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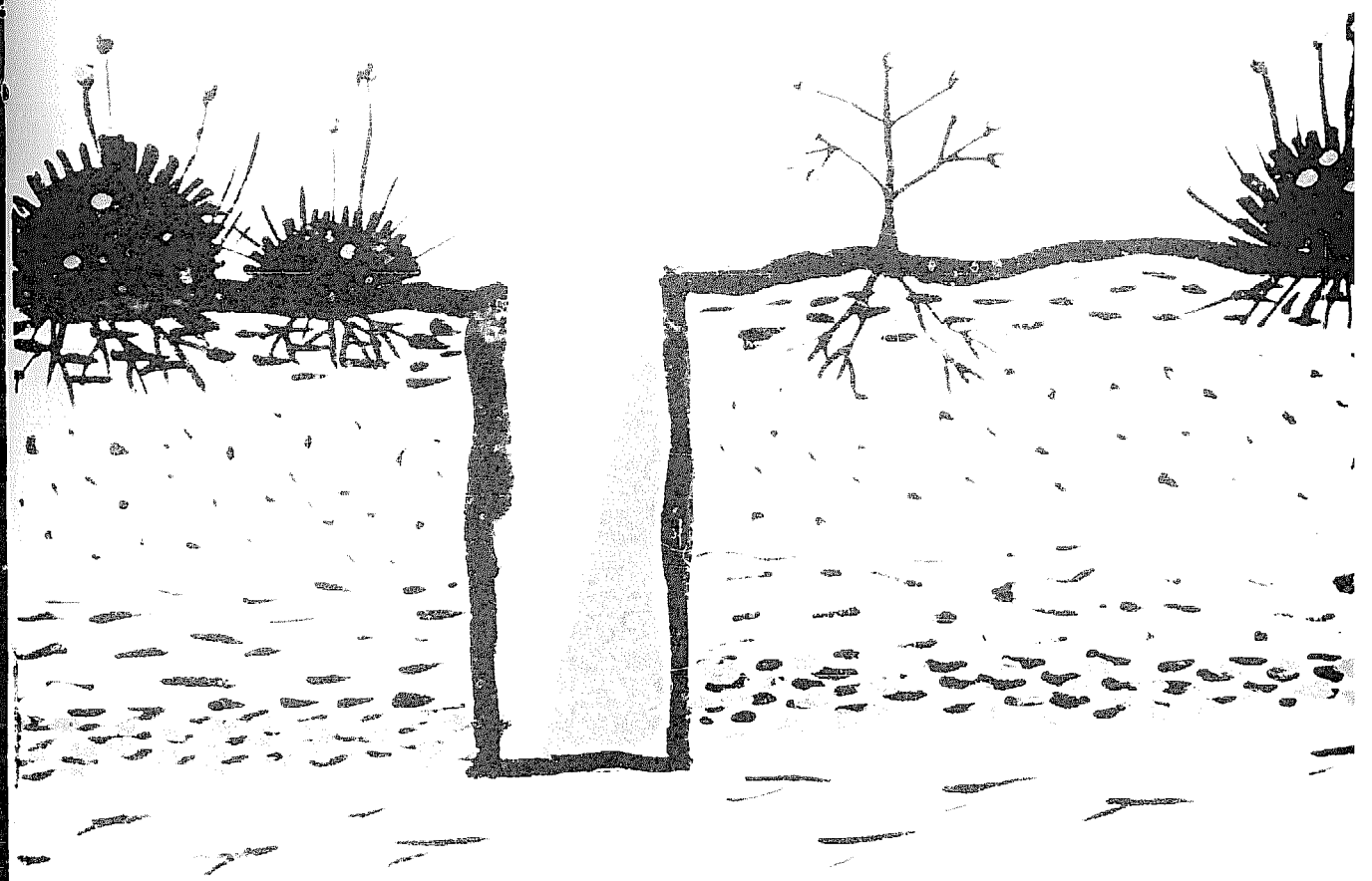
better farming series 4

the soil

how the soil is made up



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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3. The plant: the flower
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5. The soil: how to conserve the soil
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better farming series 4

The soil

How the soil is made up

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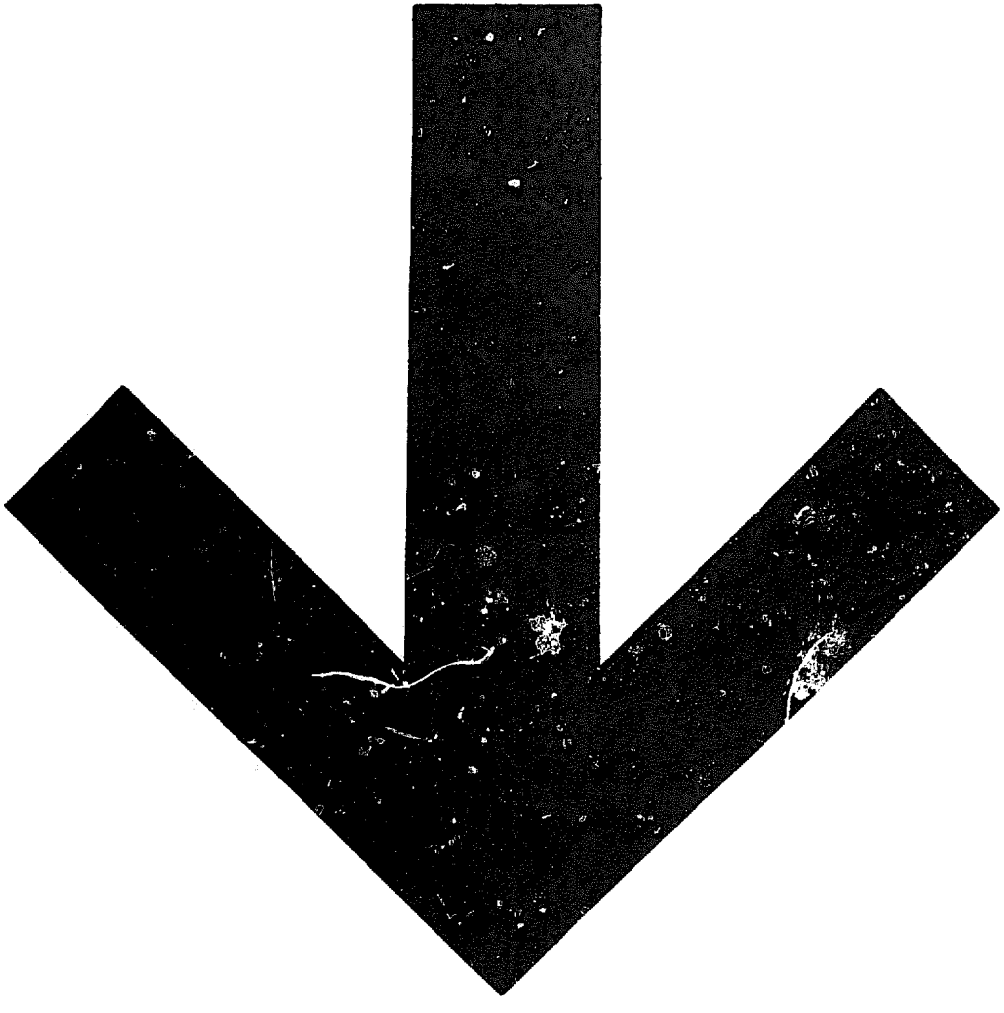
PREFACE

This manual is a translation and adaptation of "Le sol — comment est fait le sol," published by the Agri-Service-Afrique of the Institut africain pour le développement économique et social (INADES), and forms part of a series of 26 booklets. Grateful acknowledgement is made to the publishers for making available this text, which it is hoped will find widespread use at the intermediate level of agricultural education and training in English-speaking countries.

The original texts were prepared for an African environment and this is naturally reflected in the English version. However, it is expected that many of the manuals of the series — a list of which will be found on the inside front cover — will also be of value for training in many other parts of the world. Adaptations can be made to the text where necessary owing to different climatic and ecological conditions.

Applications for permission to issue this manual in other languages are welcomed. Such applications should be addressed to: Director, Publications Division, Food and Agriculture Organization of the United Nations, Via delle Terme di Caracalla, 00100 Rome, Italy.

The author of this English version is Mr. A.J. Henderson, former Chief of the FAO Editorial Branch.



OUTLINE OF COURSE

- **Why we study the soil** 4
- **Different kinds of land** 5
  - The soil 9
  - The subsoil 10
  - The parent rock 10
  - Examples of different soils 11
- **What is soil made of?** 13
  - Soil is a mixture 13
  - Sand 15
    - Sandy soils 17
  - Clay 18
    - Clay soils 20
  - Silt 21
    - Silty soils 21
  - Humus 22
    - What humus does 23
  - Some practical advice 26
- **Air in the soil** 28
- **Water in the soil** 29
  - Circulation of water in the soil 30
  - Practical advice 32
- **Living creatures in the soil** 33
  - Earthworms 33
  - Rats and other animals 33
  - Termites 34
  - Other insects 34
  - Microbes 35
- **Suggested question paper** 37

PLAN OF WORK

FIRST WEEK

Why we study the soil

The soil layers

- Read pages 4 to 12.

Is there a big hole in your village?
If there is, look at it carefully.
If there is not, dig one.

- Compare what you see with the drawings.
  Perhaps you don't see all the layers
  shown in the drawings.
- Take a good look at the part of the soil
  where the roots are.

SECOND WEEK

What is soil made of?

Sand, clay and silt.

- Read pages 13 to 21.
- Do the experiment described on page 13.
  Take a good look at it.
- Learn to see what the soils are like where you live.
  Are they clay soils?
  Or sandy?
  Or silty?
- Do carefully all the experiments shown.

THIRD WEEK

Humus and the soil.

- Read pages 22 to 27.
- To help your memory reread pages 4 to 21.
- Look carefully at the drawing on page 23.
  It will help you to understand.
- Find out what crops make the soil poor in humus.
  How is humus added to the soil?

FOURTH WEEK

Water and the soil.

- Read pages 28 to 36.
- Do the two experiments described on pages 30 and 32.
- Take a good look at the drawing on page 31.
  It shows you all the movements of water in the soil.
- Reread the whole booklet.
- Answer the question paper.

When you have understood fully,
try to answer all the questions.
Do not rush.
Make sure you understand before you write.

WHY WE STUDY THE SOIL

- **In the old days people knew the land very well.**

  They knew how to choose their fields.
  They knew how to work each field.
  They knew when to give their fields a rest.

- **But in traditional farming,**
  people did not produce much;
  they needed very little.

  There were few tools.
  There was little trade.
  People had few needs;
  food was always the same,
  and people did not often go outside the village.

- **Now people have new needs.**

  The number of people grows; they dress better,
  they eat better, and look after themselves better.
  More roads are needed, more hospitals, schools,
  more food and clothes.

- **So farming must yield more.**

  This means that farming techniques must change;
  farmers must evolve;
  farmers must produce more.

- **To produce more food, farmers must**

  know their fields better;
  choose their fields well;
  work their fields well;
  conserve and improve their fields.

All land is not the same; every piece of land
has its qualities and its defects.

DIFFERENT KINDS OF LAND

There are several kinds of land, for example:

cultivated land – the fields that are farmed;

cultivable land – fields that can be farmed
only if they are cleared;

land that cannot be farmed,
because nothing grows on it;
you cannot farm stone or laterite.

WHAT IS THE LAND LIKE IN YOUR VILLAGE?

In your village maybe a hole has been dug,
in order to make a well,
or to get earth to make bricks.

Or maybe a ditch has been dug between two fields.

Let us dig a hole ourselves.

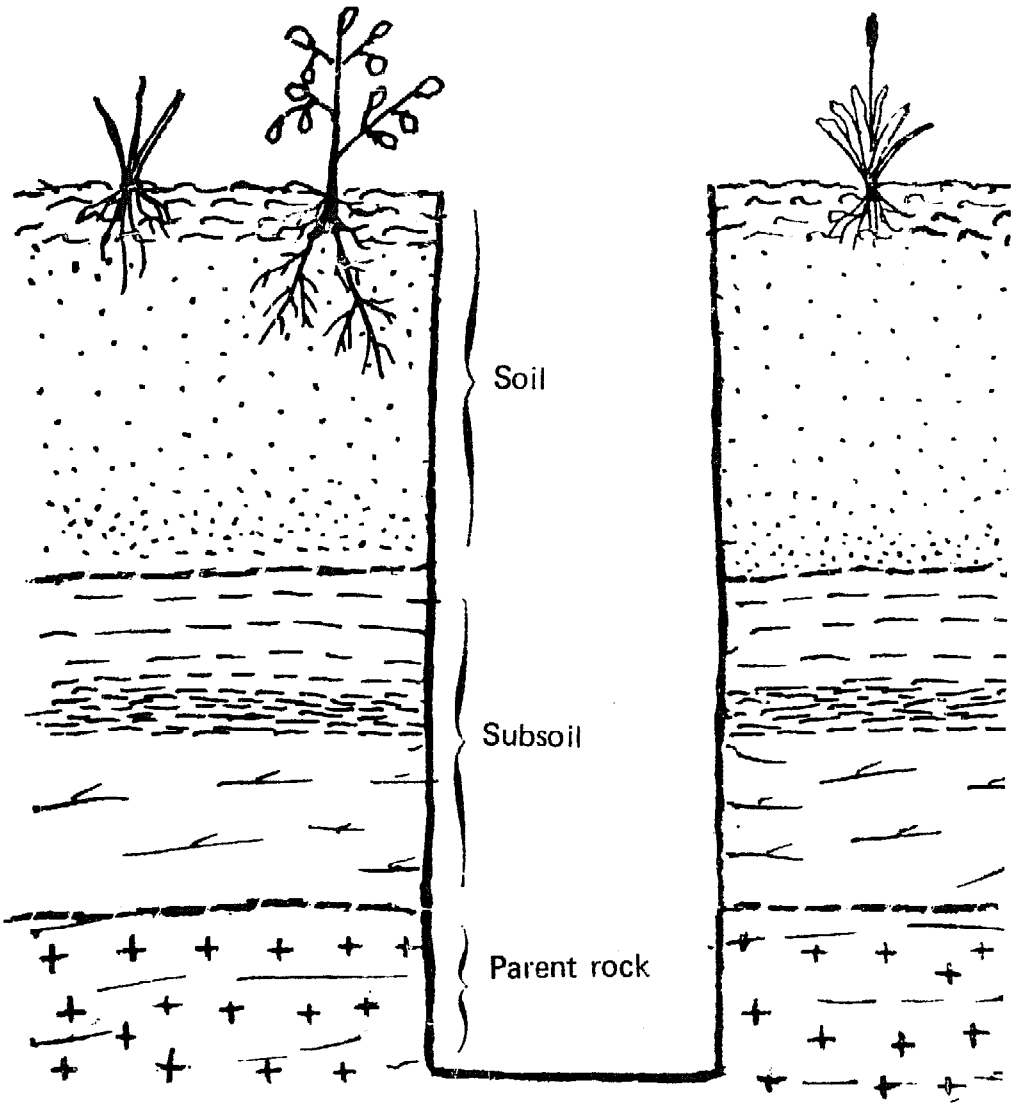
Let us dig it **deep,**
and **quite straight.**

What do we see?

The soil is made up of different kinds of earth,
of different layers.

These layers

- are not of the same colour;
  that on top is often darker.
- are not of the same depth.



By making a hole you can see the layers of soil

- In the first layer
  we find roots;
  this is the soil.

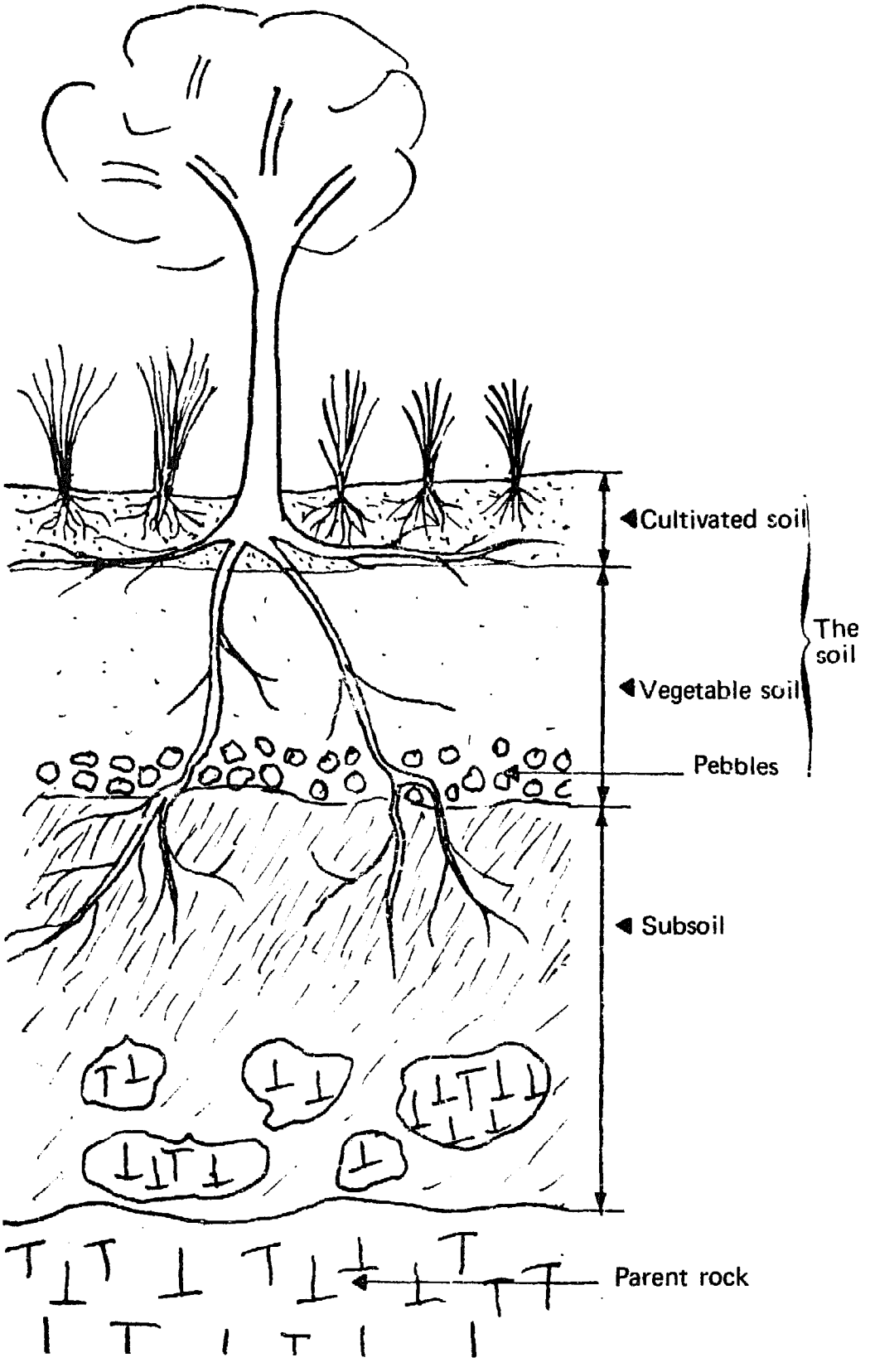
The soil is the layer of earth
where roots find their food.
The soil is more or less deep.
The soil is more or less rich in food.

- Below the soil is a harder layer.
  It is difficult to make a hole in it.
  This is the **subsoil.**

- Even deeper is rock,
  called the **parent rock.**

Sometimes you can very clearly see
the difference between two layers.

Sometimes the layers are alike.
You cannot see the difference very clearly.



Good land: it has deep soil

The soil

Let's take a look at the hole we dug.

The earth where we find roots is the soil.

The soil has several parts.

- On the surface is the **cultivated soil.**

  This first layer is what we work;
  we turn it over with a hoe or a plough;
  we pile it up in mounds or ridges.

  In this layer you find living roots,
  for example, creeping roots (see Booklet No. 1, page 22)
  or fibrous roots (see Booklet No. 1, page 21).
  This is where they find their food.
  You also see dead roots and rotting leaves and stems.

  The more this layer is deep and rich,
  the more fertile the soil is
  and the finer the plants are.

- Below this layer is the **vegetable soil.**

  It is often lighter in colour
  and contains more sand.

  Tap-roots go through this layer
  when it is not too deep (see Booklet No. 1, page 23).

  There are often little pebbles
  below this layer.

The subsoil

The subsoil is often very deep.

It is always very poor.
It has little mineral salts (see Booklet No. 1 page 19).
It is hard and difficult to dig.

It is here that tree roots
find their water during the dry season.

The parent rock

Below the soil and the subsoil
we find **stone** or **rock**.

This rock is very hard.
It changes very slowly into earth.

This is the **parent rock.**

Note

Fields are very different one from another.

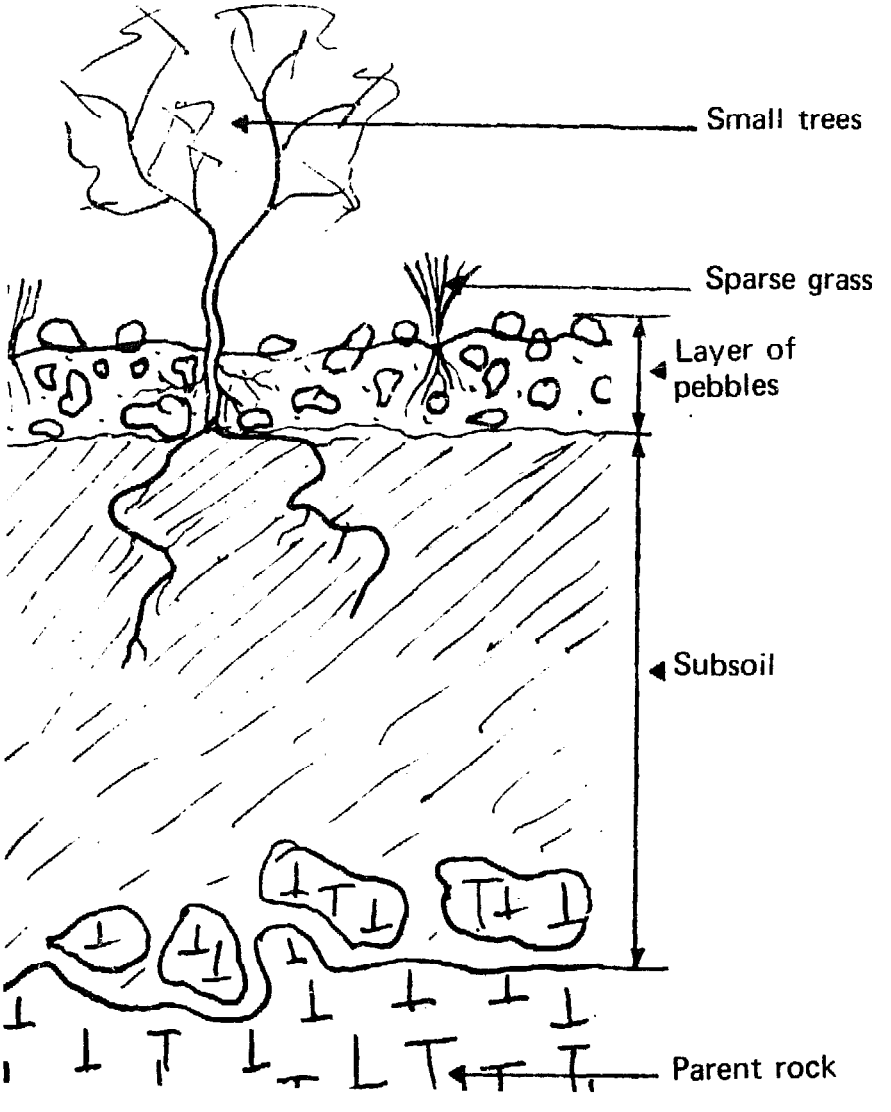
The depth of the different layers varies a great deal.

Some layers may be missing altogether.

EXAMPLES OF DIFFERENT SOILS

- **Savanna soils**

The depth of soil varies a great deal.
Often the soil is missing.
You can see the pebbles.



Bad savanna soil

The subsoil is **very unstable.**
It may become **very hard.**
Then a **hardpan** forms.
Roots cannot penetrate it.
Nothing can be grown on it.

- **Mountain soils**

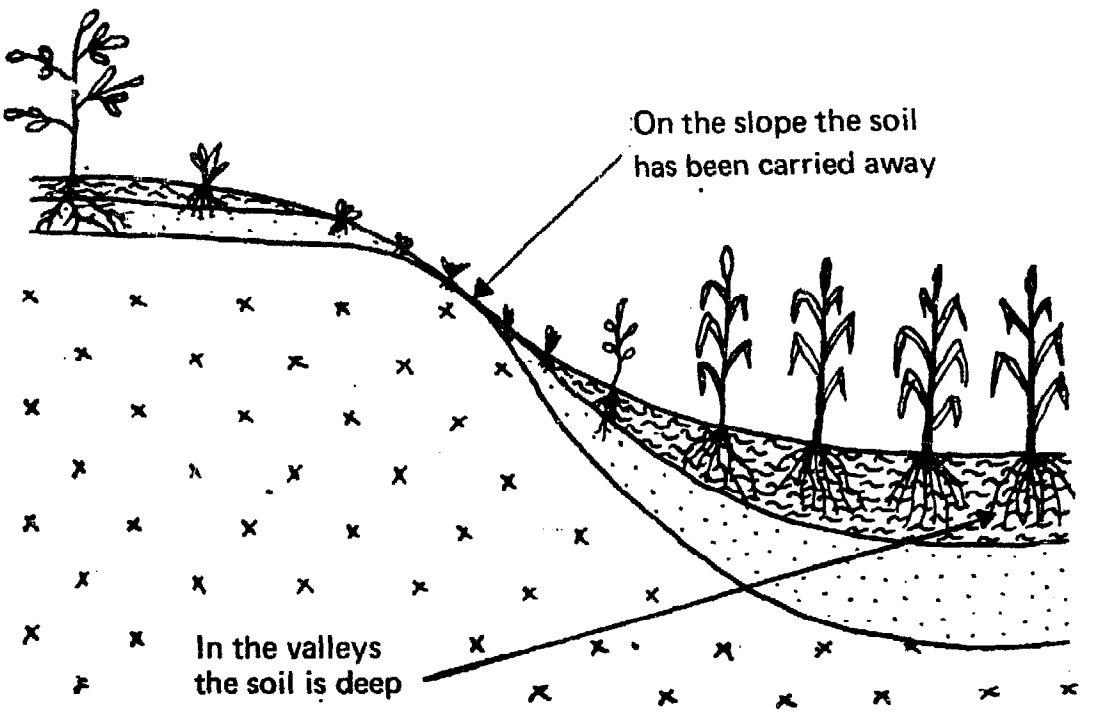
In the mountains there is often
neither soil nor subsoil.
You can see the parent rock and nothing grows.
If there is a little soil on the parent rock,
a few small trees
and some grass grow among the stones.

- **Forest soils**

The soil is rich.
The subsoil is always very poor;
it contains no mineral salts;
it does not become hard
and does not form a hardpan.

- **Soils of the same village**

In various fields of the same village
the layers of soil can be very different.
On the slopes, for example,
the soil may have been carried away by the rain.
That is why the soil
is deeper in the valleys.

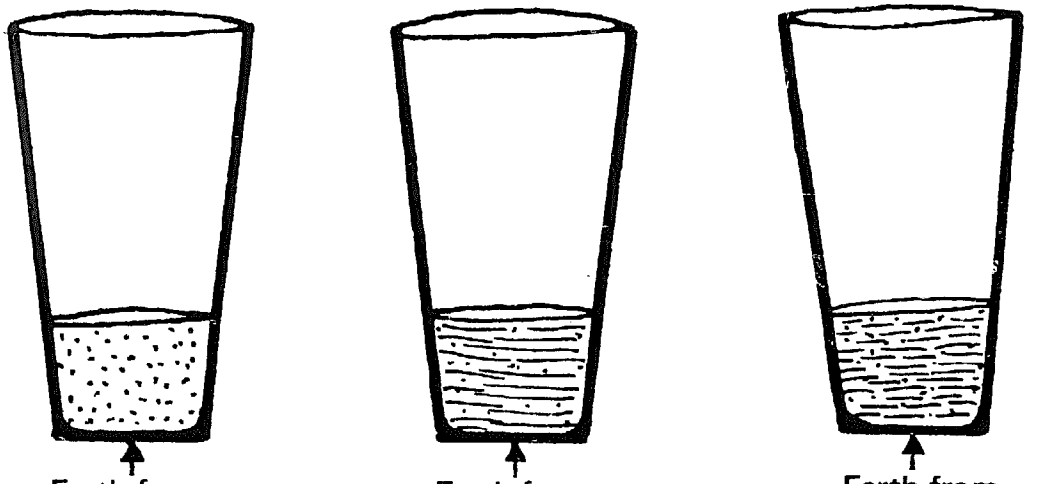


WHAT IS SOIL MADE OF?

Soil is a mixture.

Get a little earth from a valley,
from a plateau
and from the side of a slope.

Put the earth from each field in a different glass.
(If you haven't got glasses, use empty bottles.)



Earth from first field

Earth from second field

Earth from third field

- In each glass or bottle

  put two fingers of earth.
  Fill up with water.

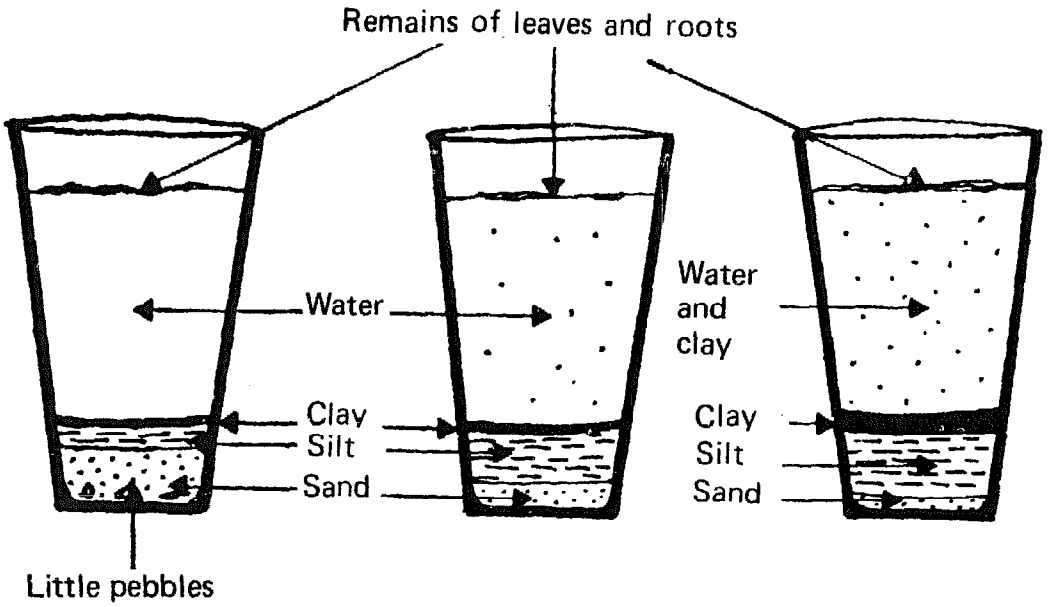
- Stir the mixture well in each glass.

  Put it down and do not touch it for five minutes.

- Stir the mixture well in each glass once more.

  Put it down and do not touch it for an hour.

An hour later, what do we see?



The earth has dropped to the bottom of the glass and the water is clear.

Look at the earth: several layers have formed.

- At the bottom of the glass there is a layer of **sand** and some little pebbles.
- In the middle is a layer of **silt.**
- Above is a thin layer of **clay.**

If the water is not clear.
that is because clay is still mixed with the water.

- On top of the water float pieces of leaves and roots. The leaves and roots rot and form humus.

Thus the soil is a mixture.

SAND

Sand is found everywhere.

Rain carries sand into hollows and streams.
It is then white or yellow and shining
because it is clean.

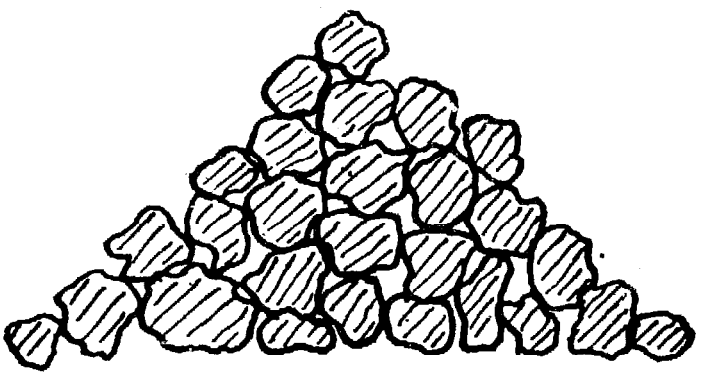
In the soil, sand is grey and does not shine,
because it is mixed with earth.

Let us take a closer look at some sand.

It is made up of **little grains.**

These grains are not all alike.

They are **very hard.**
If you rub a piece of iron with them,
they scratch the iron
because sand is harder than iron.



Grains of sand

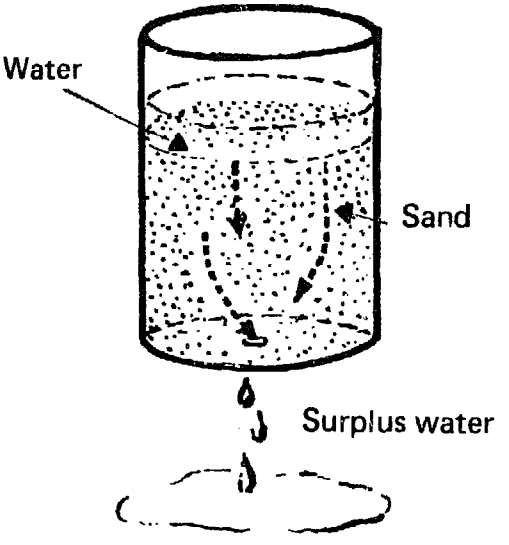
- **Sand is permeable.**

Take a can.

Make a hole in the bottom of it.

Fill the can with sand.

If you pour water on to the sand, it goes through.

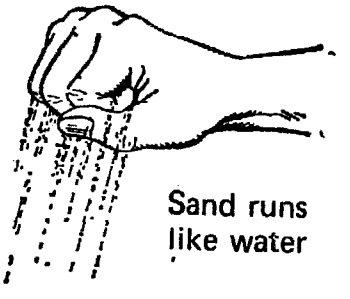


We say sand is **permeable** because it **lets water through.**

- **Sand is unstable.**

Take some dry sand in your hand and let it run gently.

The grains slide over each other; you cannot make a ball of sand.



- **Sand in the soil.**

Almost all soils contain sand.
Soils that contain a lot of sand are called **sandy soils.**

SANDY SOILS

Like sand itself, sandy soils are:

- **permeable.**

When it rains on sandy soil,
the water passes through easily.

You can walk on sandy soil after rain.
Sand does not stick to the feet like clay.
Sand does not make mud. It is

- **easy to work.**

After the first rains,
sandy soils are easy to work;
they do not stick to tools like clay.

Sandy soils are called **light soils.**

- **unstable.**

The grains of sand do not stick together.

In the rainy season,
water easily carries them away.

In the dry season,
the wind can lift them up
and carry them a long way.
In the northern savannas
people speak of a sand wind.

Groundnuts, cassava, yams and coconut trees
grow very well in sandy soils;
the roots easily penetrate them.

But sandy soils hold water and mineral salts badly.

CLAY

Adobe walls and pots are made of earth.
This earth is called **clay.**

Usually the clay is found
in the third soil layer: the red layer.

Because of this,
a hole has often to be dug
to get earth for bricks.

Usually the clay is mixed,
which is what gives it a red
or sometimes a brown or black colour.

When the clay is not mixed,
it is white.
This is **kaolin.**
It is pure clay.
Kaolin is used to whitewash houses.

• Clay and water

Wet clay takes whatever shape it is given,
such as bricks, pots and stoneware jars.

Wet clay sticks to the fingers;
it makes mud.

When it is dry,
clay forms hard lumps.

If you crush a lump of clay,
it becomes dust finer than flour.

When it is dry,
brown or black clay loses its water and cracks.

Red clay also loses its water,
but does not crack.

Red clay can be used
to make bricks and stoneware jars.

If dry clay is made wet again,
it becomes soft and sticky.

If clay is baked,
it becomes very hard.
The stoneware jars keep their shape.

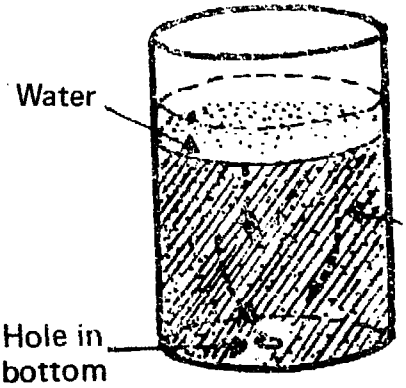
Clay is impermeable.

Take a can.

Make a hole
in the bottom of it.

Fill the can with clay.

If you pour water
on to the clay,
it does not go through.



Water does not go through

We say clay is **impermeable**
because it **does not let water through.**

Clay in the soil

Almost all soils contain clay.

Soils that contain a lot of clay
are called **clay soils.**

CLAY SOILS

Like clay itself, clay soils are:

- **impermeable.**

When it rains on a clay soil
the water does not go through the soil easily.
The water takes a long time to disappear.
You can see the mud. So clay soils are

- **difficult to work.**

Wet clay sticks to the hands.
It also sticks to tools.

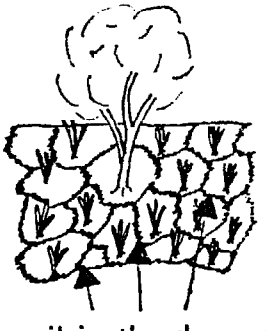
For this reason clay soils
are very difficult to work after the rains.

Clay soils are called **heavy soils.**

During the dry season
clay soils become very hard.
Cracks form in them.

The lumps are difficult to break.

Clay soil in the rainy season.
Water remains in the soil.



Clay soil in the dry season.
Cracks form in the hard soil.

Soils with much clay
are difficult to work
and are often too wet.
Soils with little clay
are easily carried away
by water and by the wind.

SILT

Certain soils are neither sandy nor clay soils.
They are made of silt.

Silt is made up of grains
much smaller than sand grains (see page 15).
Because of this, silt does not let water through
as easily as sand does (see page 16).

Silt does not form dust as fine as clay dust;
because of this
it is not impermeable like clay (see page 19).

Wet silt does not stick like clay.
However, silt can be made into lumps.

Soil that contains a lot of silt
is called **silty soil.**

SILTY SOILS

Like silt itself, silty soils are:

- **not as light as sandy soils.**

The silt grains are closer together
than the grains of sand.
Thus water does not go through so easily;
silty soils do not dry quickly.
They are harder to work than sandy soils.
Wind and rain do not carry them away so easily.

- **less heavy than clay soils.**

Silty soils stick less than clay soils.
They are less hard to work.
They do not crack when dry.

HUMUS

In the soil
there are dead leaves and roots.

They rot
and change into humus.

You cannot see humus
as you see sand, clay and silt.

- **Dead plants change into humus.**

Leaves, branches and dead trees
rot in the soil.
We say they decompose.
Even big trees rot in a few years
on wet soil.

Many worms and insects
live in a rotting tree.
You can often see them.

But other living things cannot be seen.
They are too small.
These are called **microbes.**

There are very, very many of them.
In a lump of earth as big as a lump of sugar
there are millions and millions of microbes.

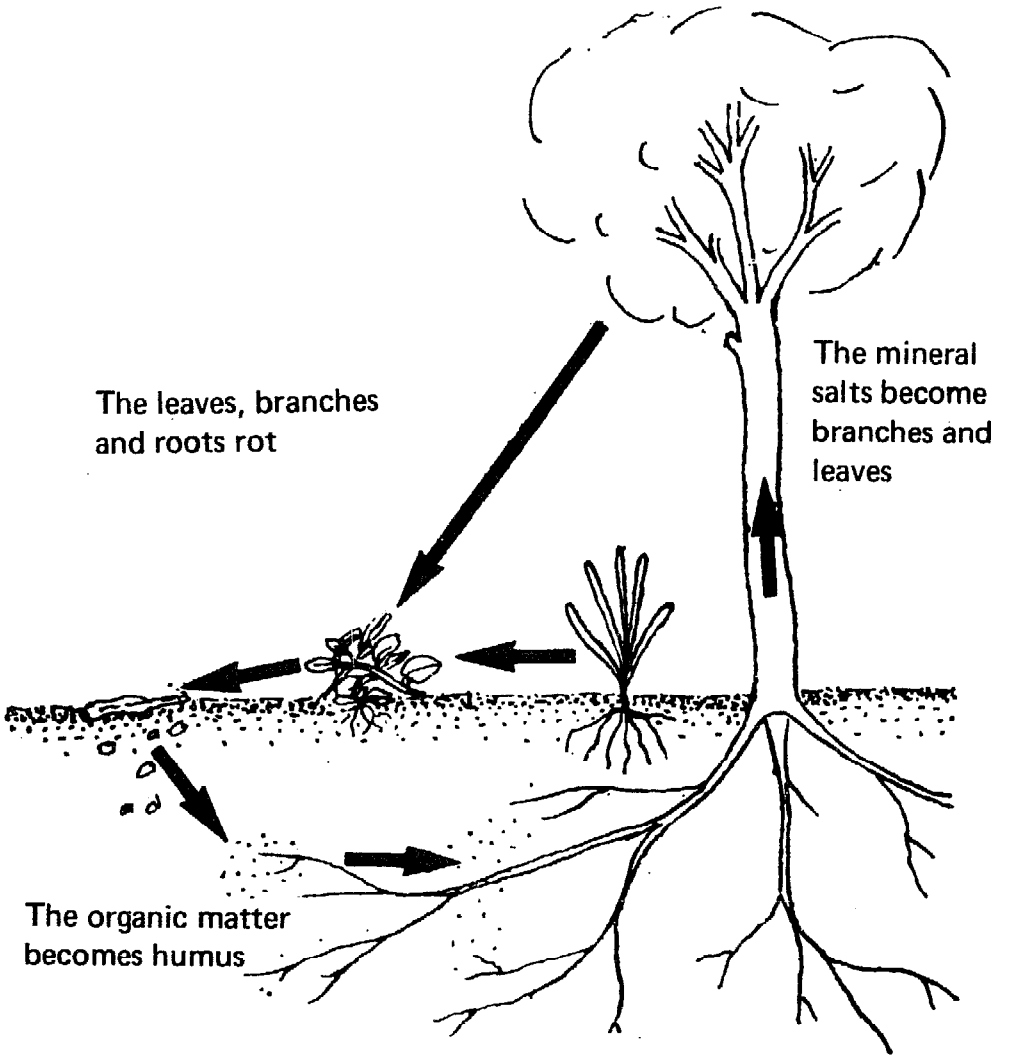
They feed on leaves, on dead branches,
on organic matter (see Booklet No. 2, page 23).
They also need air to breathe, and water.
If there is no air and water,
the plant does not rot.
The organic matter does not decompose.

Organic matter
decomposed by the microbes in the soil
is humus.

WHAT HUMUS DOES

- **Humus makes soils richer.**

From the soil the plant gets mineral salts
(see Booklet No. 1, page 19).
The leaves turn the raw sap into elaborated sap
(see Booklet No. 2, page 20).
The plant feeds on elaborated sap.
Wood and leaves are organic matter
rich in mineral salts and carbon.
Organic matter rots and makes humus.
Humus returns to the soil
the mineral salts used by the plant.



Humus returns the mineral salts to the plant

• Humus improves soils

Heaps of bricks, cement and sheet iron
do not make a house.

To make a house they must be arranged,
must be **joined together.**

Sand, clay, silt and pebbles without humus
do not make a good soil.

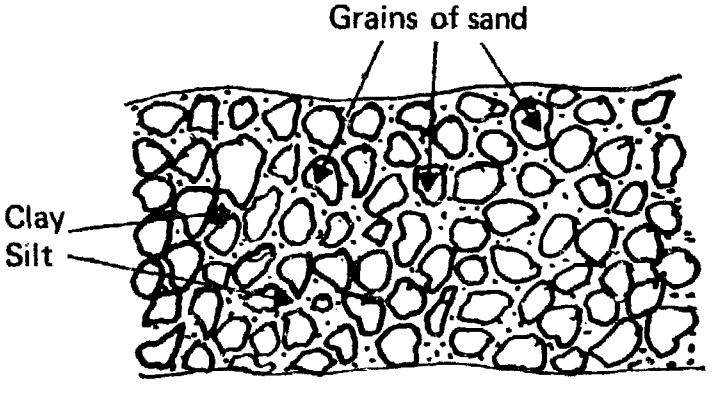
They must be arranged,
must be **joined together** to make a good soil.

The way in which sand, clay, silt and pebbles
are joined together
is called the **soil structure.**

It is the humus which joins together
sand, clay, silt and pebbles.

Humus is necessary for soil structure.

Bad soil structure



This structure is bad because there is **no humus.**
The sand, clay and silt
are not joined together.

Air and water circulate badly.

Roots penetrate badly,
breathe badly
and feed badly.

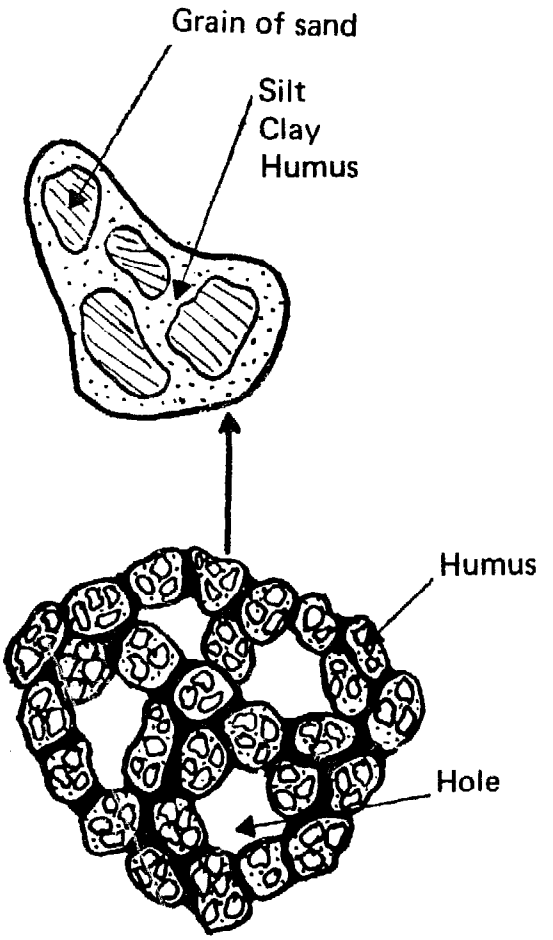
This is a bad soil structure.

Good soil structure

The structure is good, because the sand, clay and silt are joined together by a mixture of clay and humus.

Air and water circulate well.

Roots penetrate well, breathe well and feed well.



- **Humus improves sandy soils.**

  Sandy soils with humus hold water better.

  They are less easily carried away by wind and rain.

- **Humus improves clay soils.**

  Clay soils with humus are less hard.

  Air and water circulate better.

Soil without humus is not good soil.

SOME PRACTICAL ADVICE

• Brush fires

In traditional farming,
leaves and branches are burned.
The fire destroys the organic matter,
so that no organic matter is left
to make humus.

The brush fire destroys the organic matter
and changes the soil structure.

Modern farmers
do not make brush fires.

• Fallow

Cassava gives an example.

When cassava is harvested, the whole plant is lifted:
the root for eating
and the stems for replanting.

Almost nothing is left either on the soil
or in the soil.

**The cassava has taken humus from the soil,
but the organic matter of the cassava
is not returned to the soil.**

So the soil is less rich.

After growing, cassava farmers **let the soil rest.**
They let it **lie fallow.**

During the fallow,
the soil gets all the dead plants;
it gets the organic matter from the dead plants,
and the soil improves.

Soil must be given organic matter.
The remains of the crop, grass, manure,
provide organic matter.

- **Some crops improve the soil.**

When you harvest a bean plant,
you take only the fruits.
The stems, roots and leaves
are left to rot on the soil.
They decompose and give humus.

Beans are a crop
that leaves organic matter in the soil.
The beans take humus from the soil
but return organic matter to it.

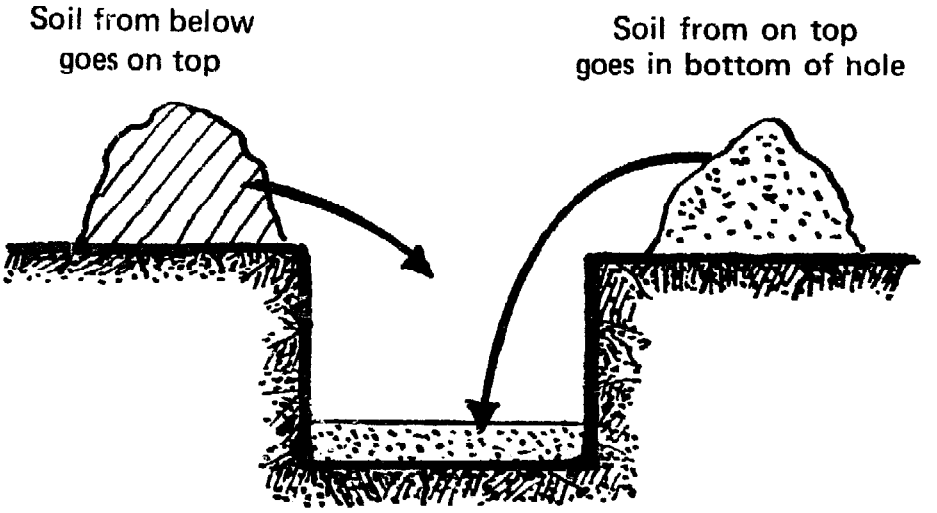
- **Manure**

Modern farmers use animal manure.
Manure returns to the soil
the organic matter taken out by the crop.

- **Do not mix the soil and the subsoil.**

The soil is rich in humus.
The subsoil has no humus.
In tilling, the farmer
should never mix the soil and the subsoil,
so as to keep his soil rich.

In planting a tree,
do not mix the layers of soil.



AIR IN THE SOIL

- **Air must circulate in the soil.**

The microbes, which are living things,
need air to breathe.

To live,
they decompose the organic matter in the soil.

If there is no air,
the microbes cannot breathe.

They cannot change
the organic matter into humus.

Roots too need air to breathe.

Without air, roots die.

They cannot go on feeding the plant
(see Booklet No. 1, page 28).

- **How to give the soil air.**

When you work the soil,
air enters into the soil.

If there is too much water
the air does not circulate well.

Water prevents air entering the soil.

So ditches are made
to get rid of the surplus water.

If the soil structure is good (see page 25)
the air circulates well.

To get a good soil structure,
there must be humus.

Humus makes it easier for air to circulate in the soil.

WATER IN THE SOIL

- **To live, a plant needs water**
  (see Booklet No. 2, page 26).

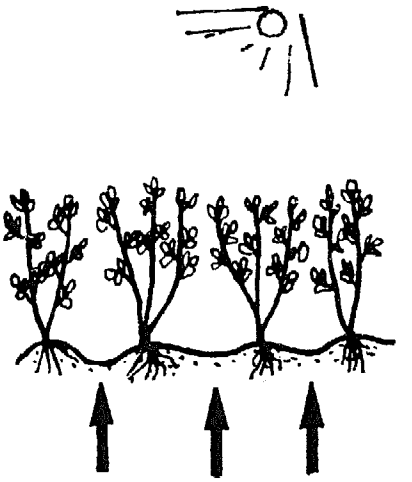
When plenty of rain falls,
the harvest may be good.
But when very little rain falls,
the harvest is bad.
To get a good harvest,
there must be enough water.

- **A plant needs water every day.**

But it does not rain every day.
When it does not rain,
the plant must be able to find water
in the soil.
Thus the soil must build up reserves of water.

**Good soil builds up reserves of water
and gives it back to the plant
when necessary.**

The soil receives water



The soil gives water back

CIRCULATION OF WATER IN THE SOIL

- **Water goes from above downward during the rainy season.**

  Water enters easily
  into soil which has a good structure.

  It also enters easily
  into light soils (see page 17).

  Water enters badly
  into a soil which has a bad structure,
  into soil which is too dense.

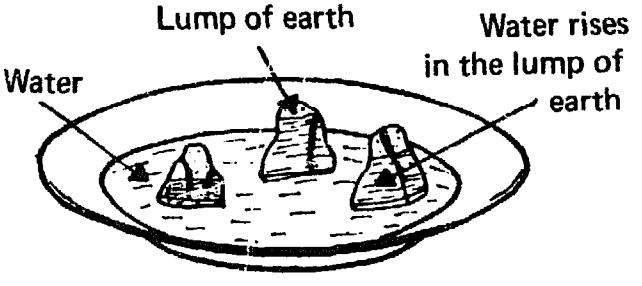
- **Water goes from below upward during the dry season.**

  Let us make an experiment.

  Put a little water
  in a plate.

  Take some lumps
  of earth
  from three
  different fields.

  Put these lumps
  in the plate.



  What do we see?

  In each of the lumps
  the water rises higher than it is in the plate.

In the same way, the water rises from the wet subsoil up to the roots.

In some lumps the water rises more quickly.

In clay soils (see page 20)
the water rises more quickly
than in silty soils.

- **In soils with a good structure,**
  water rises more quickly
  than in soils with a bad structure.

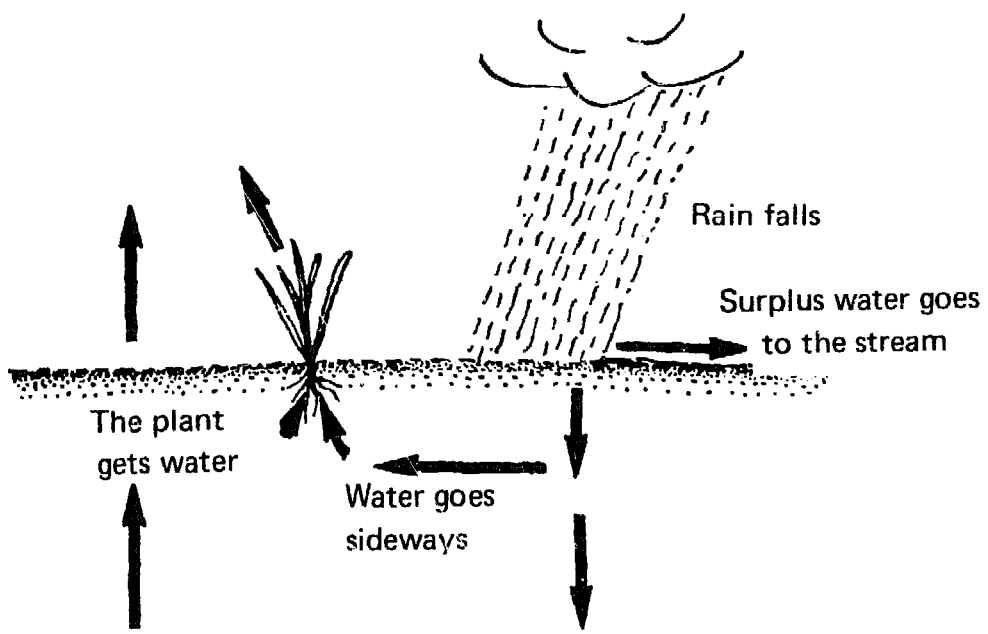
  If the structure of the soil is good,
  the water goes in better and stays there;
  the earth builds up reserves.

  A clay soil holds water better
  than a sandy soil.

  When it rains a lot
  the water may sink very deep into the earth.

  If it meets an impermeable layer of soil,
  it remains there.

  When we dig a well,
  we may find this water.

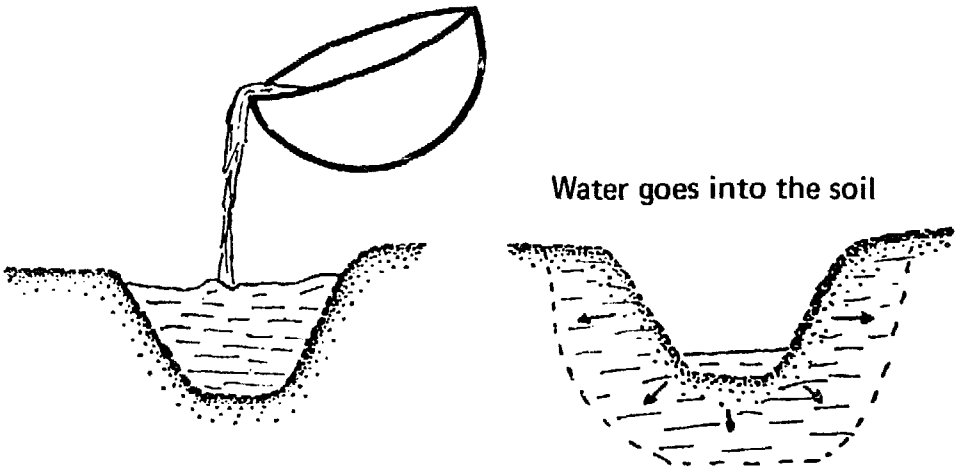


- **Water goes sideways.**

  Let us make a hole in the earth
  and then pour water into the hole.

  The water goes into the hole from above downward,
  but it also makes the sides of the hole wet.

  In the soil water also goes sideways.



PRACTICAL ADVICE

To get good reserves of water in the soil,
it is necessary to:

- **improve the soil structure,**

  by adding organic matter
  such as manure and the remains of plants.

  The organic matter becomes humus.

- **work the soil,**

  since water does not go into soil that is too dense.

  Working the soil
  at the beginning of the rainy season
  enables the soil
  to put a lot of water into reserve.

LIVING CREATURES IN THE SOIL

- **Earthworms**

There are a lot of worms in the soil.
If we put together
all the worms living in a hectare of soil
(in a football field),
they would make a big heap
and would weigh as much as two oxen.

Worms eat the remains of plants
that are mixed with the earth.
Worms also eat a lot of earth.
You often see on the surface of the soil
the little heaps of earth that worms have left.

Worms make a lot of holes in the soil.

Worms improve the soil structure (see page 25).

By making holes and by eating earth,
worms mix humus, sand, silt and clay.
They work the soil like the farmer with his hoe.

So worms are very useful in the soil.

- **Rats and other animals**

Rats, rabbits and lots of other animals
dig big holes.

These animals
eat roots, young stems and leaves.

They are not useful.

- **Termites**

Termites destroy dead plants.

They make holes in dead plants.

For instance, they destroy wood.

Part of the organic matter
remains on the spot,
mixes with the soil
and produces humus.

The rest is taken away by the termites
to their nests.

Termites bring up fine earth.

They go deep into the soil
to get fine earth.

They bring it up
to make their nests.

When a nest is destroyed,
the fine earth is mixed with the cultivated layer.
This layer becomes deeper.

**But termite nests are sometimes very big and very hard.
They are a nuisance to the farmer.**

- **Other insects**

In the soil there are also many other insects
such as ants and caterpillars.

These insects disturb the soil as worms do
and decompose organic matter.

Certain insects eat leaves or roots
and kill the plants.

Insects, both good and bad, change the soil.

- **Microbes**

We saw that there are very many microbes in the soil (see page 22).

Some microbes change organic matter into humus.

Other microbes bring nitrogen to plants.

We know that leaves get carbon from the air (see Booklet No. 2, page 21).

There is also **nitrogen** in the air.
To grow, plants need nitrogen.
But leaves cannot take nitrogen from the air.

In the soil there are microbes that can take the nitrogen in the air for their own food.

When these microbes die, they remain in the soil and decompose.

The microbes' nitrogen is changed into mineral salts (see page 23)

The roots of plants can absorb these mineral salts through their root hairs (see Booklet No. 1, page 17).

Everywhere in the soil there are microbes
that can take in nitrogen.

Some of them gather on plant roots
where they form little beads, or nodules.

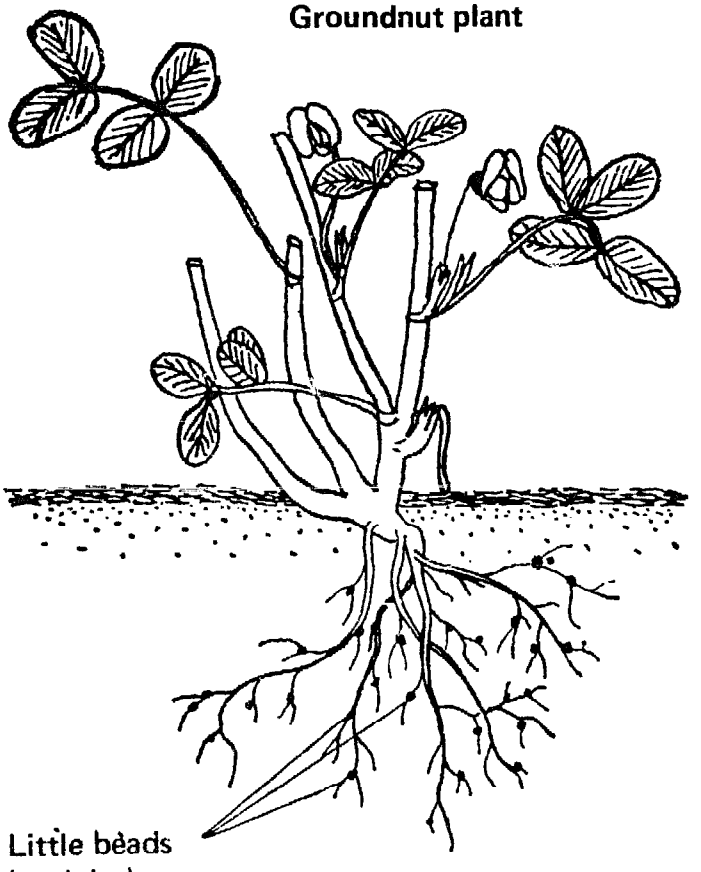
**The microbes in these little beads
bring nitrogen to the plants.**

Not all plants have these little beads.

They are found only on plants of the **legume family.**

Groundnuts, Dolichos bean,
Crotalaria, beans, peas,
Stylosanthes are all legumes.

Groundnut plant



Little beads
(nodules)
formed by microbes

SUGGESTED QUESTION PAPER

FILL IN THE MISSING WORDS

The ..... is the layer of earth where .....
..... find their food.
Good land should have ..... soil.

All soils are not alike. A ..... soil contains a lot of sand.
A clay soil contains a lot of .....

In the soil there is also humus. Humus returns to the soil the .....
..... used by the plant.
Humus improves the ..... of soils.
Crop remains, ... and
..... add humus to the soil.

There are also many microbes in the soil. They .....
organic matter and give the soil .....

ANSWER THE FOLLOWING QUESTIONS

What is the soil?

Why do we call clay soils heavy?

What do you do to get good reserves of water in the soil?

What is the depth of soil of your field?

What is fallow?

Why do you have fallow land?

How can you improve the soil structure?

Is it good to make a brush fire?

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