ORGANIC CROP NUTRITION

How natural plant nutrition works

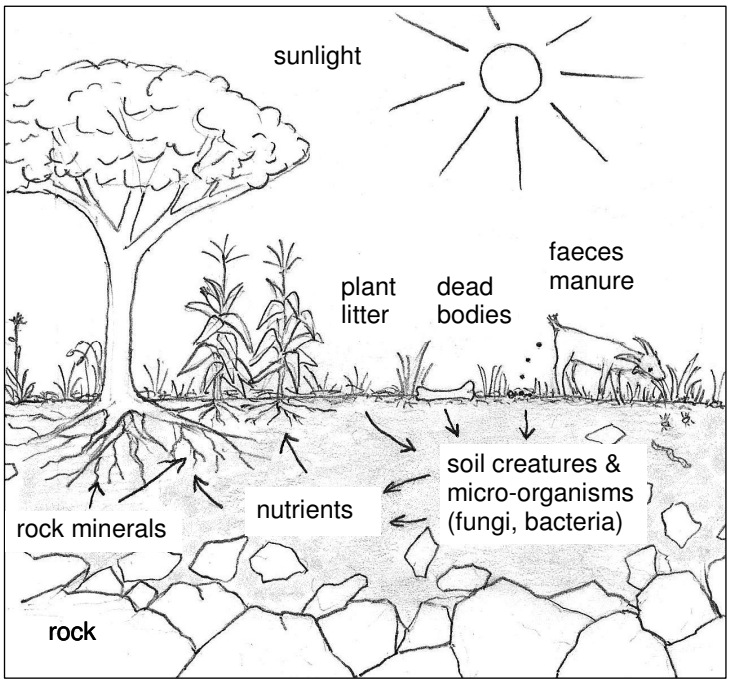
Green plants are able to photosynthesize: with sunlight, carbon gas and water they produce sugars, which they later transform to plant matter. Humans and animals can obtain nutrients only by consuming and digesting plants (or animals which feed on plants).
Both plants and animals also require minerals. Humans and other animals extract them from the food they eat. Plants take up minerals and other useful compounds from the soil solution which surrounds their roots. They depend on the processes of the soil ecosystem where millions of micro-organisms are constantly busy with feeding from organic and inorganic matter in the soil while breaking it down and converting it chemically. Some of the resulting compounds and byproducts, like nitrate, ammonium, or phosphates, but also a whole range of other minerals are taken up by the plant roots for use in the plant.

Organic nutrient management: "Feed the soil and not the plants"

The organic philosophy of crop nutrition is to take proper care of soil organisms, because they are responsible for the processes on which plant nutrition has always relied. Organic farmers believe this is best accomplished by feeding the soil organisms with organic matter and natural rock minerals, and by avoiding toxic chemicals and practices that are harmful to the soil creatures.

Organic producers have to maintain and improve the soil they manage and have to replenish what is harvested. Management by neglect is not accepted as organic - it is not sustainable as soils will get poorer and poorer.

Soil fertility is regenerated by using and recycling renewable resources from plant and animal origin which add organic matter to the soil. Organic matter is central to soil fertility: it binds and stabilizes nutrients, promotes biological activity, improves soil structure, regulates soil acidity, enhances water infiltration and drainage, and decreases erosion. Organic matter is especially important for very poor soils where mineral fertilizers are not efficient because of poor nutrient retention.



Inorganic fertilizers

Commercial inorganic fertilizers provide nutrients to the plant directly, in soluble and highly concentrated form. They are available to the plants immediately. Organic farmers have reservations about this approach:

- Mineral fertilizers do not support soil biotic life, but may actually reduce it if they are applied without addition of organic matter over a long period. Many inorganic fertilizers also increase soil acidity, creating a hostile environment to plants. As a result, soils and plants may become increasingly dependent on synthetic inputs and if they are not provided constantly, yields will decrease.
- Soluble nutrients, especially nitrate, are easily washed out by leaching and may create environmental problems like contamination of ground water.
- Flooding the plants two or three times with high amounts of only two or three important nutrients may create imbalances in the plants leading to reduced resistance against diseases and insect attacks.

Organic fertilizers

In organic farming, fertilizers have to be of natural origin. Fertilizers from recycled plant and animal material (livestock manures, green manures, composts) are less concentrated than mineral fertilizers and contain high amounts of organic matter. Before their nutrients can be taken up by plants, organic matter has to be broken down by micro-organisms; nutrients are therefore released slowly and over longer time. This also means that they are sometimes not available in the quantity required by some crops.

Breakdown of organic matter is speeded up by:

- Tillage, as this adds oxygen so the soil.
- Addition of nitrogen, as this allows the soil organisms to multiply and to be more active.
- Moisture, as water is required for all biological processes.

The most common fertilizers used in organic agriculture are described in the next sections.

Livestock manure

Livestock manures have been a primary source of nutrients and soil organic matter for hundreds and thousands of years. They are the most widely used organic fertilizers. It is strongly encouraged in organic farming that livestock is integrated into the farm operation and manuring is part of a system where nutrients are continuously recycled.

Nutrient content of manures

The amount of nutrients in manure from different animals can vary widely and are very dependent on handling methods. Especially nitrogen content decreases over time. Nitrogen can be quickly lost to the atmosphere and is easily washed out by rain. To avoid nutrient losses, cover manure and compost heaps, and apply manure when the soil is moist, and work it in superficially. For average contents of main nutrients provided by different animal manures see Table 1 on page 4.

Fresh manure includes risks

Manure includes some health and environmental risks, as it contains relatively high levels of human, animal and plant pathogens. Soluble and volatile nutrients may cause water and air pollution, and it may also contain weed seeds, parasites, and veterinarian drugs. Fresh manure and urine can also "burn" plants due to high ammonium content. Farmers can protect people and the environment from these risks. This is what you can do:

- Compost animal manures and urine before application.
- If you apply fresh manure, keep an interval of at least two months between manure application and harvest of crops for human consumption.
- Use fresh manure only in moderate amounts and spread it uniformly and superficially.

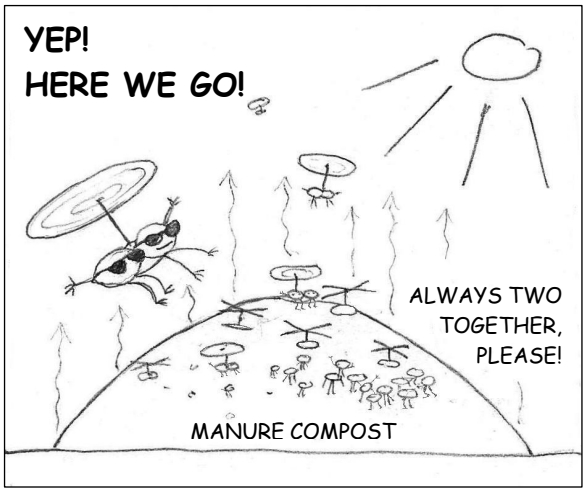
Composting of manures

One of the best means of handling manures is composting. Composting stabilizes the nutrients in manure and makes them more available to plants. Composting reduces pathogens as well as livestock parasites, and builds populations of beneficial organisms. Composted manure has a highly beneficial effect on soils and crops.

How much manure do you need to fertilize one acre?

A nice rule of thumb is that one dairy cow and her calf produce just around the amount of manure to fertilize one acre planted with Napier grass or another common crop like maize or potatoes per year. This is around 15 tons of manure per year - if you collect all the manure continuously.

Note: Your cow and calf need around one acre planted with fodder for their own nutrition – and this acre should also be fertilized! To put it bluntly: Animals provide enough manure to fertilize their own fodder, but there will not be much left for other crops!



Leguminous green manures – the most efficient nitrogen providers

Green manures and cover crops are a major source of organic matter and nutrients, and they protect the soil from erosion and crusting.

Green manures are grown during the off-season or can be intercropped with a main crop. They can be cut or grazed to feed animals. They are worked into the soil or left as mulch to decay and to provide nutrients before the next crop is planted. Suitable plant species have deep root systems that bring nutrients up to the soil surface and are tolerant of drought or nutrient stress. For more information please refer to our leaflet No 6 "Green manures, cover crops, mulching, weeding".

High nitrogen fixation rates

The most important green manures and cover crops are leguminous plants that together with bacteria are able to capture nitrogen from the atmosphere to build up plant material. When they decay, this nitrogen can be used by the next crops for their growth.

Nitrogen fixation rates can be between 15 to 80 kg N per acre! Green manuring is therefore the most efficient way to provide nitrogen to your farm and to replace synthetic nitrogen fertilizer.

Rock phosphate

Rock phosphate is (after compost) the most widely applied phosphate source in organic farming.

The phosphorus from rock phosphate is released more easily in moderately acidic soils, and long-term benefits are higher. Rock phosphate usually contains calcium as well and reduces soil acidity when it dissolves in the soil. P is released slowly and stays in the soil for many years.

Rock phosphate should always be added to compost or manure, as a natural acidification process caused by organic matter and the activity of some specialized fungi increase availability of phosphorus. When rock phosphate is mixed into composts in generous amounts while setting up the heap, it should become available to plants in most soils.

Not all crops respond in the same way: Legumes and millets respond best and directly to addition of rock phosphate, whereas on maize the effect may be only long term.

Recommended application rates

- Generally, use 50 - 150 kg per acre and per year
- To fertilize one acre, mix 100 kg rock phosphate with 4 tons of farm yard manure.
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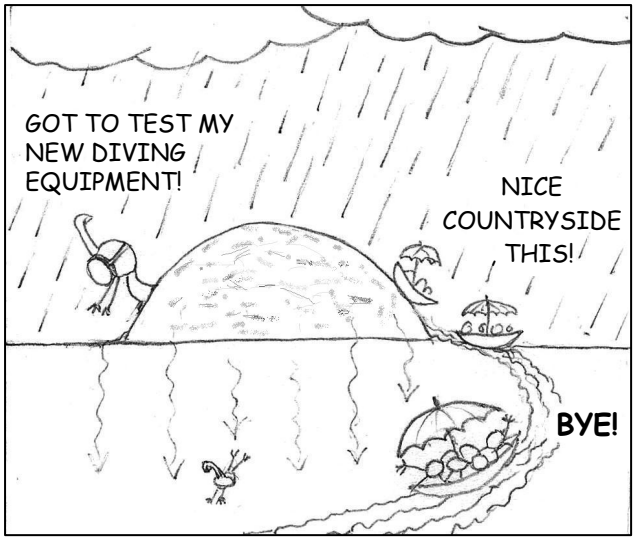
- Per planting hole, mix one spoonful of rock phosphate with 2 to 5 handfuls of manure or compost and work them well into the topsoil. Take care not to inhale the powder.



Compost

Compost is a very good source of organic matter and some nutrients, particularly for smaller farms. It is an ideal phosphorus provider when mixed with rock phosphate. Compost is very low in nitrogen compared to a synthetic nitrogen fertilizer. But it is most essential as it supplies organic matter and improves soil fertility. In mature compost, nutrients are stable and their solubility is decreased. Weed seeds and soil born diseases are also decreased. It is almost impossible to produce and to use too much compost on the farm; compost is always a scarce resource!

Ashes

Wood ash is a good source of calcium and potassium carbonate. It can be mixed into compost. Ashes raise soil pH (reducing acidity). However, if very large quantities are applied repeatedly, this can have an adverse effect on soil structure.

Supplemental fertilization

Crop rotation, manuring, green manures, cover crops and composts provide an abundant supply of minerals. Supplemental fertilization can be beneficial or necessary in specific situations, but for poor soils and for soils that have been heavily exploited for many years, a serious soil-building programme with green manures and cover crops that increase soil organic matter should always have first priority.

Foliar Feeds

Foliar feeds provide nutrients to plant leaves and stems and are absorbed there. Commercial foliar feeds are usually soluble fish or seaweed-based products or humic acid extracts, while teas (liquid manures) are watery extracts from plants, manures, or compost and can be produced on farm.

Foliar feeding can provide some nutrients when they are needed urgently. They usually provide some quick nitrogen. Foliar fertilization also seems to stimulate the roots and biological activity in the root zone.

Mineral supplements

Supplementing important minerals such as calcium, magnesium, copper, iron, and others should only be done after soil testing. Organic farmers are encouraged to have their soils tested for deficiencies of all major nutrients and minerals from time to time!

Always do a comparison to test new products!

A wide range of further products like humates, humic acids, enzymes, catalyst waters, bio-activators, or surfactants are commercially available. Their efficacy is often unclear. Organic farmers are encouraged to try them - but always compare a new input with a “check”! This means you should not treat more than half your field with a new remedy, and in the end you should compare the yields with the yields from the part of the field which you just treated normally!

More about nitrogen (N)

Nitrogen deficiency causes uniform yellowing of older leaves, progressing upward in the plant. In young plants, nitrogen deficiency causes the whole plant to be pale and yellowish green with weak stems.

All forms of nitrogen which can be taken up by plants and which are found in the soil or in fertilizers tend to transform and to disappear. They can be washed out with water in the form of nitrate, or they go into the air as ammonia and nitrogen gas (N_2). See the illustrations!

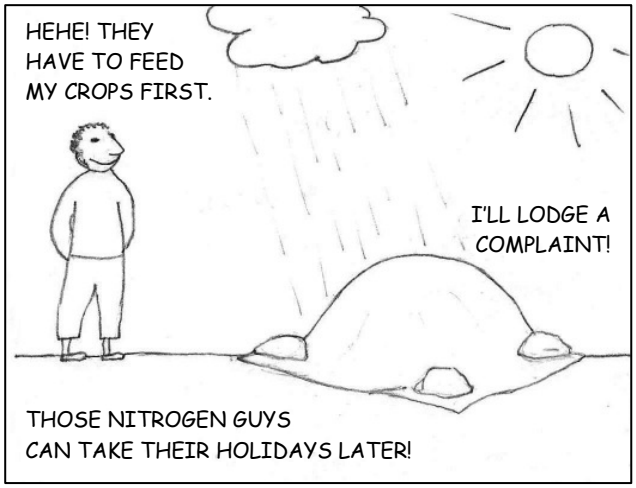
This is why compost and manures should not be exposed to sun and rain and should be worked into the topsoil. They should be used as soon as they are applicable, as their nitrogen content diminishes steadily.

Organic farming and nitrogen

Nitrogen management is probably the greatest challenge in organic farming. Nitrogen is mainly recycled from two sources: from nitrogen-fixing green manure plants and from animal manure which is usually composted.

Composting recycles and stabilizes at least a part of the nitrogen which is present in all plant materials and animal manures. Nitrogen applied in this way is more stable and less likely to leach or volatilize, but it is also not as readily available to the plant. As a result, organic crops may have slower growth rates, and sometimes less lush green vegetation.

You may now also see why leguminous species are so important: they convert the nitrogen they catch from the air into recyclable plant material.



Phosphorus (P)

Phosphorus is absolutely essential for both plants and animals as an energy carrier and for growth and reproduction, flowering and fruiting. Deficiency is rather difficult to identify. Plants are dwarfed or stunted and develop only very slowly. Stems and the under sides of the leaves may become purple.
In healthy soils rich in organic matter, special fungi attaching to the roots help the plants to extract phosphorous from the soil. P does not get lost as easily as N.

Potassium (K)

Potassium deficiency starts with browning dry leaf tips on older leaves, and later the spaces between the veins get yellow, while the veins still remain green. The leaves may start curling up.
African soils often do not have large amounts of potassium, as it easily washes out with rain.

Table 1: Nutrient contents of common organic fertilizers

Nitrogen	Phosphorus (P_2O_5)	Potassium (K_2O)
• Leguminous crops that are used as green manures or as mulch provide between 20 to 80 kg N / acre which can be used by subsequent crops. • Blood meal / feather meal 12-15% N. They are applied directly to the crops. • Urines from all species contain pure urea (up to 1% N). It is not a stupid idea to urinate on the compost heap! • Poultry manure 8-20 kg N/t • Pig manure 3-5 kg N/t • goat / sheep manure 2-4 kg N/t • cattle manures 2-3 kg N/t • Compost * 1 kg N/t • Manure teas and plant teas provide easily available nitrogen and can be used as top dressing or foliar feeds	• rock phosphate 20-33% • bone meals 12-25% • poultry manure 10-25 kg/t • pig manure 3-6 kg/t • goat/sheep 2.5-4 kg/t • cattle manure 2-3 kg/t • compost * 4 kg/t	• wood ash 3-7% • goat / sheep manure 12 kg/t • cattle manure 5-12 kg/t • poultry manure 5-12 kg/t • compost * 6 kg/t • pig manure 3-7 kg/t • urines: 1-3 kg/t
	* Content of purely vegetative compost. If compost is prepared with livestock manures, rock phosphate and wood ash, the product will have higher nutrient contents. **Nutrient contents of manures and composts are highly dependent on handling and storage and on feed quality!**	

Is organic crop nutrition the solution?

It can not be denied that the situation of farmers in Kenya and other African countries seems severe. In contrast to most developing countries on other continents, per capita food production is declining and among the lowest in the world.

Many reasons for this have been identified. Lack of governmental support and investments are one thing. Another thing is the drastic population increase within few decades, and pressure on land leading to deforestation and soil depletion. In a tropical climate where organic matter decomposition is fast, continuous cropping can have severe consequences. Soils are more vulnerable, as nutrients leach out easily and erosion rates can be high. Water can become scarcer as retention in the soil is decreased.

Together with the ongoing climate change, this is fatal. The subsidies for mineral fertilizers between 1960 and 1985 improved crop productivity to some extent, but not soil quality. When African governments stopped the subsidies, many farmers were already sitting on degraded crop land. Nowadays, small-scale farmers can hardly afford any fertilizers, with the result that the soil-mining goes on.

Poor seed quality and low-yielding crop varieties are further problems. But the potential of improved crop varieties cannot be realized on nutrient-depleted soils! Together with poor water management, this is the main reason why their contribution to crop yield increases has been very low in Africa.

What can farmers do in a situation which seems so hopeless? We do not promise you that organic farming is the solution to everything. But it is certainly an essential part of the solution. Improving soil productivity starts with building soil fertility and careful resource management. Many people think that combining organic and conventional techniques is the most promising way forward. Negative effects of conventional methods should be avoided by restricted and clever use of synthetic inputs, while both methods contribute to increased production.

You should also know that increasing soil organic matter takes many years. But in the long run, there is actually no other choice, if soil depletion is to be stopped. It is better to start now!

Publication of ***The Organic Farmer***. The magazine for sustainable agriculture in Kenya. www.organicfarmermagazine.org
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