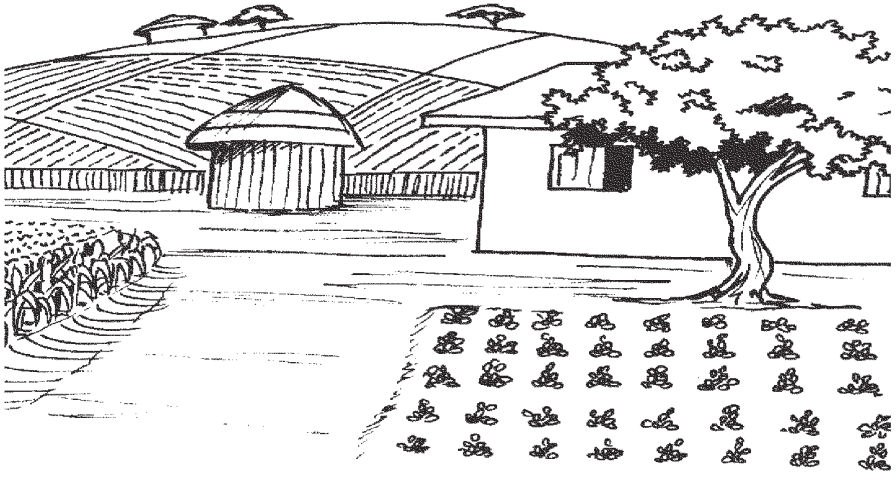
Farmers Training Notes **2**

THE LIVING SOIL
in Organic Agriculture

KOAN

Kenya Organic Agriculture Network

The Living Soil *in Organic Agriculture*



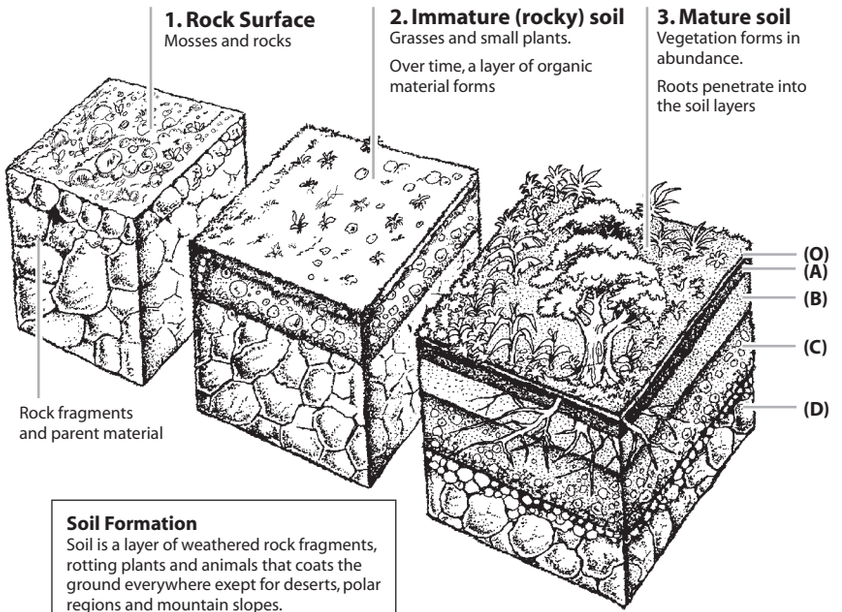
Soil is the top-most thin, ever-changing and living layer of the surface of the earth, without which land life would be impossible. It is that medium which has the potential to support plant life due to its complex composition of nutrients, air and living organisms, among others.

SOIL FORMATION

Like other planets within the solar system, the earth was initially a dry solid rock mass. Over time, its top-most layer has been breaking up and weathering down to fine particles as a result of the forces of wind and water that hammer it. This has been going on for millions of years and continues to do so. The continuous weathering has resulted in varying sizes of the original rock material, ranging from very small, microscopic particles, to huge rock boulders. To the farmers, the smallest of these particles are the backbone of their activities for they form what we refer to as the soil.

On the soil, plant life has found a hold and their roots have also helped to crack the underlying bedrock further as they penetrate deeper in search of water and life sustaining minerals. As the plants grow, they age and die. Their remains break down and mix up with the soil, forming a dark to dark-brown material which is porous, spongy and rich in trapped mineral nutrients. This material is referred to as "humus". Humus traps air and water as it continues to hold the mineral nutrients within the rotting vegetation. Equally, dead and dying members of the animal kingdom (fauna) add to the rich humus.

Below is a diagram illustrating soil formation



Soil Formation
Soil is a layer of weathered rock fragments, rotting plants and animals that coats the ground everywhere exept for deserts, polar regions and mountain slopes.

Soil Layers

Horizon O: Vegetation plus partly decomposed plant matter
Horizon A: Zone of leaching from which positive ions and clays are removed
Horizon B: Zone of enrichment where minerals and chemicals accumulate
Holizon C: Bedrock partially weathered by ground water
Horizon D: Unaltered bedrock (parent material)

THE LIVING SOIL, ORGANISMS AND MINERAL NUTRIENTS

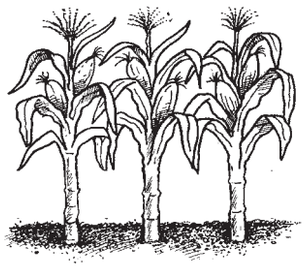
Within a soil rich in humus are millions of living organisms from members of both the plant and animal kingdoms. The invisible organisms are referred to as microscopic fungi and bacteria. These two play a crucial role in the continuing processes of soil formation and maintenance of plant food stability. While some micro-organisms must make use of soil air to survive (aerobic), others require none (anaerobic). The visible organisms are referred to as macro-organisms, which belong to the plant and animal kingdoms (flora and fauna). In a natural environment, organisms play a big role in balancing the plant nutrients uptake mechanisms, without direct adverse influence on the plant health.

It is when they are eliminated by synthetic agricultural inputs that the soil starts to die, and crop plants signal this trend through poor performance and output, and disease infestations.

Mineral Nutrients

In addition to supporting millions of different living organisms, both visible and invisible, the living soil holds, within it, a wide range of mineral particles, which vary in their importance as plant food. While same types of mineral are crucial, others play a minor role as plant food.

The most important mineral nutrients are referred to as macro-nutrients. They are Nitrogen, Phosphorus and Potassium. In order of importance, they are followed by Calcium, Magnesium and Sulfur. Other nutrients which are required by crop plants, but in less quantities are known as trace elements (nutrients) and include Iron, Zinc, Copper, Boron, Chlorine and Molybdenum. Both macro and trace nutrients categories form the backbone of crop development. Each of these nutrients has a basic role in crop development and production cycle as indicated below;

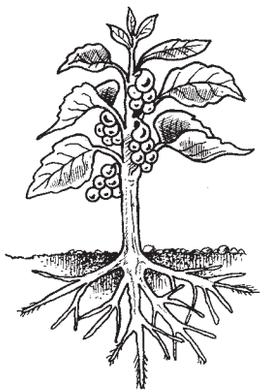


Nitrogen

- It helps in leaf and stem development (it promotes vegetative growth)
- It is a component of chlorophyll
- It aids in the formation of amino acids and protein
- It increases the size of grains (cereals) and their protein content
- It regulates availability of phosphorus and potassium

Deficiency symptoms:

- Leaves turn pale yellow to yellow in color
- Stunted growth, short roots
- In severe cases leaves fall off and flowering is reduced



Phosphorus

- It promotes root development
- It is essential for cell division
- It is necessary for seed germination, flowering, seed and fruit formation
- It hastens the ripening of fruits
- It strengthens plants and minimizes lodging in cereals
- It influences palatability of forage and vegetables

Deficiency symptoms:

- Leaves start turning purple
- Retarded development of actively metabolizing organs like roots
- Stunted growth

Potassium

- It strengthens plant structure and enhances the plant's ability to resist diseases
- It is important in enhancing yields of tuber and root crops
- It improves the quality of fruits
- It enhances nitrate uptake
- It is important in carbohydrate translocation

Deficiency symptoms:

- Yellowing (chlorosis) along the leaf margin
- May lead to leaf curling
- Scorching at leaf tips and margin while the inside of leaves remains green
- Premature leaf fall, increased lodging

There are twelve macro and micro-nutrients. Neither of them can support plant growth alone, and the farmer will require more information on how to acquire organic inputs that will need to be processed or applied to supply a combination of the nutrients, in order to achieve quantitive supplies of healthy organic crop products. The objective is to feed the soil,which in term will nature health crops

In the living soil, there is a healthy inter-play of living organisms, water, air and mineral nutrients that results in healthy crops without recourse to synthetic fertilizers. In the living soil, disease –causing organisms or pathogens are quickly overwhelmed into extinction as long as the organic farmer maintains a stable environment that is free of conditions that facilitate their multiplication.

THE DEAD SOIL

Soil life depends on the continuous replenishment of organic matter, soil air, healthily-acquired mineral nutrients, and non-pathogenic living organisms. To maintain soil life, organic farmers are encouraged to adopt farming techniques that preserve and improve soil structure, fertility and organic matter content.

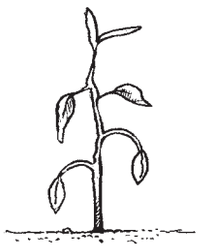
On the other hand, dead soil simply refers to that soil which is totally deficient in humus, soil air and water, beneficial living organisms, poorly structured and textured and is either too acidic or alkaline. In short, the dead soil cannot support the growth and development of even those plants that are useless to farmers. Farmers have their own indigenous knowledge that helps them to detect whether the soil is poor,

acidic, fertile or high in organic matter content. They do this by observing the plants growing in the soil as highlighted below:

Healthy soil

(a) Soils high in organic matter content (fertile soil) commonly support the growth of:-

1. Pig weed (*Amaranthus spp*)- an annual herbaceous plant
2. Wondering Jew (*Commelina benghalensis*) – an annual trailing weed
3. Thorn apple (*Datura stramonium*) - an annual poisonous weed
4. Black jack (*Bidens pilosa*) annual weed
5. Macdonald eye *(Galinsoga parviflora*) annual weed



Dead soil

(c) Poor soils commonly support the growth of: -

1. Double thorn *(Oxygonium sinuatum*)
2. Striga weed *(Striga spp*) parasitic annual plant that affects cereals
3. Poverty grass - a perennial arable grass weed

HOW WE KILL OUR SOILS

Naturally, the soil will "die" through water-logging. Artificially, we kill our soils by poisoning it with synthetic fertilizers and pesticides among other activities. While synthetic fertilizers lock up naturally- available mineral nutrients, others raise or lower acidity or alkalinity levels such that specific crops fail to grow beyond the seedling stage. A good example here is that excessive acidity reduces bacterial activity, and hence reduces the rate of organic matter decomposition. Equally, a very alkaline soil is unsuitable for nitrogen-fixing bacteria, hence a soil low in nitrogen.

Burning of vegetation, be it life or dead, is even worse. Burning kills billions of living organisms, both macro and micro. Earthworms, whose casts are important sources of soil nutrients, die, nitrogen-fixing bacteria are eliminated, soil air and water are eliminated, while humus - that most crucial plant food granary - is destroyed by burning. Devastating wind and water erosion blow away or carry down-hill, soil that is too light after burning. Soil surfaces subjected to continual burning are so devoid of nutrients that even the hardiest weeds fail to take root.

Burning is especially detested (avoided) by true organic farming practitioners who embrace many organic farming principles among which maintenance of the

natural ecosystem and diversity within and around the farming area, protection and enhancement of natural flora and fauna are basic tenets.

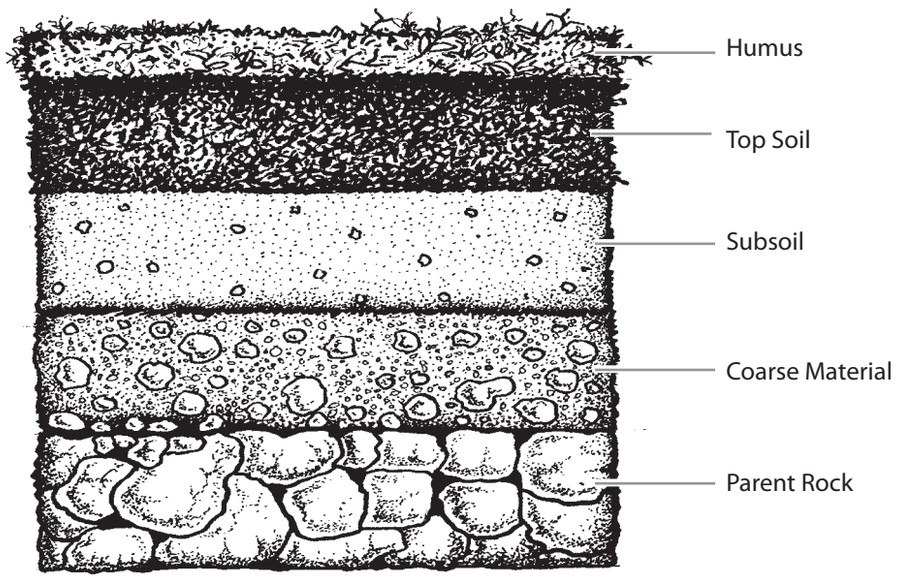
Ploughing or tillage disturbs the balance among soil insects, fungi, bacteria, viruses and other soil life. Soil disturbance breaks up the root channels and soil structural units so that the soil cannot perform its intended function. Soil disturbance also causes rapid loss of organic matter upon which the crop and many soil organisms feed; therefore, we should disturb the soil as little as possible.

THE SOIL PROFILE

The vertical arrangement of soil layers gives us a good idea of what to grow and where. This vertical arrangement gives us a picture, outline or profile of the soil layers when observed from a roadside embankment; or even a pit excavation. The narrower the top layers, the younger the soil, and hence the fewer the crops it can support, especially perennial crops.

The top-most layer in a soil profile is the thin humus layer. This is, however, only found in areas with vegetation cover or where a lot of organic matter is added in the soil. The humus layer is usually 2-5 cm thick except in forested areas where the organic ground mat can be as thick as 75 cm.

The diagram below illustrates the layers of a soil profile.



The next layer is the top-soil, which appears blackish in color. It is the home of organisms, holds the plants roots (mostly the hair roots), is well aerated and is also a repository of accumulative mineral nutrients. Below this layer is an impermeable layer called the **hard pan.** The hardpan impedes drainage and resists root penetration. The other layer is the sub-soil, which is usually compacted and less aerated. It is has accumulative mineral nutrients that leach from the top soils. This layer is followed by coarse material and finally the parent rock.

Soil sampling and testing

Soil sampling is often done at the beginning of the cropping season to obtain the nutrient status and their availability across the farm. Sampling may also be done during the growth cycle of the crops. It is essential to know the depth to collect the soil samples, which will depend on what is to be investigated. For example, soil samples to determine soil fertility will require to be taken from the plant root zone while soil samples intended to characterize the process of nutrient leaching or pollution will require numerous soil depths. In the sampling procedure, samples are taken evenly across the farm, avoiding irregularities and borders of the field.

Bear in mind that soil characteristics can vary significantly from one spot to another, even in a small garden or field. Taking samples from different locations in the field is crucial to get the most accurate measure of nutrients and other organisms. Mix the samples collected from several locations to create an **average** or **composite** sample. Make a reference map for sample collection to determine the number of samples to be taken from a given field.

Soil testing

Soil testing is a way of analyzing a soil sample to determine nutrient content, composition and other soil characteristics, including contaminants. A soil test is an excellent tool that informs the farmer of the status of soil fertility and pH. It also provides the necessary information needed to maintain optimum fertility year after year. Soil fertility fluctuates throughout a growing season each year. The quantity and availability of mineral nutrients are altered by the addition of fertilizers, manure, compost, mulch and lime among others, in addition to leaching. Large quantities of mineral nutrients are removed from soils as a result of plant growth, development, and harvesting. A soil test is the only precise way to determine whether the soil is acidic, neutral, or alkaline.

Most soil nutrients are readily available when soil pH is at 6.5. When pH rises above this value, nutrient elements such as phosphorus, iron, manganese, copper and zinc will become less available. When soil pH drops below 6.5, manganese can reach a toxic level for some sensitive plants.

Some of the material in this book was adapted from the books below:

1. Sustainable Agriculture – by ILRI
2. Natural Pests and Disease Control – by Henry Elwell and Anita Maas
3. Organic Farming – by John Njoroge
4. Soil Fertility Management - by John Njoroge

BOOKLETS IN THE FARMERS TRAINING NOTES SERIES

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Kenya Organic Agriculture Network (KOAN) is the National Coordinating Body for organic agriculture activities in Kenya. KOAN's mandate is to coordinate, facilitate and provide leadership and professional advisory services to all members and stakeholders in the areas of production, technical training, marketing, certification, lobbying and advocacy. It seeks to promote the organic agriculture movement in Kenya, to evolve and become a highly beneficial and integral industry with direct impacts on the environment, poverty reduction, employment and wealth creation.

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