers and the soil will be dependant on non-organic fertilizers indefinitely. Also, many non-organic fertilizers do not provide all the nutrients and minerals the plants need to grow.

Even in highly developed countries, where there is good access to information, many problems are still experienced due to use of non-organic materials, let alone in still developing countries.

Some serious problems that can happen are health problems (sometimes skin, lungs, and even cancer), and problems to do with soil, such as too many nutrients in the soil. If there are too many nutrients in the soil:

- Nutrient 'lock up' will occur, which means that there are nutrients stored in the soil, but they are not available to plants for use
- Excess nutrients will be wasted, especially nitrogen, and washed away by water into wells, ponds, rivers and oceans. This also causes problems for water quality, which can effect fish and water plants, animals, humans and all living things in the surrounding environment

Another thing to consider, besides the negative impacts on the environment and ourselves, is that non-organic fertilizers are expensive, while it is not definite that a farmer's produce will sell to the market. This can make it difficult for farmer to pay back the money or loan they have used to buy non-organic fertilizers.



Notes...