3

Rows of vetiver grass reduce nutrient losses by 50-90%

Healthy and productive soils

17 • Introduction

The soil is one of our most important resources. It is the base for food production and for plant growth. Plants again are essential for the existence of animal life.
However, the soil is not often looked after:

- Crop residues are burned instead of used as fertilizer.
- Soil is depleted by the continuous growth of the same crop.
- The felling of trees causes soil erosion, which leads to desertification.

How to build healthy soil

The material which today is commonly regarded as 'soil' is usually only a compacted residue of rock minerals. Healthy topsoil consists of minerals and air, in addition to water and living organisms, such as plant roots, microorganisms, insects and worms and the organic materials they produce. It is by reintroducing the missing components that new topsoil is formed.
There are six essential ingredients for soil formation:
1. Minerals
2. Air

Gully resulting from erosion

3. Water
4. Living things IN the soil (plants and animals) and their by-products
5. Living things ON the soil (plants and animals) and their by-products
6. Regular and patchy disturbances

For soil to form, it needs to be living (4). To be living, the soil needs to be covered (5). To be covered with healthy plants and decomposing plant litter, soil needs to be managed with appropriate disturbance systems (6).

Cover the soil to keep it alive

Many people believe that new topsoil cannot be formed. But then - how did all the topsoil get here in the first place? We know how quickly we lose it when we ignore the fundamental importance of components 5 and 6. To turn things around, we need to encourage soil building processes every day in our land management.

Rules for building topsoil:

- No bare soil. The soil must always be covered with plants or plant litter.
- Produce organic matter - for example by giving the land a rest from grazing, or by growing green cover crops with minimum tillage.
- Graze or slash the groundcover periodically. Use high stock densities for short periods to place organic matter both in and on the soil (This prunes the roots and tramples the litter).

High levels of biological activity are required to form topsoil. Soil conditions must be such that soil organisms can flourish. The more organic material there is on and in the soil and the faster it decomposes, the faster new topsoil will form.

A smell of compost indicates high levels of biological activity, particularly fungi. The activities of beneficial soil microbes are important for the formation of soil aggregates (lumps of soil particles) which give soil its structure, improve porosity and water-holding capacity.

The soil should feel light and springy under your feet. Can you easily push a screwdriver in up to the handle?

Adapted from "How to build new topsoil" by Christine Jones on the website: www.managingwholes.com

In this chapter the following will be described:

- Systems for testing the soil (18)
- Systems that improve fertility and soil life production of compost, minimum tillage system and agroforestry systems (17-19)
- Systems for soil conservation and to reduce erosion (20-21)

18 • Soil Examination

Introduction

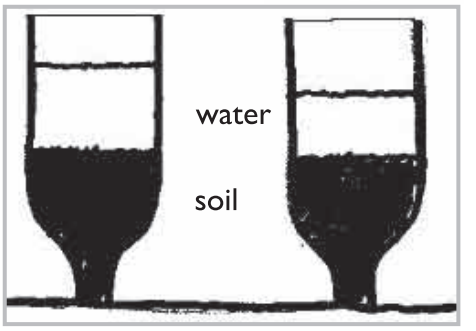
It is very useful to analyze soil quality in several parts of the field in order to better determine its use.
The best way is to run chemical analysis/ tests on soil samples, but that is seldom possible in rural areas of Africa.
In many places, however, there is local knowledge that can provide information on what kind of crops can be grown. This can be seen from what kind of weeds grow on the fields.
It is useful to spread such knowledge on to communities where it does not exist.
There are also simple systems for analyzing soil structure - especially to determine the amount of sand in relation to clay. This is important information because a soil without clay and organic material - like a sandy soil - cannot hold water or nutrients.
These are therefore leached from the soil.
Fertile soil should have at least 3% organic material and 5-30% clay. If there is more clay, the soil is more difficult to cultivate.

Water infiltration

Try an experiment to show how water moves through sandy and clayish soils:

1. Cut out the bottom of two plastic bottles.
2. Stick their necks in to the ground.
3. Fill half of the bottle with sandy soil and half of the other bottle with clay soil.
4. Fill both bottles with water and observe how long it will take for the water to drain from each bottle.

Then try the same thing to compare sandy soil and soil mixed with compost (In the absence of compost, use animal manure).

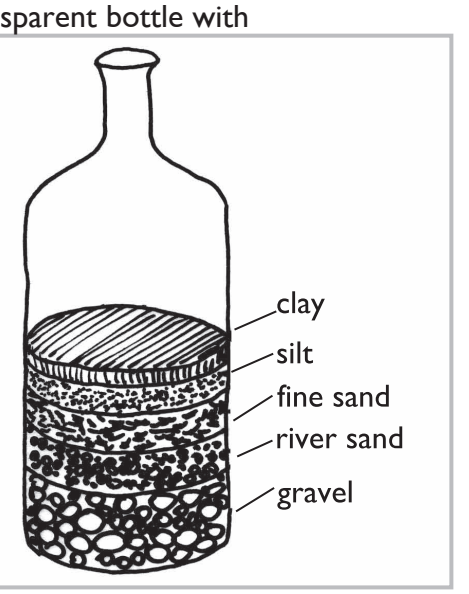


Infiltration measurement

Soil structure

Make an experiment to quantify the amount of clay, silt, fine sand, coarse (river) sand, and gravel:

1. Take a sample of soil.
2. Fill a clean and transparent bottle with 10-20 cm of soil.
3. Add a spoonful of salt and fill the bottle with water.
4. Shake it for a couple minutes and then let it rest.
5. Measure and calculate the percentage of each layer.



System used to determine soil structure

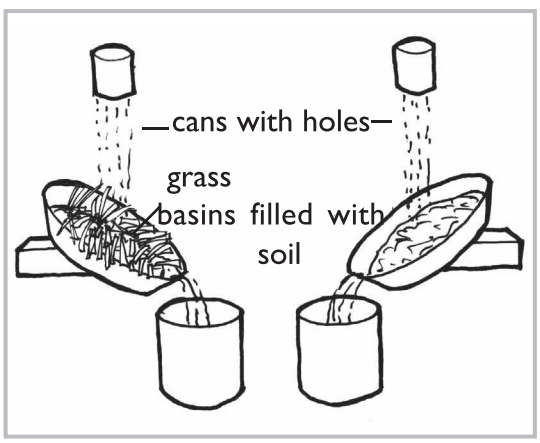
Amount of organic material and water

If you have access to a scale that registers small quantities, you will be able to calculate the amount of water and organic material in the soil:

1. Take a sample of soil and note its weight (W1). Keep it in a closed container or plastic bag until you can weigh it.
2. Dry it well by spreading it out in the sun on a piece of plastic to make it easier for water to evaporate.
3. Register the weight of the sample after some hours in the sun (W2). The differ-

ence is the weight of evaporated water: W(evaporated) =W1-W2

4. Put the dry sample on top of a piece of sheet metal and leave it over a really hot fire for 10-15 minutes.
5. Let the sample cool and register its weight (W3). The difference is the weight of organic material that has been burned: W(organic material)=W2-W3

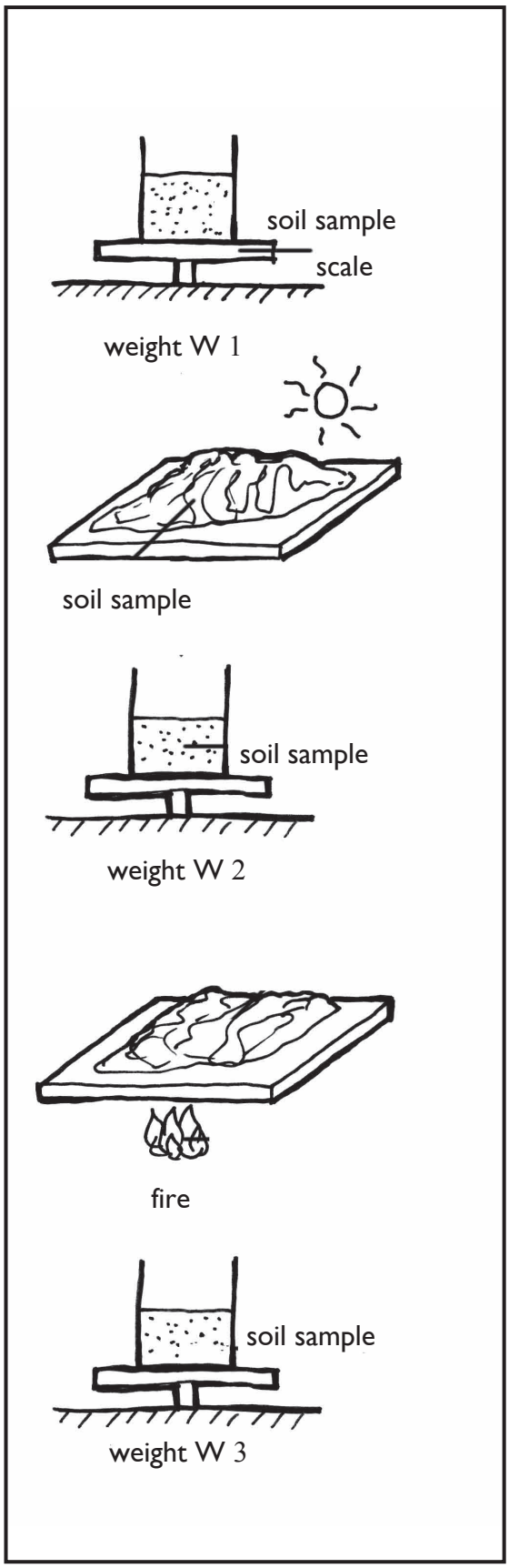


Demonstrating the effect of mulching

The effect of mulching

The following experiment shows the difference between water movement in two situations: (a) when the field is covered by mulch (dead plant material); and (b) when the field is left uncovered.

1. Fill two basins with the same kind of soil.
2. Place them so that they lean sideways, by placing a brick under one side.
3. Cover the soil in one of the basins with grass cut into small pieces.
4. Use a nail to make many holes on the bottom of one (or two) aluminium cans.
5. Place a glass (or transparent plastic bottle with the neck cut off) at each basin to catch the run-off.
6. Fill the cans with water to simulate rain falling over the two basins. Make sure both basins receive the same amount of "rain".
7. Compare the amount of water and soil in the two glasses (bottles).



19 • Production of Compost

Chemical fertilizer, manure (animal dung and plant material that has not been systematically decomposed) and compost (systematically decomposed organic material) is food for the plants and for the life in the soil. Such food is necessary to keep the fertility of the soil and to maintain a good crop production.

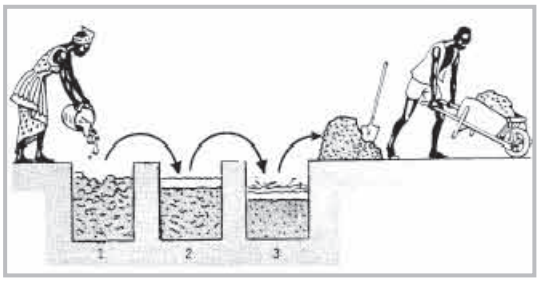
Compost is made when various materials are broken down by microorganisms. These materials can be a mixture of animal manure, vegetable waste matter, household waste, cooled ashes, sweepings, weeds, leaves, straw, groundnut or cotton cake, etc. Anything that cannot be broken down (decomposed) should be removed: cans, plastics, glass, etc.

Composting is done in pits when it is in a dry climate. This will keep the compost more humid and therefore speed up the process. In a humid climate it is better to use heaps - to prevent the compost from becoming too wet. If the compost is flooded the microorganisms cannot function.

Compost heaps require less work than pits. The figure explains the classic process of preparing compost. The process is the same, whether it is for a "pit" or a "heap".

1. Dig three pits of about 1.5 x 1.5m, side by side (or make three heaps). Dig the pits about 50 cm deep, so that it is easy to turn over the plant material and to empty it.
2. Fill the first compost pit. Add layers of plant material, changing with thin layers of animal manure, ash and soil. The soil or dung makes the process work faster since these contain the microorganisms that break down the plant material.

Cut big objects (such as banana tree trunks, maize stalks) into smaller pieces.



Composting with three pits/heaps. 1- being filled, 2- decomposing, 3- ready for use

Burn woody waste which does not decompose in your stove. Burn also diseased plants or plants infested with insects, and put the ashes on the compost heap. The contents of the pit should be humid, but not too wet, to decompose well. Water or shelter the pit as the conditions require.

3. After a month, fill pit number 2 with the contents of pit number 1. The reason to move it is to mix it and give access to oxygen. Water it (unless it is very wet) and pack the pit well. Cover it with a layer of earth, which you stamp down and water from time to time. When pit number 1 is empty, you can fill it up again with new waste.
4. After another month fill pit number 3 with the contents of pit number 2 and air it well. Cover it with a little earth and branches to protect it from evaporation and rain, but do not pack it. Fill pit number 2 with the contents of pit number 1 and refill pit number 1 with new waste.
5. At the end of the third month you can empty pit number 3 and use the compost. Continue in the same way every month, emptying and refilling the pits.

Work the compost into the soil in the same way as manure. Composting has the advantage that microorganisms spreading plant and human diseases are killed by the high temperatures during this process.

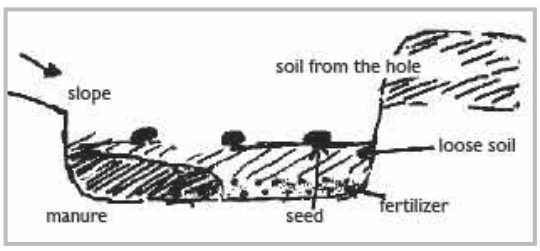
20 • Conservation Farming

Why minimum tillage

The field can be prepared for planting by the time of the first rains

It is necessary that agricultural systems develop as the global population grows. Nature is degraded because the land is abused or misused. Every year many productive fields become unproductive because of degradation of fertile soil.

Minimum tillage is an alternative to such poor farming methods. The main idea behind minimum tillage is not to plough but to disturb the soil as little as possible. This system has been used by commercial farmers in countries like Brazil, US and Zimbabwe for some time and has shown that fields become more fertile and better incomes are reached while using less fertilizer. The system has recently been adopted by small farmers in Southern Africa - with good profits.



Profile of a hole before the seeds are covered

The basic concept of minimum tillage

When soil is tilled the good structure that has been formed naturally is destroyed. The valuable humus is then buried deeper down. The soil structure is spoiled and the soil is left without a protective cover. The result is soil erosion when heavy rains fall.

With minimum tillage one works together with nature and not against nature. Never plough the soil. A method is instead to dig planting holes where the new crop is planted. These holes attract water. The residues from former crops should be left as a protective mulch to prevent evaporation of water from the soil. This will also prevent high soil temperatures that destroy living conditions for many soil organisms.

Another advantage of the minimum tillage system is that it gives the possibility for farmers to begin to prepare their land as soon as they have harvested. This is not possible with conventional tilling because the soil is too hard to till before the rains fall. Farmers are therefore not able to plant early and benefit from the period of the first good rains.

Land preparation can also be spread over several months and is therefore more suitable for women farmers.?

In minimum tillage the compost, manure or fertilizer is placed directly in each planting hole. It is thus used more efficiently than when it is spread over the whole field.

This makes it easier for the farmer to have enough manure for all his fields.

Minimum tillage is thus a way to save water, soil and money.

It is essential to use crop rotation to avoid that some insects develop uncontrollably and that a lack of specific nutrients in the soil is developed.

Minimum tillage initially requires more time for weeding. The farmers must avoid planting on a larger area than they have the capacity to maintain. But if the weeding is done well from the beginning, the land will after a few years have fewer weeds because less and less seeds will get the chance to germinate.

Example on how to prepare a model field

Organize the model field so that one part is worked conventionally and that minimum tillage is used on the other part.
Tell the members of the farmers' club/students/ children to bring:

- *a water can full of water,*
- *a handful of maize or other kind of seeds, such as beans and peanuts,*
- *a handful of fertilizer,*
- *a bucket filled with compost or manure,*
- *a 50 m string with marks every 70 cm. These marks can be made with paint, knots, bottle caps pressed around the string, etc.*
- *two sticks/branches of 90 cm to measure the distance between the lines,*
- *40 pegs to mark the lines (20 cm long and sharp).*

a. Weed the field with a hoe
Do not remove or burn the weeds. Leave it as a protective mulch.

b. Measure the field
Use the string to measure an area of 50 x 50 m. Mark each corner of the square with a peg.

c. Determine in which direction the land slopes
Decide where to place the planting lines so that they follow the contours of the soil (the opposite of up-down). If the land is sloping more than one metre over the 50 m then it is necessary to establish vetiver contours to avoid erosion (see section 23).

d. Mark the lines
Mark the lines precisely so that the holes are easy to find each year. An advantage of planting on top of the old roots is that this will provide oxygen for the new plants as the roots decompose. The distance between the lines should be 90 cm. Use a 90 cm long stick. Mark each line with a peg on each end.

e. Dig the holes where you will plant
- *Use the string that is marked every 70 cm.*
- *Move the string to the first line and place it on the two pegs.*
- *Make the holes where there is a mark.*
- *While people are digging the holes, check if it is being done properly and correct them if necessary.*
- *The holes should be 15cm deep and 35cm wide.*
- *All holes must be on the same side of the string and be evenly spaced.*
- *When all the holes of the first line are ready, move on to the next planting line.*

It is possible for 5 people to prepare one hectare in one day.

f. Demonstrate how to apply manure/ fertilizer and seeds
- *Put a soft drink can filled with well decomposed manure or a bottle-top of fertilizer at one side of the hole.*
- *It is best to apply the manure in August - but it can be done up to the time of planting.*
- *Cover the manure or fertilizer with soil so that the hole is still 5 cm deep.*

g. Demonstrate the start of the rains
- *Use a water can filled with water to demonstrate rain. Say "Today is November, 15 - it rained a little" and sprinkle some water over the holes. Explain that you have to wait for more rain and not to plant after the first weak rains.*

- *Continue with the demonstration: "Today is November, 20. Now it is really raining". Pour much water over the holes. Ask people to watch how the holes absorb the water.*

Explain that:
When it rains heavily (after November 15) and the holes get filled with water, soak the seeds overnight (see section 37) and plant them the next morning, when the water has soaked into the holes.
If you are using chemical fertilizers (along with manure) it is best to apply these when you apply the seeds. Use one side of the hole for the seeds and the other for the manure/fertilizer. Keep the fertilizer 3 cm from the seeds.
Burry four maize seeds (see the planting guidelines on the next page regarding other seeds) in the soil at the other side of the hole. Do not put them in contact with new manure or fertilizer. Cover them with a 2,5 cm deep layer of earth (2-3 fingers deep). Break up any lumps of soil, so that the seeds have good contact with the earth.

h. Explain how to weed
Explain that people should weed every 2 weeks to get rid of weeds while they are still small. It is much faster to weed the field with small weeds. When the weeds are 5-7 cm, one hectare can be weeded by 1 person in 3- 4 days. If the weeds are left until they are 15 cm, the crop will suffer and the same job will take 10 days. Weed on time and do less work.
Explain also that they must keep weeding until the harvest. This is to prevent the weeds from spreading their seeds.
People should be prepared for extra weeding the first years.

What everyone should know

1. What is minimum tillage

Mulch between the holes reduces evaporation

Minimum tillage means that the land is not ploughed, or dug deeply. Permanent planting holes are made, and only these are tilled. Residues from early crops are left in the field as mulch to protect the soil. A minimum of 30% ground cover is recommended, but the more the better.

2. Advantages of minimum tillage
The farmers can get the land ready before the rains start. This way they can plant earlier and benefit from the first rains.

In areas where animals are traditionally used to till the fields, this is especially good for farmers who do not have animals. With minimum tillage they do not need to wait to borrow or rent animals until the other farmers have tilled their lands.

- The soil becomes more and more fertile because humus is formed in it.
- Mulching with plant residues helps to reduce soil erosion.
- The mulch also helps to keep water in the soil.
- More water is available for the crop because it accumulates in the holes.
- The plants do not dry so fast during drought spells.
- It is easier to give the exact amount of manure/fertilizer that the plants need.
- Gradually there will be less weeds because they are prevented from spread-

ing seeds, and no old seeds are dug up.

3. How to do minimum tillage

See the instruction on the previous page.

4. Planting guidelines

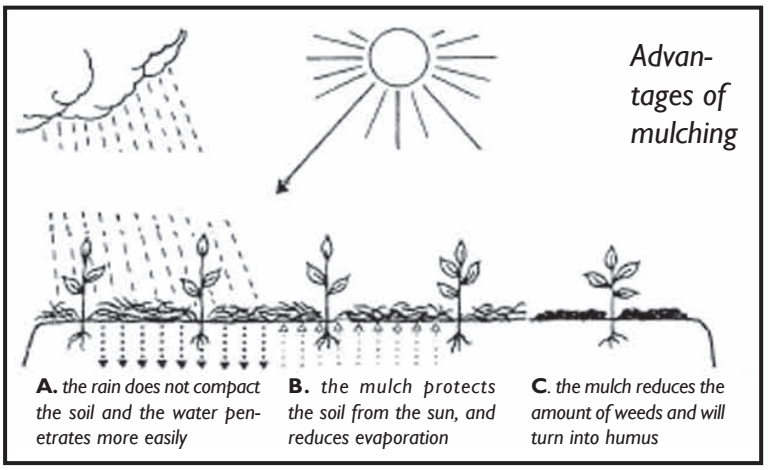
The following planting guidelines (from Conservation Farmers Union) apply for Zambia. It applies to all of them that the farmer must select the correct variety for the area:

- Maize: plant 4 seeds in each hole after November 15, when at least 50 mm of rain have fallen. Plant the day after heavy rains. Never plant in soil that is getting dry. The hole should not be more than 2.5 cm deeper than the rest of the field.
- Cotton: Fill most of the soil back into the planting hole. Plant a pinch of (5-6) seeds in each end of the holes, very close to or on the surface. Plant in dry soil from mid October.
- Pigeon pea, cowpea, gram: Plant after a good shower of rain into moist soil. The area should be kept free of weeds which means that the farmer sometimes needs to weed before planting! Plant 5-6 seeds across the hole at a depth of 2.5 cm.
- Groundnuts: Groundnuts should be planted on lighter sandy soils. Plant as early as the rains allow. Plant 8-10 nuts across the hole, at a depth of 2.5 cm.
- Soya beans: Soya beans should be planted December 15-30. Plant into moist soil after a good shower of rain. After backfilling, plant 10- 12 seeds across the hole at a depth of 2.5 cm.
- Sorghum: Sorghum should be planted December 1-15. Plant 5-6 seeds at each end of the planting hole after a good shower of rain and cover with 2.5 cm of soil.
- Sunflower: Sunflower should be planted December 1-15. Plant 2-3 seeds at each end of the planting hole after a good shower of rain. Sunflower should not be planted deeper than 2 cm. Otherwise germination will suffer.

Water accumulates in the holes

5. Thinning

Thin the crop early when the plants are 7.5 cm or smaller. Late thinning will disturb the surviving plants. Cotton should be thinned to 2 plants at either side of the planting hole, so that there are 4 cotton plants in each hole. Thin the weakest plants out, leaving a space between the plants you choose to

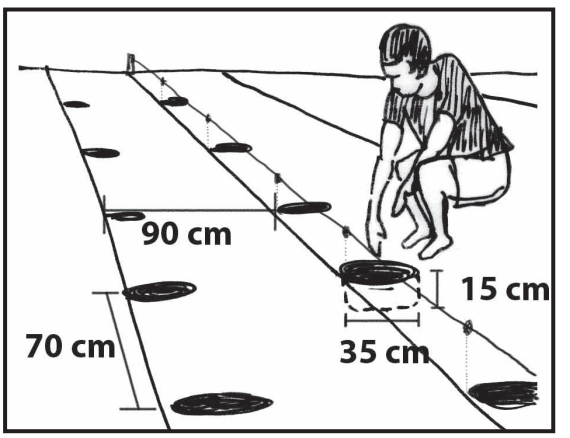


Advantages of mulching

A. *the rain does not compact the soil and the water penetrates more easily*

B. *the mulch protects the soil from the sun, and reduces evaporation*

C. *the mulch reduces the amount of weeds and will turn into humus*



Use the same distances and use the same holes every year

grow. Maize should be thinned to 3 plants per hole. However, if only 2 plants have emerged in a hole, leave 4 plants in the next one to compensate. If germination is poor, it may be necessary to supply extra seeds. The earlier this is done the better. No thinning is recommended for other crops as long as planting has been done correctly.

6. Pot holing

If the early rains are poor, pot holes should be dug in the areas between the rows. The holes should be dug one metre apart and be the same size as the planting holes. Pot holes help to hold rainfall and let it infiltrate into the soil. After 3 or 4 rains they will fill up with soil, but by this time they have done their job.

7. Topping maize

When the maize plants are mature (not the cobs), it is a good idea to top the stalks just above the cobs. Drop the tops in the area between the rows. This will speed up drying and reduce damages from termites and wind. Termites will harvest the toppings rather than attacking the crop. Some farmers believe that residues attract termites. This is correct, but the termites harvest the residues rather than attacking the drying crop. This happens when the ground is bare.

8. Ripping

A farmer can carry out minimum tillage using a ripper. A ripper does not turn around the soil, but loosens the soil in a furrow, in which the crop can be planted. This work can be done in the dry season, since it is not so heavy to pull as a plough. This enables the farmers to plant early. The ripper does not get disturbed by the residues lying on the ground. This methods is also promoted in areas with less rain.

9. It is important to remember

Do crop rotation. If you plant maize on the same land every year, diseases will appear.

Leave at least 1/3 of the residues on the field. Talk to your neighbours in order to avoid animals from eating all the residues.

Get extra workforce for tilling the land and it will become more fertile year after year - so do not give up if your first experience is not great.

Drawings and text adapted from the Zambian Conservation Farmers Union and DAPP Zambia

21 • Improved Fallow

How to grow your own fertilizer and get animal fodder and firewood at the same time by using legumes.

Idea

Legumes are plants with pods, like beans or peanuts. The idea is to use legumes to provide fertilizer for the other crops in the fields. At the same time these plants can provide firewood and food for animals.

This section describes two different systems which may be implemented, depending on how much land is available:

- If there is enough land available, the system of improved fallow should be used. This means that an area is set aside for these legume plants.
- If there is a shortage of land, like in Malawi or close to the big towns, a system of alley cropping should be used. This means that the legumes are grown in between the other crops. This system is best if rainfall is at least 1000 mm. If there is less rainfall, and there is no irrigation, fewer legumes should be planted, or they will take too much water from other crops.

Introduction

The yields on small farms in Southern Africa are low. There are many reasons for this:

- lack of productive varieties,
- losses to diseases, insects, birds and animals,
- lack of knowledge about the importance of crop rotation, erosion control, water harvesting methods, increasing organic matter in the soil, composting, etc.,
- lack of funds for inputs such as fertilizer, lime, pesticides.

This section describes some of the so-called "agroforestry" systems. These are systems where trees are grown together with the other crops.

Systems which:

- are simple to use,
- require little input other than labour and the first seeds
- are easy to adapt to the local conditions
- benefit the farmers by supplying firewood and animal fodder, besides increasing the yields,
- can be expanded and spread to others by collecting and using the seeds from the legumes.

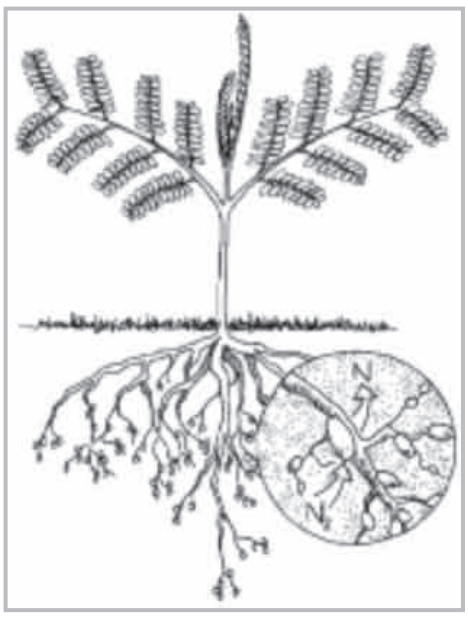
Agroforestry systems are especially useful for farmers in areas where there is a shortage of firewood and where they need fodder for animals. Many farmers in Southern Africa have access to more land than they can farm, and the system of improved fallow can thus be a good alternative.
Fallows have traditionally been used to let the soils rest (for many years) to regain their nutrients.

Leucaena - very good as fodder plant

Improved fallow consists of growing legume plants on a field for two or three years,

before beginning to grow traditional crops again. The advantages are:

- The deep roots bring nutrients up to the surface of the soil, which the traditional crops would otherwise not be able to reach.
- The roots and leaf material from the legumes will add organic material to the soil as they decompose. This improves the conditions for beneficial microorganisms, worms, etc., and its ability to retain water and nutrients.
- Leaves and twigs can be cut for animals and provide fodder in the dry season, when there is no fresh grass.
- Trees help to reduce the destroying forces of heavy rains and protect the soil from erosion.
- Firewood is produced.



Bacteria in nodules on the legume roots fix nitrogen from the air

In Zambia more than 15,000 farmers have taken up the improved fallow system, and even with the drought in 2002, the average yield of maize grown with this system was 3.4 T/ha. Other small farmers who used neither fertilizer nor improved fallow harvested only 1.3 T/ha.

The improved fallows also produce up to 10 T/ha of fuel wood per year. This can greatly help women (and men fetching firewood) in areas with large distances to firewood. The system thus helps to preserve the woodlands around the villages.

The twigs can be cut for animal fodder. This is very nutritious food, and 2-3 T/ha of fodder can be harvested every year.

Microorganisms that live in nodules on the roots of legume plants can use the nitrogen from the atmosphere and transform it into nutrients (ammonium), which the plants can use.

Nitrogen is the important element in proteins, and this is why legumes such as beans, peas, etc., have much higher protein content than other plants. It is possible to see the small nodules on the roots. The inside of the nodule is red in colour if functioning correctly. If they are not red, then the correct bacteria are missing in the soil, and these should be mixed with the seeds. This is called inoculation. One can obtain these bacteria by mixing the seeds with soils where the nodules are red. Because of this system of fixing nitrogen, many legumes can grow on nutrient-poor soils.

Instruction

How to make an improved fallow with leguminous trees:

The first thing to find out, is which tree is best suited for your area.

Most of Southern Africa has poor soils, a long dry season, and a shorter rainy season with less than 1000 mm of rain. Many of the commonly used agroforestry crops are adapted to these conditions, because they can fix nitrogen and because they have a deep root system.

The legume mostly used in these areas is Sesbania sesban. It provides good fodder and firewood while increasing the yields after the fallow considerably. It is quite easy to remove, when the field is again needed for food production.

The local agricultural workers will know if any agroforestry trees have been introduced in the area. Many NGOs are also using them in their projects, and may be able to supply seeds if they are not locally available. ICRAF (International Centre for

Research in Agroforestry) is active in many countries of Africa. Otherwise it is normally possible to obtain seeds from the national or regional forestry departments.

The amount of rain in the specific area is important for deciding how many leguminous trees can be planted. The less rainfall there is, the fewer trees should be planted.
It is best to start the fallow system in an existing crop of cereals because as these grow taller, they will not be out shaded by the trees.
This system will not reduce the cereal yield, but gives the trees a chance to get well established.

Conditions for living systems always vary and trials should be made to determine row distances, direct seeding/nursery, etc., best suited for your specific area.

Improved fallow with *Sesbania sesban*

- Sow Sesbania four weeks after half of the maize has emerged.
- If you have few seeds, raise them in a nursery 1- 1½ months before the rainy season, and plant them when they are 3 months old, between the maize rows.
- The distance between the rows should be 1-2 metres. The better soil and more rain, the less distance.
- The distance between the trees in the row can be 0.5-2 metres.

Sesbania sesban
- Regrows well when cut back. It is best to leave 25 % of the leaves.
- Do not cut it to less than 1 metre.
- Do not cut more than 4 times a year.
- Good fodder for goats, sheep and cattle, but it should not be more than 20% of their food.
- Do not feed it to chicken, pigs or rabbits.
- Let the Sesbania grow during the next one or two rainy seasons, depending on the need for the land.
- Collect the seeds and use them for the next fields.
- Sesbania cannot grow if the soil is very sandy.

Sesbania sesban - a useful plant to improve soil fertility and provide firewood

The twigs can be used as fodder or to cover the soil (mulch) or as fertilizer. Some Sesbanias are annual. They die after a year. Others live from 4 to 5 years and produce much fuel wood.

Improved fallow with pigeon pea

Pigeon pea is well suited for dry areas and poor soils.
- Plant the pigeon pea at the same time as the cereal.
- Plant them between each of the cereal rows.
- Let the pigeon pea grow during the next one or two rainy seasons, depending on the need for the land.
- Do not use this system close to cashew trees, since pigeon pea is host for the cashew pest - tea mosquito bug.

Pigeon pea - efficient for improved fallows

Pigeon pea - *Cajanus cajan*

- Pigeon pea is widely used as food (in India - dahl).
- It has high levels of vitamin A and C.
- It can be grown under very dry conditions and on very poor soils.
- Yields will be very low if waterlogged for 3-4 days.
- It can produce up to 10 T/ha of firewood on good sites.
- Good fodder for all kinds of animals.

Alley cropping using Leucaena or Gliricidia

This system can be used where there is little extra land available - for example close to towns. It will only work if there is enough rainfall (over 1,200 mm), or if watering is possible. Otherwise the trees will take too much water from the crops.

Gliricidia - when there is more rain, and also for live fencing

Alley cropping means that hedges of legumes are kept permanently in the fields. The trees are cut down (pruned) regularly to keep them from shading the crop.

The pruned leaves and branches are used for fodder, mulch or firewood.

On sloping land the hedges should follow the contour to reduce soil erosion. On such locations it becomes more important to prune the hedges to prevent shading the crops.

On flat land the hedges should run east-west to reduce shading.

Establishing an alley system with Leucaena or Gliricidia

- Raise the seeds in a nursery 2-2½ months before the start of the rainy season.
- Leucaena seeds need pre treatment stirring for 3 minutes in 80° water.
- Plant the trees just after the maize has been sown.
- Gliricidia can be raised from cuttings.
- Prune the tree to 60 cm next year when the maize is sown- but only if it is well developed.
- Use the prunings as mulch - that is to protect the soil.
- If growth is fast, the legumes should be pruned 1-2 times while the maize develops.

22 • Soil Conservation

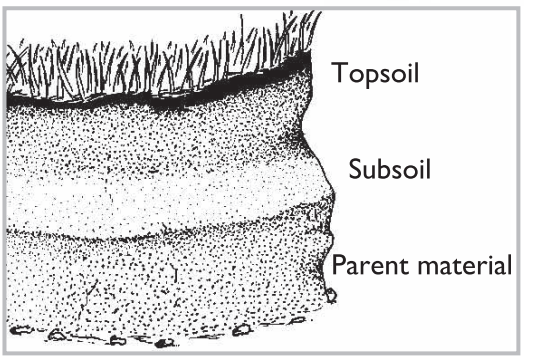
Introduction

A natural forest that is not disturbed by felling trees, ploughing of land, burning or killing of animals and insects, can be considered to be in balance. However, this natural balance does not apply to most land under cultivation, because most agricultural practices disturb the natural balances.
Too often this results in loss of soil through erosion and also reduces soil fertility. However, with good farming practices, much can be done to restore soil fertility. Soil conservation includes all the agricultural practices that are employed in maintaining or improving the soil. It is necessary to learn about some of the soil and crop management practices that lead to soil infertility, in order to avoid them.

Soil Structure

Topsoil
The first layer of soil is called topsoil. It is dark, because it contains humus. Humus consists of materials from dead plants and animals that are partly decayed.
The more humus there is in the topsoil, the more fertile the soil is. This is because humus binds nutrients and water and it gives the soil a good structure so that air and water can penetrate.
Topsoil is therefore an important layer.
The crops that we grow have most of their roots in this layer. This is where they get the nutrients and water they need for growing.
The topsoil layer is often 20-30 cm deep.

Subsoil
Subsoil may be very shallow or very deep. It is lighter in colour and does not contain as many nutrients as topsoil.



A fertile soil forms a darker topsoil over the subsoil

What is soil erosion?

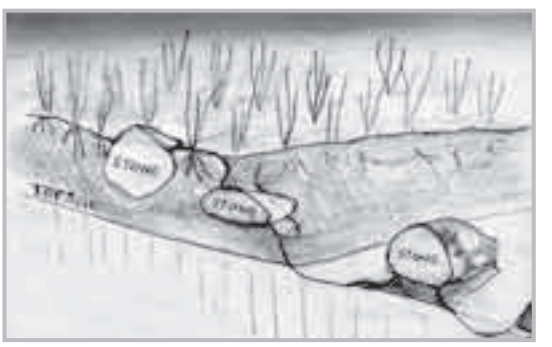
Soil erosion occurs when soil is moved away by either wind or water. Every year thousands of tons of good topsoil is washed away from the fields. In Malawi it is estimated that on average 35 Tons of topsoil is washed away per hectare of farm land. This costs Malawi over 300 million US$ in lost nutrients every year.
Soil erosion especially takes place where the soil is bare and it is worst on slopes and hillsides.
Wind erosion is mainly a problem in dry and flat areas with little vegetation.

Types of soil erosion:

Rill erosion is often seen in fields. It looks like a network of very small streams that take away the fertile topsoil. Crops will not grow well in these conditions.

Gully erosion
If the rill erosion is not stopped this can develop into large gullies. They are easily seen and can quickly become several metres wide and deep. They look like big rivers in the landscape and make it impossible to use animals to till the field.

Sheet erosion removes the fertile topsoil. Small stones are left on top of the surface



Sheet erosion
This is more difficult to see; it means that a small layer of topsoil is lost all over the field. This often happens due to wind erosion. Sheet erosion can be identified by looking for stones that are raised above the remaining surface. This is because the topsoil has been washed away and the small stones remain.

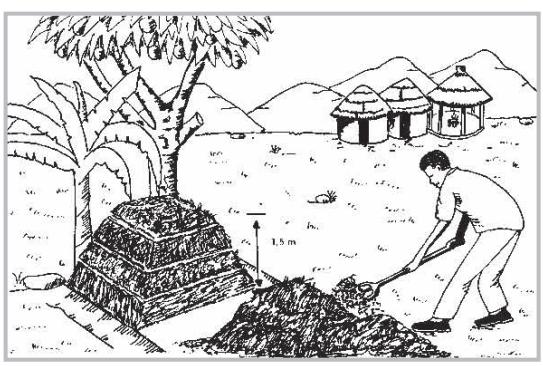
Farming methods that cause soil erosion

1. Overgrazing
Overgrazing is a big problem in many parts of Africa. Too many animals, especially cattle and goats, graze on very small pieces of land, thus destroying the vegetation, which in turn causes soil erosion.

2. Lack of soil organic matter
Soil that contains humus (organic matter from dead plants and animal, which are partly decayed) is more resistant to erosion. Humus works as glue that binds soil particles together in clumps. These clumps do not easily wash or blow away. Soil with organic matter behaves like a sponge when absorbing water. Therefore, the soil is less exposed to erosion when it is given organic matter.

Compost heaps are best suited for humid areas

3.Tillage
Tillage increases the risk of soil erosion. This is because tillage crushes the soil and thus produces large amounts of powdery material. After ploughing, the soil lays bare. When the raindrops hit the bare loose soil, mud is formed, which easily washes away.



4. Mono cropping
Planting the same crop on the field year after year reduces soil fertility, because the same crop removes the same nutrients from the soil.
Mono cropping also builds up diseases in the soil, which reduces the yield.

5. Ploughing across contours
If ploughing is done across the contours (up-down) even on slightly sloping fields, it can lead to severe erosion.

6. Cultivating on steep slopes
Farming on steep slopes without constructing contour bounds or terraces will lead to severe erosion.

7. Lack of windbreaks around big fields
This will lead to wind erosion. Especially if the field is tilled and lies bare.

How to conserve soil and improve fertility

1. Make and use compost
Compost is a source of organic matter for the soil.
It is best to place compost into the planting holes or mix it into the ground in order to avoid loosing valuable nutrients. Mixing the compost into the soil will also improve the soil structure because it will increase the soil's ability to retain water and provide valuable nutrients.

2. Use animal manure on the field
Animal manure also provides nutrients that help to maintain soil fertility, but more nutrients are made available to the plants if it is first turned into compost.

3. Plant windbreaks

Plant windbreaks on the side of the field, where the wind blows from. This will prevent the topsoil from blowing away.

4. Use crop rotation

Crop rotation will make the soil more fertile. Crop rotation means that the farmer does not plant the same crop in the field every year.

An example of good crop rotation:

First year maize, second year cotton, third year groundnuts, fourth year maize. The crop rotation must include legume crops, because they will improve the soil fertility. Furthermore, crop rotation secures that organisms carrying diseases do not accumulate in the soil and this will help to keep the crops healthy.

5. Contour ploughing

This is ploughing along the contours. It is very important to prevent rain water from washing the soil away. It is only when the land is totally flat, that it is not necessary to use contour ploughing. In order to find the contours, the farmer can make and use an A - frame.

Making an A-frame

The A-frame consists of 3 straight sticks e.g. bamboo.

The two legs are cut to exactly the same length. The stick across is placed exactly on the same height from the ground on both legs.

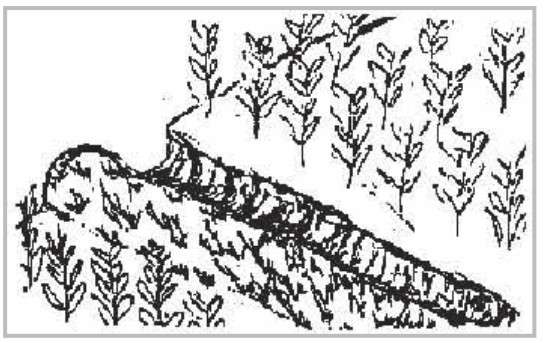
The 3 sticks are nailed or tied together with fibre or string. A mark is made exactly in the middle of the stick across.

A string with a stone at the end is tied to the top of the frame. When the rope hangs over the mark on the horizontal stick, then the two feet are placed at the same level.

6. Contour bunds

In sloping areas the farmer ought to construct contour bunds. These can be made of soil or rocks. They can also be made by planting vetiver along the contour lines. Soil will then gradually accumulate in front of the vetiver hedge and form a natural terrace.

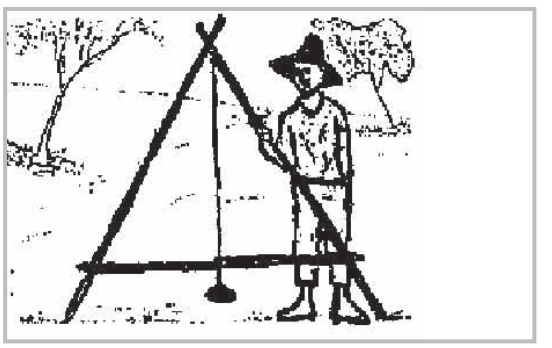
The contour lines can be measured with an A- frame.



A furrow and a bund to stop rainwater flowing downhill

7. Plant vetiver grass

Plant vetiver hedges across gullies and around dams in order to protect against erosion.

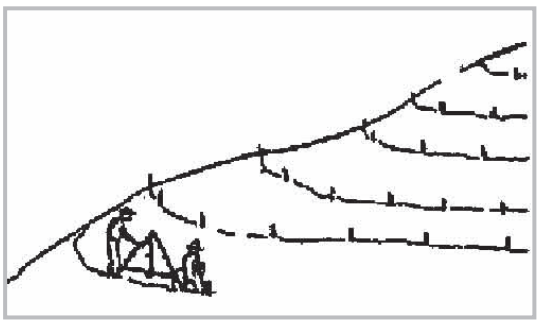


The A-frame

8. Practice minimum tillage

Minimum tillage ensures that the soil is not broken down into very small particles that can easily be blown or washed away by rain.

Minimum tillage can be done using permanent planting holes dug with a hoe, ploughing or with ripping the lines for planting with draft animals or a tractor.



Marking the contours with an A-frame

9. Avoid burning

Never burn crop residues.

Chop them and spread them all over the field. This will protect the soil against the destructive action of the rain drops. It will at the same time provide the soil with organic matter, which will improve the soil fertility. Avoid late burning of the bush, because it will leave the soil bare. Early burning or no burning must be practiced

Follow the contour lines to prevent the water from running off

10. Use improved fallowing

Degraded land can be rehabilitated by using the system of improved fallowing (see section 21). The roots of the legume tree will have broken hard plough pans and brought up new nutrients which the normal crops cannot reach. The roots and leaves will also have improved the soil's fertility.

11. Leave Msangu trees in the field

The msangu tree grows in many parts of Southern Africa, and can with good result be left in the fields. The tree fertilizes the soil and it does not compete with the crops for light since it drops the leaves at the start of the rain season. Maize and sorghum grown under Msangu trees give very good yields. (see more in section 50).

23 • Rainwater Harvesting with Vetiver

Idea

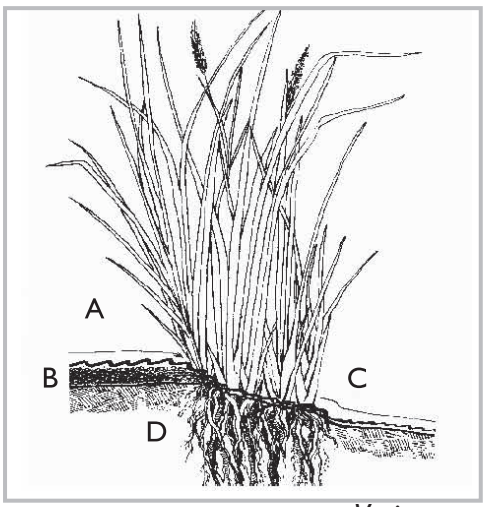
The idea is to improve your crops by getting more rainwater to stay in the soil instead of running off. This is done by growing vetiver hedges which at the same time reduce soil erosion.
Water running down a sloped field carries much topsoil. It is retained by the vetiver grass (A, in the picture) and most of the topsoil is deposited there (B). Some water runs through the hedges (C). The deep roots - 2 or 3 m - hold the plant firmly to the ground (D). The roots also open up the ground, so that more of the rainwater penetrates into the ground - it is "harvested".

Introduction

Most farmers in the developing world are totally dependent on rainwater. Most of Southern Africa has one rainy season where it is possible to grow crops, and a dry season where only the few with irrigation can produce.
Vetiver hedges enables farmers to harvest rainwater so they can grow vegetables/ crops for a longer period.
This works two ways:

- Rainwater running on the ground is stopped or slowed down.
- The big root system opens up the soil and enables more water to penetrate into the ground.

The vetiver hedges must be planted in contours (same level) with 10 metres between hedges. They will efficiently stop soil erosion, which in a country like Zimbabwe has been calculated to annually remove 50 tons of soil per hectare per year. This not only creates problems in neighbouring Mozambique (floods) but with this soil many nutrients are lost, which could have been used by the crops.
The extra water in the soil will extend the growing season or make it possible to grow crops that need more water.
The system can even be used in very dry areas by planting vetiver hedges in the dry river beds. It will be possible to grow crops behind the hedges in the period after the short rainy period. The vetiver grass will survive periods of flooding.

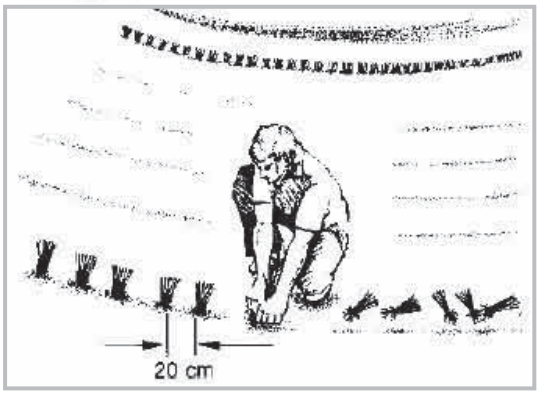


Vetiver grass. Description of A-D in the text

Start making the system in a small area, so you find out the best ways of growing vetiver under your conditions, and so you can see that it works.

Instruction

How to make a vetiver nursery:
A vetiver nursery is best made in a humid area, that is too wet for normal farming. It can also be made on a small scale by using wastewater from the kitchen, bath, etc (see section 41 about waste water cleaning).
Vetiver is very easy to grow and can grow under nearly all conditions.
If you have little water for watering it is best to grow the plants first in plastic bags. If there is enough water, plastic bags are not needed and they can be planted directly in the ground.



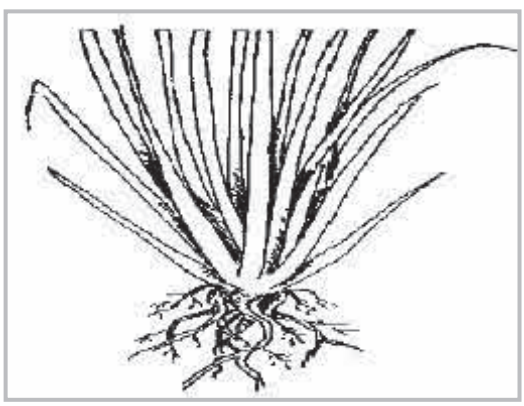
Plant with 15-20 cm between the grass tillers

If you do not know anyone who has vetiver plants, find suppliers at "The Vetiver Network" ***www.vetiver.org.*** Or contact the GAIA-Movement.

A vetiver nursery

Start by getting some vetiver plants. If you have to transport them, keep them out of the sun and with the roots in water.

- Cut the leaves at 20 cm and the roots at 10 - 15 cm.
- Mix cow dung (or compost or clay) into a bucket of water.
- Place the vetiver with the roots in the bucket.
- After 4-5 days in the shade small new roots are seen.
- Separate the tillers and plant in polybags (plastic bag with small holes used in nurseries).
- The better soil or compost in the bag the better.
- If available add some fertilizer.
- Water them daily.



Vetiver tiller ready for planting with leaves cut to 20 cm, and roots to 10 cm

After about one month the plant should have at least 2 new shoots and is ready to plant out. Before planting them out they must be hardened. This is done by reducing watering.

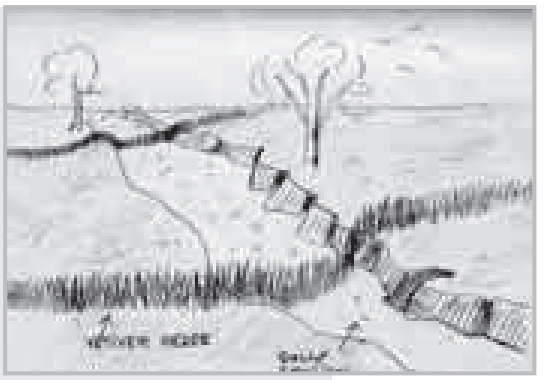
Planting contour rows in dry areas

- Plant them in the beginning of the rainy season.
- Prepare the contour lines for the hedges by using an A-frame.
- If possible, avoid planting them in the shade.
- Make a small ditch 10-20 cm deep - this will give the plants some more moisture.
- If you do not use polybags, dip the roots in mud slurry (mud mixed with water) so they do not dry out while you are planting. Cover them with wet sacks, and plant the same day.
- Planting distance should be no more than 15 cm.
- Plant 3 tillers in each hole.
- Plant so the pale greenish area at the bottom of the leaf base is just covered.

If there is no rain, water every second day until the plants are growing well. Water at least 2 times per month during the first dry season or if the rains fail.
When they grow well it is good to trim the plants to a 50 cm height. This makes them grow new shoots and close the hedge.

Pictures and information from:
- Vetiver Grass Fact Sheet from "Natural Resources & Mines" Queensland, Australia
www.nrm.qld.gov.au/factsheets
- DAPP in Zambia
- CARE/WWF/Helvetas - Presentation on Conservation Agriculture

Example of Malawi - from the website www.vetiver.org



Vetiver grass planted to restore a gully.

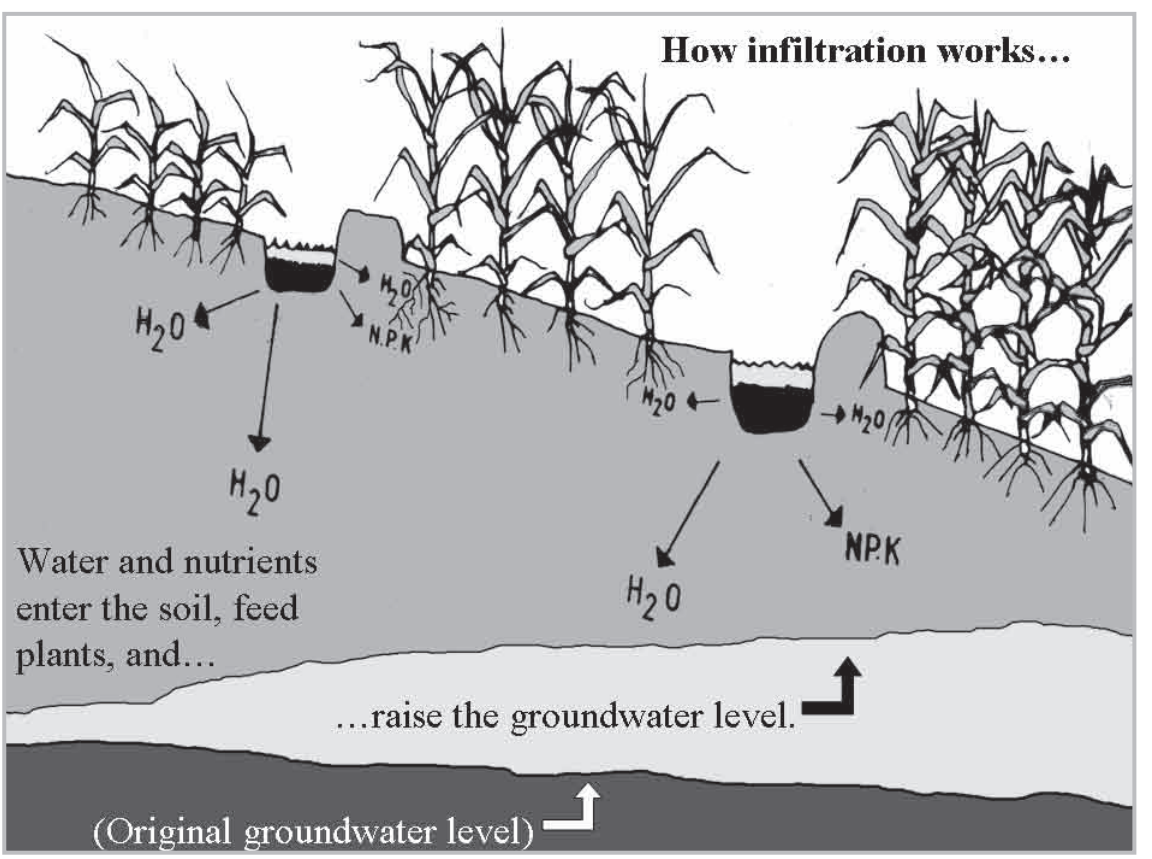
"An example of how contours and vetiver grass, put in 3 years ago, and now fully effective, have enabled food crops to be harvested, even in a drought year.

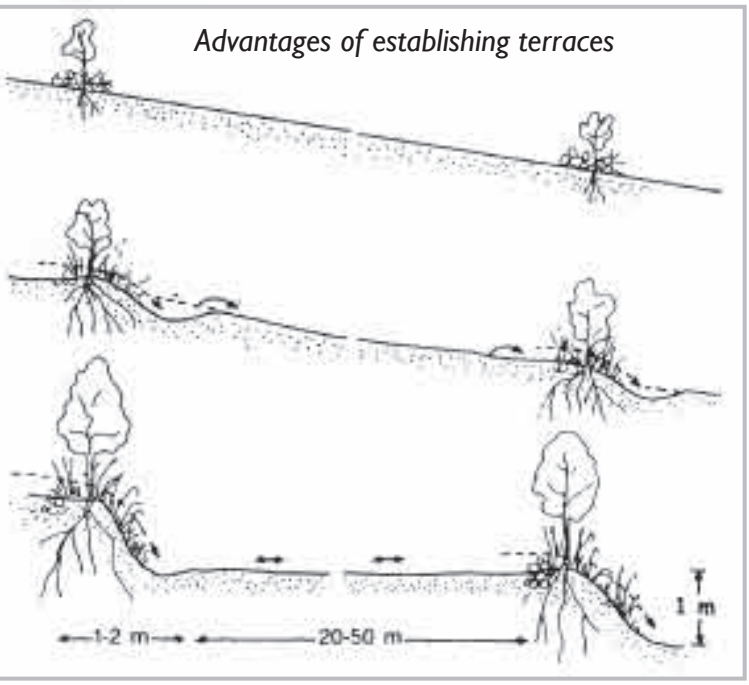
Travelling farther westwards within the Kaluluma EPA, we came to Kachilakwanya village, which in the past had suffered from very deep gully erosion, due to the torrential force of water run-off from adjacent hills, and the deep red soils here which eroded easily once the vegetation on the sloping soil surface was removed.

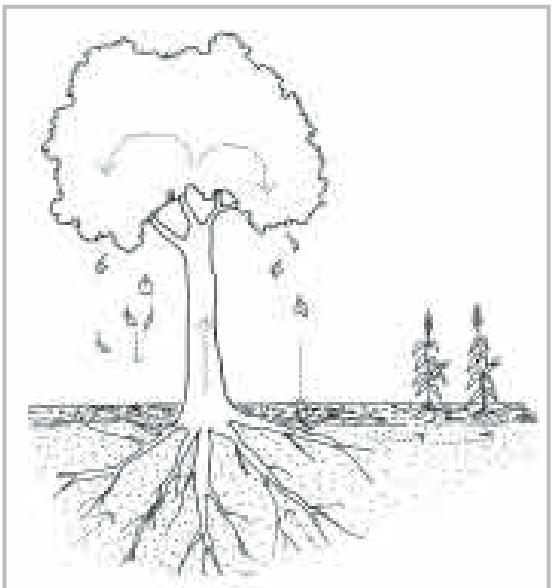
Cohen Sichinga had come here previously, in 1999, had seen the awful problem of increasing erosion, and then took on the huge task of surveying the whole area together with the village people, marking out a total of 11 contours from the hill range downwards, each contour then planted with vetiver grass at a close spacing, the results of which are excellent. In just 3 years, the vetiver grass hedges became tight and continuous, each impressive contour hedge extending for a kilometre or more in length, and many of the original gullies have disappeared completely.

This is a remarkable success story, which needs to be more widely known, for even in an appalling drought year, such as this one, the few rain showers which did come have been harvested, the precious moisture having percolated down into the soil, due to these contours and the vetiver grass, and some food crops have been harvested".

Trench farming also improves water balances

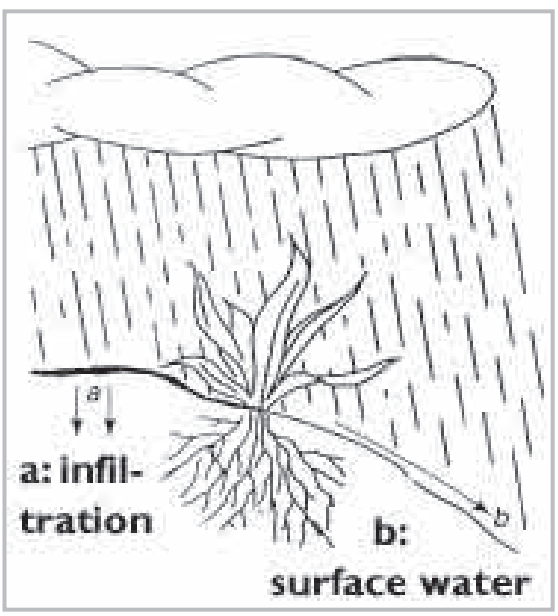






Trees function as "nutrient pumps" - supplying nutrients from deep down to other plants

Trench farming in Northern Mozambique



24 • Vermi-compost

Many people know that earthworms are friends of farmers. They play a crucial role in decomposing organic material because they eat the soil. Inside the earthworms there are perfect conditions for microorganisms, and the nutrients are therefore very efficiently released. Another product is humus, which consists of organic material that is not easy to break down. This improves soil structure and enables the soil to better hold water and nutrients. In addition earthworms make holes in the soil and improve aeration.
Soils with earthworms therefore need less chemical fertilisers. A way to improve soils is to supply vermicompost - a high quality compost made by raising worms on organic waste.

Production of vermicompost

The worms can be raised on organic waste such as cattle manure, kitchen waste, garden cuttings, etc. The waste must be free of glass, metals, etc.

- Make a bed three feet wide and as long as required.
- Make a low cost shelter of hay, grass, etc., at a height of 6-7 feet to provide shade.
- Mix the dung and other organic waste well together and form into a dome shape.
- Water every 5-6 days and turn over the dome every two days.
- Check the temperature of the dung every 5-6 days. When no heat is felt, it is the right moment to add the worms to the compost.
- Add 3 kg of worms to a bed of 10 x 3 x 1.5 feet.
- Cover the bed with banana leaves, or other shading material etc.
- Water (with a watering can) twice monthly during the rainy period and once every day during the dry period.
- The worms are able to convert all the organic waste into vermicompost in 45-50 days.

The worms make vermicompost from the top and gradually go to the inner layers and feed on the waste. Vermicompost is ready when it is black and has a texture like tea leaves.
A maximum of 80% of the raw material used is converted into vermicompost.

Vermicompost is easy to make from cow dung and kitchen wast

Harvesting the vermicompost

- Stop watering the bed when the vermicompost is ready.
- Remove the top layers of vermicompost when they are ready. In the end the worms are left with a small quantity of dung.
- Prepare in the meantime a similar such bed alongside the original bed.
- Use the culture from the first bed to make vermicompost in the second bed.

Precautions

1. Do not compact the waste by standing in the beds, or before adding the worms
2. The vermicompost should be scraped off in a way that the eggs and the worms are not removed and they go down to the lower layers

3. Protect the worms against wild animals and birds.
4. Do not use fresh animal manure to make vermicompost as this will destroy the worms.
5. Maintain moisture in the beds at all times.
6. Avoid sunlight.
7. Harvest the vermicompost by hand. Do not use any tools.

Advantages of vermicompost

1. When compared to farm yard manure, the quantity of actinomycetes (biological organisms) in vermicompost is many times higher and this increases the resistance of the crops to pest attack.
2. Vermicompost improves the moisture holding capacity of the soil and increases the availability of water to the crops.
3. Loss of water through evaporation is minimized when vermicompost is applied. This results in reduced irrigation requirement in the crop.
4. The humus content in the soil is increased and erosion losses due to heavy rains therefore have less impact than in the normal soils.
5. There is a better distribution and availability of nutrients to the crop in soils where vermicompost is used.

More and more Indian farmers are seing the benefits of using vermicompost

Application of vermicompost

10 quintals (1000 kg) of vermicompost are sufficient for one hectare of land.

Information and photos, Humana People to People India,
www.humana-india.org