Farmers Training Notes **8**

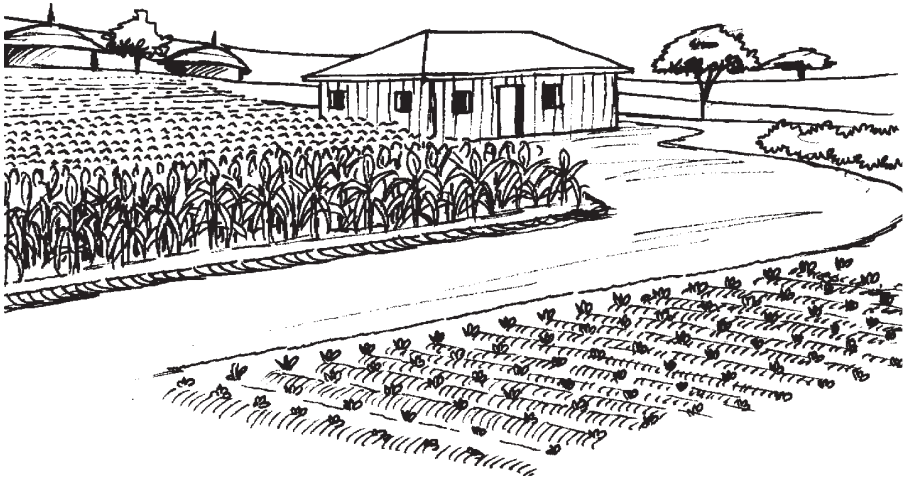
CROP ROTATION AND ITS ROLE IN SOIL FERTILITY

in Organic Agriculture

KOAN

Kenya Organic Agriculture Network

Crop Rotation and its role in Soil Fertility *in Organic Agriculture*



1. Soil fertility

Soil fertility is the inherent capacity of a soil to support crop growth in all ways, from the time of planting to full maturity. Due to the high humus content, virgin forest soil may have all the basic requirements necessary for crop growth, but after subsequent use, this soil will lose its natural or inherent capacity to support optimum crop growth. On the other hand, once poor, the soil may be enriched through field activities that will make it as productive as before.

In organic agriculture, soil management emphasizes on farming methods that, among others will:

- Preserve and improve the soil structure
- Either stabilize or increase soil fertility
- Increase and stabilize organic matter content within the soil, more so humus
- Protect the soil from erosion hazards, hence reducing or eliminating nutrient loss
- Maintain a diverse and healthy soil life.

In this regard then, a well-designed organic enterprise should lay emphasis on:

- A carefully designed crop rotation, planting plans and crop selection
- Proper composting and soil fertility enhancing approaches

- Tillage practices that will promote biological activity through addition of high quality organic matter in the soil
- Use of friendly, natural soil amendments to correct nutrient deficiencies.

2. CROP NUTRIENTS

Crop nutrients are elements that are crucial for crop growth and development. Apart from nitrogen, oxygen and hydrogen (which originate from the air and water), all other nutrients are minerals, which are released from rocks during weathering or from humus.

Main Crop Nutrients

Mineral nutrients that are crucial for crop growth and development are classified into macro (major) and micro (trace) nutrients.

i) Macro or major nutrients

These include phosphorus, potassium, calcium, magnesium and sulphur. Among these, phosphorus, potassium and calcium are a must for all crops and their deficiency, however minor, can result in disaster because each of them has a major role in crop growth and development.

ii) Micro or trace elements

These include iron, copper, manganese, zinc, molybdenum, boron and chlorine. They are required by crops in very small (trace) quantities to support growth and development. Their roles in crop growth are minor.

3. PLANT FEEDING: NUTRIENT UPTAKE FROM THE SOIL

Water or moisture is a major component in plant feeding. All plants require it to dissolve mineral nutrients. Humus and clay particles are very small, and are thus capable of holding moisture around and within them, as opposed to sand whose particles are rather too large to hold moisture. Through a process known as Caution Exchange Capacity (CEC) humus (and clay) particles are able to hold the nutrient ions that are easily absorbed by plant root hairs in the form of very dilute solutions. The greater the amount of humus, the higher the CEC, hence the greater the nutrient-holding capacity of the soil. This explains why addition of humus increases the fertility of sandy soils.

4. ROLE OF CROP ROTATION IN SOIL FERTILITY

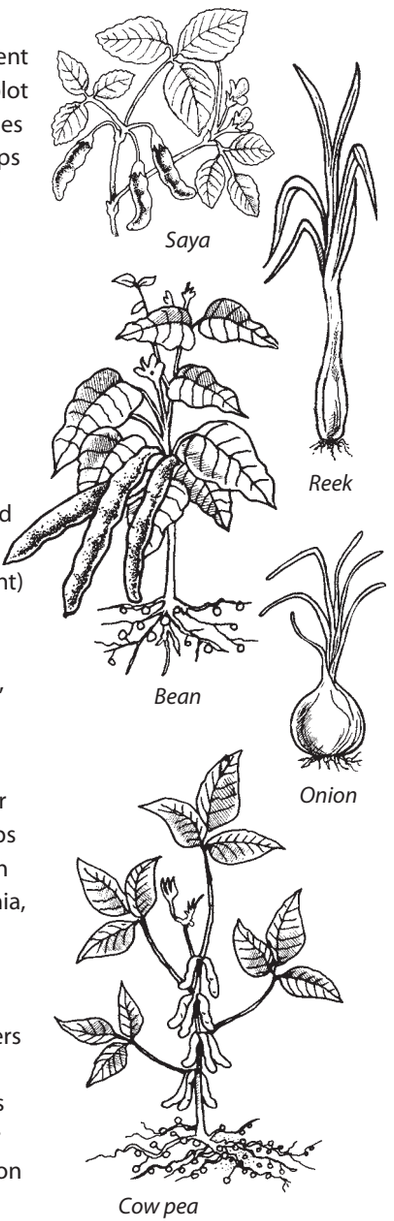
Crop rotation simply means the growing of different crops in sequence or season after season in one plot or field. A good rotation system needs interchanges or variation of at least four different classes of crops such as:

i) Leguminaceae - Groundnuts, field beans, soya, cowpeas, french beans, runner beans.
ii) Cucurbitaceae - Pumpkins, melon, squash, marrow
iii) Graimae - Maize, millet, sorghum
iv) Cruciferae - Cabbage, kale, brussels sprout, broccoli, cauliflower radish.

Other crop families include:

- Chenopoiceae - Beetroot, spinach, swiss chard
- Solanaceae - Pepper, potatoes, tomatoes, black night shade, aubergine (brinjal, eggplant)
- Compositae - Artichoke, lettuce, endive, chickory
- Umberlliferae - Carrots, celery, parsley, fennel, parsnip, dill, coriander
- Liliaceae - Garlic, leeks, onions, shallot.

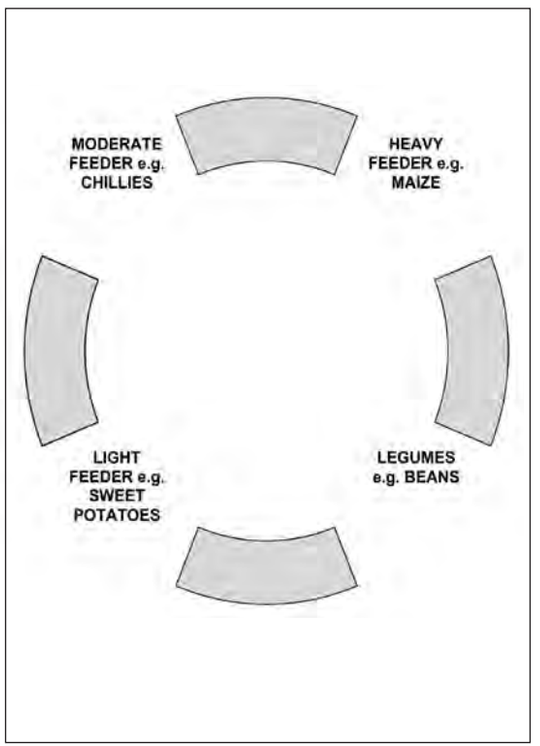
Equally, good fertility-building rotations are easier to achieve if they include such green manure crops as crotolaria (sunhemp) and velvet bean, and such agro-forestry species as sesbania, sesban, leucaenia, tephrosia and calliandra, among others. A good rotation regime emphasizes that 'heavy feeders', also known as 'taking 'or 'nutrient hungry crops', such as brassicas, are followed by moderate feeders like cucurbits. Moderate feeders are followed by light feeder crops like carrots. Finally, light feeders are followed by legumes, also known as 'giving' or 'nutrient enhancing crops', to complete the rotation cycle.



An example

1ST SEASON	2ND SEASON	3RD SEASON	4TH SEASON
Brassicas (takers)	*Cucurbits (moderate)*	*Roots (light)*	*Legumes (givers)*
Cabbage	Pumpkins	Sweet potato	Cowpeas
Kales	Melon	Carrot	Beans
Spinach	Marrow	Cassava	Soya beans
Lettuce	Gourds		
Agro-forestry crops/trees in intermittent rows within the field for shade, nitrogen fixation and livestock feeding.			

The following chart is another good example of a crop rotation system.



Each crop has its own specific characteristics, which can be highlighted and turned into good use through a well-planned rotation regime. These characteristics include:

- Ability to fix nitrogen (legumes)
- Ability to break life cycles of pests and diseases, hence ease in controlling them. This is because different crops have different pests
- Ability to deter the growth and development of weeds (allopathy), among others

5. CROP NUTRIENT REQUIREMENT

Different crops have different nutrient requirement. The following table shows nutrient requirement by different crops.

Very low	Low	Medium	High	Very high
Carrots Garlic Radish	Asparagus Beans Courgettes Cucumber Fennel Onions Parsnip Tomatoes Turnip	Broccoli Aubergine Cabbages Cauliflower Kales Lettuce Potatoes Pumpkins Spinach Sweet pepper Sweet potatoes	Beet roots Celery Leek Brussels Sprout	Chinese cabbage Rhubarb Cabbages Broccoli Black night shade

6. ROOTING SYSTEM

Consider whether the crop is deep or shallow rooted. A deep-rooted crop should not be followed by another deep-rooted one. The same principle should apply for shallow-rooted crops. Deep-rooted crops have tap roots that go deep into the soil to reach the leached nutrients. These are later brought up to the upper soil horizons where shallow-rooted crops can reach them. Deep-rooted crops also help in breaking hardpans.

7. NATURE OF THE PLANTS

This refers to whether the crop is upright, creeping (such as the vine), tall or short, its ability to cover the soil against the sun, erosion and humus accumulation. For example:

Upright Crops	Creeping (Vines)
Kale Cabbage Amaranth Irish potato	Sweet potatoes Yams Pumpkins Courgettes
Tall crops	Short crops
Snow peas Garden peas Broccoli Kales Amaranth Tomatoes Maize, Sorghum, Millet	Carrots Cabbage Cauliflower Spinach Irish potatoes Coriander Lettuce Beet roots Leeks White onions.

Each crop has its own specific characteristics, which can be highlighted and turned into good use through a well-planned rotation regime. These characteristics include:

- Ability to fix nitrogen (legumes)
- Different nutrient demand
- Soil cover against the sun, erosion and humus accumulation
- Deep rooting ability which helps to bring up nutrients from lower soil horizons to upper horizons where shallow-rooted crops can use them.
- Ability to break life cycles of pests and diseases, hence ease in controlling them
- Ability to deter weed growth and development (allopathy) among others.

Before embarking on a rotation regime, farmers are cautioned to consider the following factors carefully:

- The type of soil and its suitability to support and promote the growth and development of crops chosen for the rotation regime.
- Climatic conditions in the general locality. Rainfall reliability is particularly important if the crops to be grown will solely depend on it.
- Market availability - farmers might opt to grow similar crops. Equally, he must explore market outlets for crops he has grown and which are not a staple in his locality.

Recognizing nutrient deficiencies in crops

As mentioned earlier, crops require certain minerals in greater quantities (macro nutrients) and others in lesser quantities (micro-nutrients). In the event that a particular mineral is inadequate, especially macro-nutrients, the crop will display symptoms as follows:

- Low levels of nitrogen will lead to stunted growth. The leaves will start changing from deep green to light green, and finally to spots of yellow. Eventually, the leaves will fall off. This should not be confused with disease infections. While nitrogen deficiency is manifested from the mid-rib, disease infections will be scattered all over the leaf, changing to brownish spots or lines, and the leaf may not fall off. Crops may produce healthy but undersize fruits or seeds if nitrogen deficiency is not too severe.
- Low phosphorus levels are manifested in grayish purplish coloring on the older leaves and slow crop development due to weak roots. Overall, crop appearance is poor.
- Potassium deficiencies often lead to slow growth, low yields and low rates of flowering. Acute deficiency is indicated by yellow or blue-green leaf margins, followed by widespread leaf browning.
- Magnesium deficiency will lead to whitening of the tissues between the leaf veins of older leaves while purple coloration will be more prominent on vegetables. Such leaves eventually fall off.
- The best way to assess the quantities of mineral nutrients in a particular field is to test soil samples obtained from across it. Upon obtaining the results, organic farmers will take steps to correct the deficiencies.

Correcting nutrient deficiencies at the farm level

Addition of nitrogen into the soil, either for continued crop growth or development has been discussed at length. The farmer will recall the use of green manure, composting and crop rotation, emphasizing on the use of legumes. Indeed, nitrogen is one major crop nutritional element that is readily available to a knowledgeable organic farmer.

Due to its high demand by plants for root development, phosphorus is a major element that requires periodic replenishment. At the farm level, organic farmers are encouraged to:

- Maintain mulch to prevent nutrient and moisture loss
- Use green manure and compost to supplement phosphorus lost during the previous cropping season
- Design a rotation regime that will ensure phosphorus levels are maintained.

The farmer is also encouraged to supplement phosphorus with Rock phosphate. This is a stable slow release form of phosphate, and a very important long term fertility building supplement for the soil in organic farming systems. It can be applied to compost piles (in small amounts otherwise it interferes with the composting process) where it will slowly break down, but at a faster rate than when directly applied to the soil. Placing it in the planting stations with well rotted manure or compost will also increase the rate of release of phosphate. Avoid positioning rock phosphate next to applications of lime as it will slow down the release of phosphate.

Phosphorus can also be supplemented by use of animal by-products such as horn and hoof meal, degelatinized or glue-less bone meal, animal charcoal, feather, hair, fur, wool, blood meals and dairy products. Such products should be approved by an authorized certifier before use. Other phosphate supplements include plant bio-accumulators or plants that can absorb and hold nutrients in their foliage such as comfy, tithonia and stinging nettle, among others.

Correcting potassium deficiencies

Potassium deficiencies in the soil can be corrected by:

- Adding Gypsum (calcium sulphate) which is a good source of calcium and sulphur and a wide range of trace elements. Gypsum helps in "unlocking" potassium held in the soil, for ready crop use.
- Adding powdered basalt, granite dust or clay minerals in biologically active soils
- Using vegetable products and by-products especially oilseed cake meal, coffee husks and malt culms.
- Adding wood ash which contains potassium and raises the soil pH. However, its use in an organically certified system is restricted to sustainable crop production.
- Using compost manure which is a good source of potassium but care must be taken to minimize leaching during storage.
- Planting deep rooted green manure crops which bring up nutrients such as potassium from lower soil horizons to depths accessible by shallow-rooted crops.

In conclusion, it is important to add that rather than relying on fertilizers, organic farmers provide nutrients to their crops by improving the fertility of the soil. Most nutrient deficiencies will be easily corrected through use of green manure and repeated application of compost for short and long term nutrient balance. Mulching also adds to the organic matter of the soil and acts as a buffer, stabilizing it and preventing pH imbalances and nutrient lock-ups. Soil amendments such as rock powders and sea weeds (kelp) are used to supply additional nutrients and to adjust soil pH. Soil amendments are necessary for building balanced soils. After years of applying organic farming methods, soil fertility and nutrient cycles will establish and amendments become unnecessary.

Maize plant without potassium deficiency

Maize plant with potassium deficiency

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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