Farmers Training Notes **3**

SOIL FERTILITY
In Organic Agriculture

KOAN

Kenya Organic Agriculture Network

Soil Fertility *in Organic Agriculture*

INTRODUCTION

Among the many problems facing farmers is diminishing soil fertility. Increased output of agricultural products can only be achieved if nutrients removed from the fields with the harvests are continuously replenished. The result of the high cost of external inputs, limited knowledge on soil fertility management and over-exploitation of the soil is diminished resilience of the soil system to provide a suitable medium for crop growth. Many conventional farmers think that it is enough to supply nutrients in forms that are readily taken by plants, i.e. synthetic fertilizers. However, available evidence indicates that among a whole range of factors determining soil fertility, organic matter plays a very crucial role. With this in mind, therefore, the concept of feeding the soil in order to maintain fertility and improve crop yields is of great importance to organic farmers.

WHAT IS SOIL FERTILITY?

Soil fertility is the capacity of the soil to produce crops by supplying nutrients (both micro and macro nutrients) in correct proportions and in adequate amounts over time. It can also be defined as the quality that enables the soil to provide the proper nutrients, in the appropriate amounts and in the correct balances for the growth of specified plants when temperature and other factors are favourable.

Plant nutrients are divided into two; macronutrients and micronutrients. These nutrients are all water soluble and enter the plant through the root system.

Macronutrients

These are nutrients which plants need in large quantities. They include Nitrogen (N), Phosphorus (P), Potassium (K), Sulphur (S), Calcium (Ca) and Magnesium (Mg).

NB: The Oxygen (O), Hydrogen (H) and Carbon (C) come from the air and water and make up 95 - 99% of a plant's weight.

Micronutrients

These are nutrients needed in very small quantities but which are as essential as macronutrients for normal plant growth. They include Boron (B), Chlorine (Cl), Copper (Cu), Iron (Fe), Manganese (Mn), Molybdenum (Mo) and Zinc (Zn).

A fertile soil is the foundation for healthy plants, animals and human beings. For soils to be productive, they must have organic matter in them. Therefore, understanding the role of organic matter in maintaining a healthy soil is essential. A farmer who uses chemical fertilizers and pesticides which are not economical or environmentally friendly, experiences soil fertility decrease from year to year. When soil organic matter decreases, it becomes more difficult to maintain crop growth because the soil reduces its water holding capacity, becomes compact and there is increased erosion due to run-off. There is also an increase in the levels of parasites, diseases and harmful insects. If on the other hand, the farmer maintains proper organic matter, the soil will support a good crop, without the need for expensive inputs like synthetic fertilizers and chemical pesticides.

Physical Properties of the soil include:

1. Soil texture (sand, silt, clay)
2. Soil structure (structural form, structural stability and strength, porosity, bulk density)
3. Organic matter
4. Water and air
5. Temperature

Proper understanding of what these components do, and how they interact help one to appreciate their considerable effect on crop production. Examples

Soil texture refers to: The mixture of different-sized mineral particles in a soil that range in size from gravel and stones to very fine clay particles**,** not forgetting the percentage of sand (largest) particles, silt (smaller) particles, and clay (the smallest)

particles. The texture of your soil influences all other soil physical properties, including drainage, water-holding capacity, soil temperature, aeration and structure.

Soil structure: Soil structure refers to how textural particles (sand, silt, and clay) are arranged into clumps or aggregates. The aggregates are bound together by clay and organic matter**.** Soil structure affects soil drainage, plant root growth, water infiltration, crop germination and aeration.

Soil Organic Matter: Of all the components that make up soil, organic matter is the most important because:

- It plays a major role in moisture retention and help crops withstand drought
- It contributes to the chemical and biological properties of the soil
- It contributes to the physical properties of the soil; i.e. it provides glue-like substances that act to stick individual particles together to form stable aggregates and good soil structure.

Soil temperature, air and water: The temperature of the soil follows the temperature of the air, but with a time lag. Deeper in the soil, air temperature has less effect on soil temperature.

Water content affects the rate of temperature change. More heat is needed to warm a wet soil than a dry one. Evaporation is occurring simultaneously, absorbing heat and keeping the soil cool. Dark soils absorb more heat; light-coloured residues tend to reflect heat, causing soils to warm more slowly. Sunshine also affects the soil temperature. Any shading, i.e. clouds, weeds, or residue, will reduce the transfer of energy to and from soil.

NB: Soil is made up of varying ratios of minerals, air, water and organic material. Soil is healthy if it consists of roughly 40% mineral, 23% water, 23% air, 6% organic material and 8% living organisms.

A fertile soil:

- Is rich in nutrients (macro) necessary for basic plant nutrition.
- Contains sufficient minerals (trace elements) for plant nutrition,
- Contains soil organic matter that improves soil structure and moisture retention.
- Has a PH ranging between 6.0 - 6.8 which is what is preferred by most plants, although some prefer acidic or alkaline conditions.
- Has a good structure and is well drained
- Has a range of microorganisms that support plant growth.
- Often contains large amounts of top soil.

Factors that determine soil fertility

1. Soil depth - deep soils afford plant roots greater volume for penetration.
2. Good drainage to avoid water logging.
3. Good aeration to promote healthy root development and functioning.
4. High water retention capacity.
5. High levels of nutrients. The nutrients should be in a form that is readily available to plants.
6. Optimal soil PH - soil pH should not be alkaline or acidic but instead be neutral.
7. Freedom from soil pests and diseases.
8. Presence of adequate organic matter and living organisms.
9. Soil texture and structure.

Ways in which soil fertility is lost

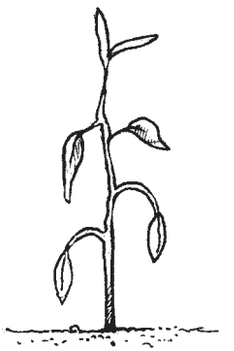
Soil fertility may be lost in many ways. Some of these are as a result of human activity while others may be out of our control. The most common ways in which soil fertility may be lost include:

- Soil erosion through various agents like water, wind and animals.
- Soil capping – this is the formation of an impermeable layer of soil on the surface which obstructs water infiltration leading to run-offs.
- Leaching of nutrients – this is especially serious with nutrients such as nitrogen, which are highly soluble in water. It is very common with sandy soils.
- Loss of nutrients through sale of farm produce off the land without replenishing the nutrients removed in produce.
- Development of a hard pan a short distance below the surface of the soil, which impedes water percolation as well as root penetration. Hard pans may be caused by repeatedly ploughing at the same depth or settlement of fertilizer residues underneath the top soil layer.
- Loss of organic matter through rapid oxidation by soil microorganisms due to unduly too frequent cultivation.
- Weeds – these compete with crops for nutrients, and moisture.
- Burning of weed and crop residues.
- Alteration of soil life, through misuse of certain fertilizers.
- The sun - In the tropics, too much exposure to the sun may lead to high soil temperatures and thus loss of soil fertility through less active soil life and drying, among others.

Good Soil

Ways of increasing soil fertility

(a) Use of Farm yield and compost manure
(b) Green manuring
(c) Retention of crop residues in the farm after harvesting instead of burning
(d) Adoption of a comprehensive rotational program
(e) Covering of the soil as much as possible
(f) Use of cover crops
(g) Reduced potential for erosion
(h) Minimal soil tillage



Bad Soil

Maintaining soil fertility

Among the more important and common methods of maintaining and/or improving soil fertility include:

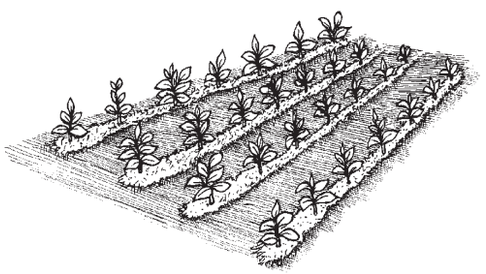
1. Improving the water retention capacity of the soil. This could be done through adding of organic matter like, green manuring, compost and appropriate tillage practices which increase water infiltration and holding capacity. Mulch could also be used to do the same.
2. Improving the drainage system to eliminate the possibility of water logging.
3. Appropriate cropping systems such as multiple cropping, rotational cropping and agro-forestry
4. Planting of local crops, which are efficient in extracting and using nutrients, could prevent or slow down the rate of depletion.
5. Minimum disturbance of the soil to conserve moisture and organic matter
6. Proper soil and water conservation and most important, control of soil erosion.
7. Improving soil aeration to promote healthy root development and activity.
8. Initiate practices aimed at increasing soil microorganism populations.
9. Improving soil depth - Deep soils offer plant roots an expanded volume for exploitation.
10. Weed control to reduce competition for nutrients and sunlight with the crops.

FEEDING THE SOIL

The soil should be treated as a living entity. Like a human being, it needs to be well fed to live, thrive and be productive. Soil conservation measures should be put in place and increased biological activities in the soil promoted. This will help the soil to build humus, which is the cornerstone of the soil and its ecosystem. Humus is a crumbly, dark-black stuff that makes plants grow and is totally a product of soil biological activity. It is full of nutrients, offers a favorable soil pH, is porous and spongy to permit air penetration and can hold moisture without becoming too soggy. The following are ways to preserve and build humus in the soil:

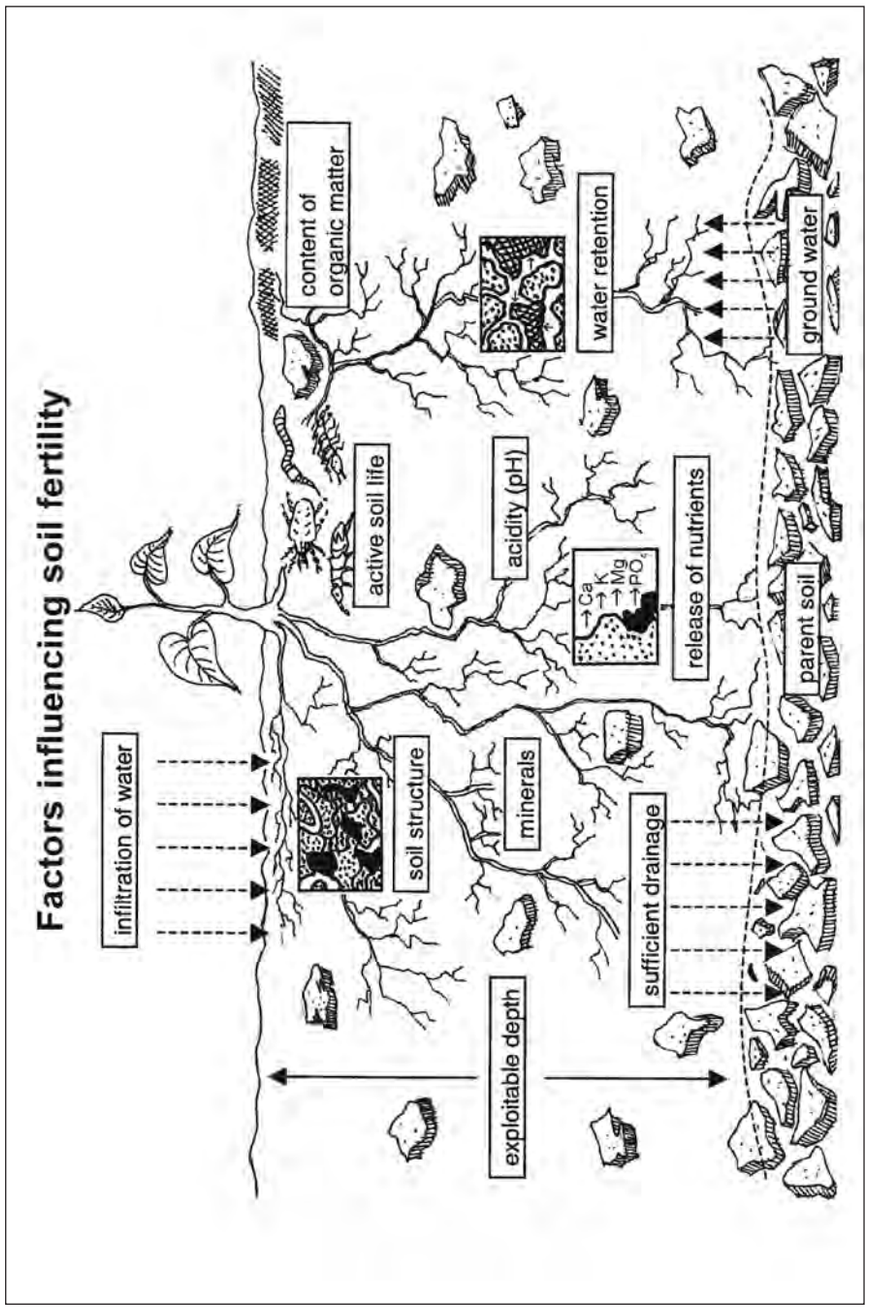
- **Nutrient release**. The process by which organic matter and humus break down and release nutrients into the soil is called mineralization. Humus is the end product of organic matter decomposition, but it too can be mineralized under the right conditions. Adding organic matter to the soil will lead to formation of new humus to replace the reserves lost due to mineralisation. Direct ways to increase humus in the soil include adding organic matter to the soil in the form of dry or green material (mulch), green manure and compost, among others. During the dry season, a lot of nitrogen accumulates in the air and is released as nitrogen flush at the onset of the rains for use by crops.

- **Manure:** Use manures that have been composted to kill plant pathogens and weed seed. Manures vary greatly in their nutrient content. Their composition varies according to the type, age and condition of the animal, the kind of feed used, degree of decomposition, moisture content and amount of bedding litter. The best feature of animal manure is that it provides most of the micronutrients needed. It also helps to establish biological activity from the microorganisms in the manure



- **Mulching**. Mulching is mostly used to suppress weeds, protect the soil from extreme temperatures, reduce the impact of raindrops and improve water infiltration as it holds water. It is also important as a means of building soil humus. Materials that can be used as mulching include crop residues, grasses cut from the surrounding pastures or fallow lands and waste plant materials or by-products from the processing of crops such as sunflower cake. Mulch does not only build the soil humus but also conserves the soil moisture and prevents contamination of the plants from soil borne diseases arising from water splashes during the wet season. It also helps the environment around the plant to dry quickly after the rains and minimize the development of damaging moulds and fungus that thrive on the plant when the air around it is damp.

- **Green manures**. Green manure is any crop grown for purposes of feeding the soil organisms as opposed to being harvested for human or animal consumption. It requires very little from the farmer, just the cost of seed and labour, and produces good organic matter where it is needed. Green manure crops include sunhemp, lablab beans, velvet beans, and a wide range of other leguminous crops and non-legumes such as mustard. Agro-forestry plants such as pigeon peas, tephrosia and sesbania sesban, among others, can be used.



❖**Compost.** Adding compost manure to the soil increases the levels of organic matter that is in short supply in the majority of tropic soils. The effects last for several years. When you add compost, you increase the levels of nutrients available to the crops leading to better yields. In addition, the soil is able to store moisture for longer periods, thus helping to protect crops from drought. The soil structure is improved and strengthened, making it less vulnerable to erosion.

❖ **Agro forestry.** This refers to land use systems and practices where trees and shrubs are deliberately combined on the same piece of land with agricultural crops. The trees will add or improve the soil humus, as the leaves fall, cover the soil and later rot. The roots will hold the soil particles together, hence control erosion. Leguminous trees will fix nitrogen. Agro-forestry helps the soil to recycle nutrients.

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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Author	**Teresia W. Ndirangu**
Editor	**Samuel Waweru**
Illustrations and Design	**Anthony Mwangi**

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.

For more information contact:

Kenya Organic Agriculture Network

P.O. Box 72641-00200, Nairobi, Kenya
ICIPE Complex, Kasarani.
Tel: 020-572-506-836 or 0704-428-465 or 0787-557-908
Email: koansecretariat@elci.org Web: www.koan.co.ke