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Women as the real Architects of Society

The role of new technologies in farmers' education and rural development

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Soil Fertility Management

Everything starts with the soil –
Health & nutrition, feeds for livestock, produce for industrial production, water availability and climate

We have to feed 9 billion people mainly in urban areas –
How do we address this challenge?

Depleting soils means robbing from our children and grandchildren –
Which legacy do we want to leave for future generations?

We can no longer ignore the soil fertility issue –
not just because it determines yields and income

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Old Principles

The principles of Soil Fertility are ancient and based on nature's rule of recycling and balance.

At Mama Chakula Foundation we teach sustainable agriculture based on:

- Returning nutrients to the soil (compost making, manure handling, no burning policy, etc.)
- Erosion control (minimum tillage, wind breaks, contour farming, etc.)
- Water retention (cover crops, mulching, SOM, etc.)
- Mixed farming (crop rotation, intercropping, farming & livestock, etc.)
- Everything has its place and role in nature (understanding weeds, pests and diseases, etc.)
- Farming is only a business if it is sustainable (income from destroying our assets - soil, water,

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New Technologies

New technologies play an important role in addressing modern problems.

At Mama Chakula Foundation we promote the use of technologies to:

- Provide farmers with information, which is necessary for decision making
- Make services available to farmers in remote locations
- Prevent nutrient losses in the soil
- Improve animal husbandry (breeds, living conditions, health, access to fodder, etc.)
- Improve farmers' livelihoods and working conditions sustainably
- Connect farmers (with each other, with providers, with sources of knowledge, etc.)
- Ensure farmers don't have to trade off their children's future for their children's school

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New Way in Soil Analysis

Around 15 years ago scientists started developing IR-spectroscopy for soil analysis to provide faster, cheaper and more accessible soil analysis to small holder farmers.

In 2013 SoilCares in Kenya build its first mobile laboratory using spectral analysis. Since then the approach to soil analysis has been revolutionized.

Live Support Systems (T) Ltd and Mama Chakula Foundation will soon offer Soil Analysis and Recommendation Services using the SoilCares spectral technology in Tanzania.

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What is Spectral Analysis?

You better see for yourself!

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f these two soils has the higher organic matter content?

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Which of these two soils has the higher clay content?

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What did you just do?

You used your eyes as a sensor!

- You used your eyes as a sensor for the visible light range of the electromagnetic spectrum
- Your sensor (eye) determines differences in colour, structure and shape
- Your brain contains a calibration set → enables you to translate the information received from your sensor (eye) into soil characteristics
- A specialist has a larger calibration set and is able to estimate/quantify the % organic matter, clay content etc.

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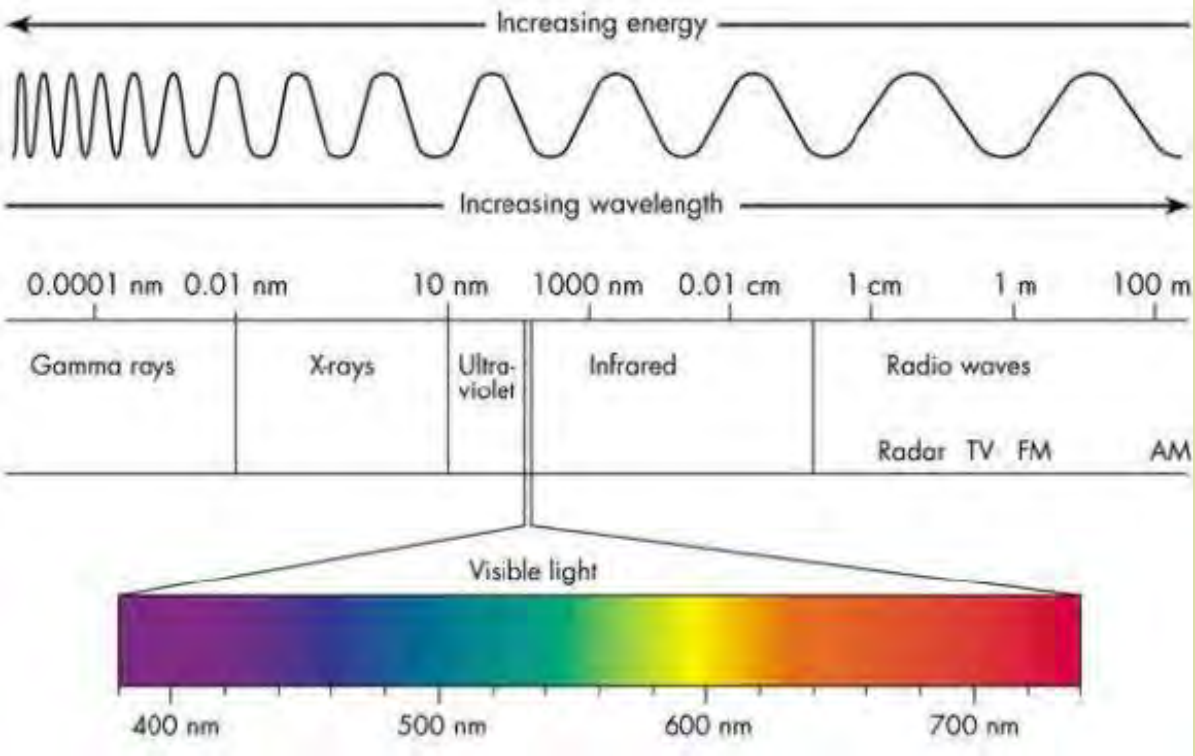
The electromagnetic spectrum



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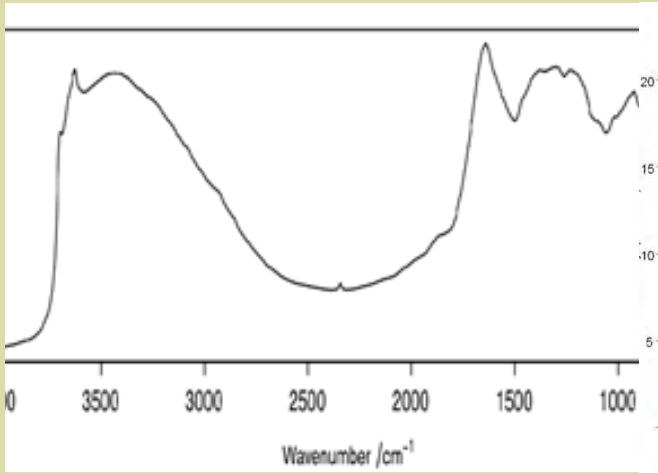
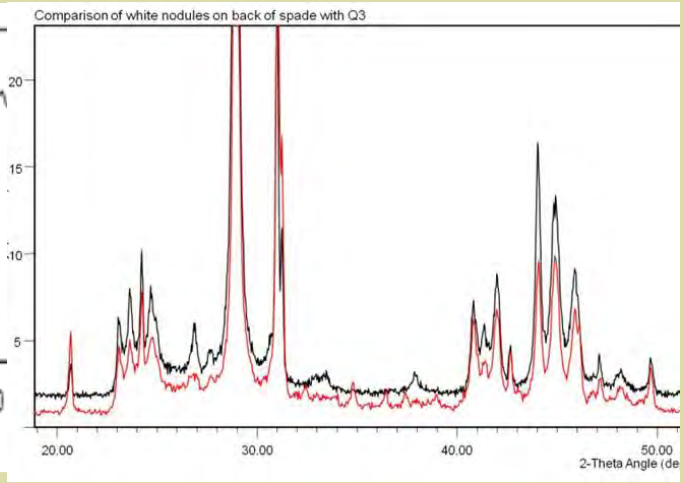
How to extract information from this?





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You need a calibration data base

Statistical modelling techniques are used to find relationships between sensor data and soil parameters

Accuracy levels are monitored to meet the highest standards

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Using sensor technology in a mobile lab

- No chemicals are used
- The only preparation is drying and grinding
- Analysis takes only 60 seconds
- The analysis & recommendations are automated
- Staff and equipment influences are minimized
- Remote sensing establishes the soil fertility status by looking at all parameters at the same time

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The Mobile Laboratory

Fast, Accessible, Affordable, Understandable, Personal, Enabling

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We need forefront technology, to provide fast, accessible and affordable agricultural analysis to smallholders and governments

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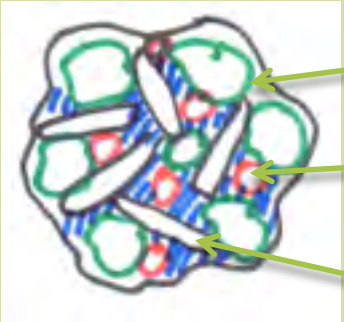
Let's take a closer look at soil:

The binding force: Organic matter $[R\text{-}COO]^-$



Organic matter particles

Sand particle

Clay particle

Water filling the empty spaces in an aggregated particle.

Water retention capacity!

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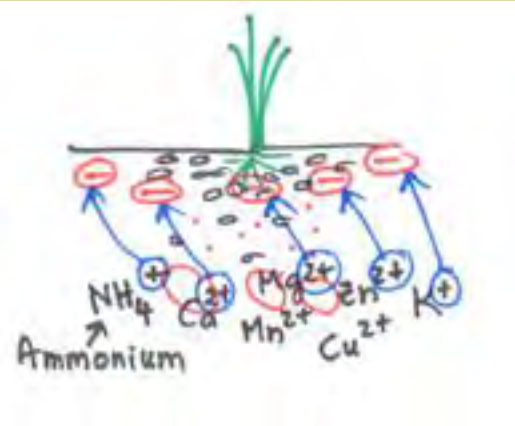
Nutrient movement



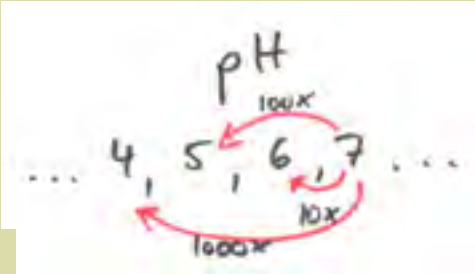
Organic matter =
R-OOH$^-$

Cation movement towards anions in organic matter

Cation Exchange Capacity CEC
The main soil characteristic influencing soil fertility!

A soil with a high CEC it has the ability to mobilize many nutrients from the soil to be made available for plants. The more organic matter in a soil, the better its CEC, because more anions with a negative charge are available to attract positively charged nutrients.

Soil perHydrogen



pH logarithmic scale

Hydrogen = H^+

Do you see the problem?

H^+ attracted to a negatively charged aggregate

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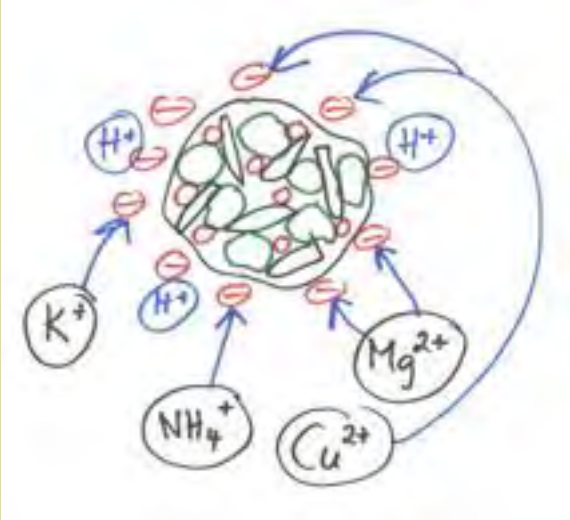
SOLUTION:

Lime ($R\text{-}CO_3^-$) + Hydrogen (H^+) → Carbon Dioxide (CO_2) + water (H_2O)



Anions attracted to a negatively charged aggregate

At a balanced pH of 6-7 nutrient availability is best, as the nutrients are attracted by the aggregates and become mobile. Roots can easily take up nutrients in this form.

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How to apply lime

Remember - Lime binds the excess H^+ and thereby raises the pH:

$$CO_3^- + H^+ \rightarrow CO_2 + H_2O$$

Because lime reacts relatively slowly, it needs to be in place well before planting acid-sensitive crops to allow adequate time for the pH change to occur.
Generally, it takes three months for lime to react with the soil. **Apply at least 1 month before planting.**
Water is required for lime to react with soil, therefore a November application is preferred so that the next crop (March) gets the benefit.
Because lime worked into soil reacts faster, apply it prior to any tillage.
Lime should be spread broadcast on the entire field. Be sure that the
uniformly, including the corners.
The choice of lime depends on the Mg-content of the soil.
Calcitic lime, it is mostly calcium carbonate (CaCo3) limestone.
It also supplies important Calcium.
On the other hand dolomitic lime also contains magnesium carbonates (MgCO3). It supplies Magnesium and should be avoided if soil is rich in Mg as it further offsets the Ca:Mg balance.

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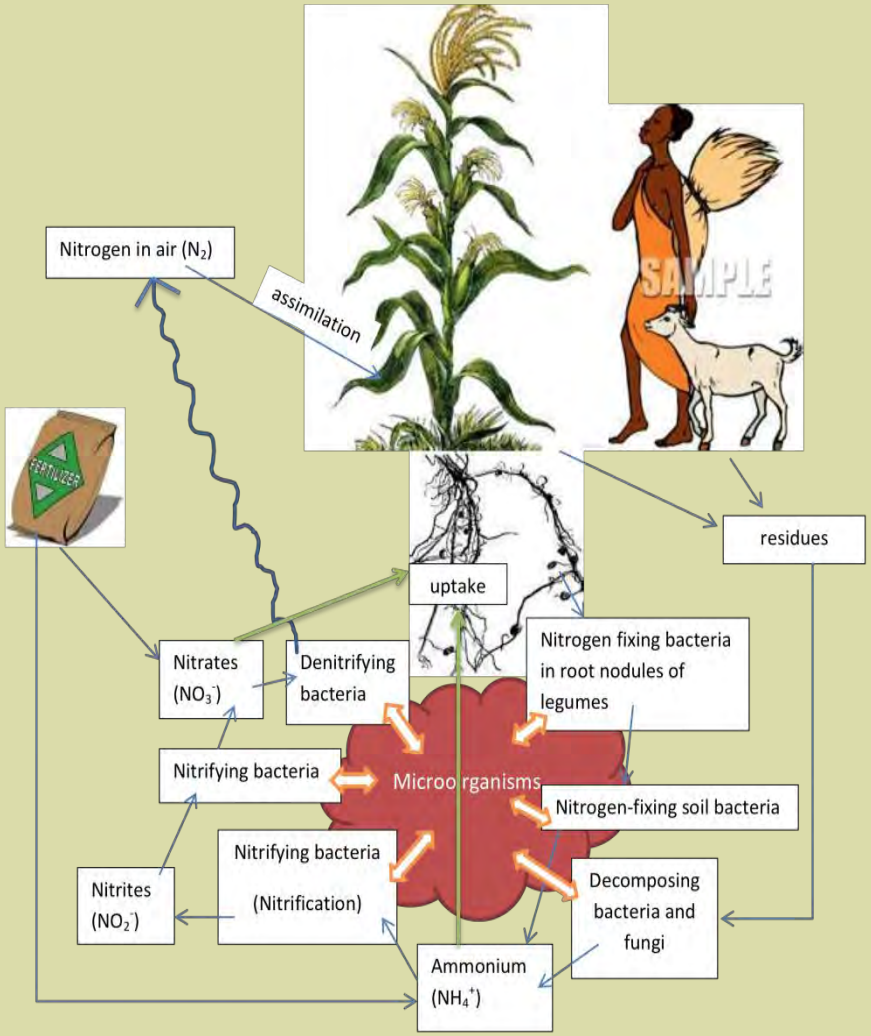
Nitrogen Cycle



1) Ammonification of ammonium (NH_4^+)

$$NH_4^+ + H_2O \rightarrow H_3O^+ + NH_3$$

2) Nitrification of ammonia (NH_3)

$$NH_3 + 1.5\ O_2 \rightarrow NO_2^- + H^+ + H_2O$$

Followed by nitrification of nitrite (NO_2^-)

$$NO2^- + 0.5\ O_2 \rightarrow NO_3^-$$

3) Denitrification of nitrate (NO_3^-)

$$6NO_3^- + 5CH_3OH \rightarrow 3N_2 + 5CO_2 + 7H_2O + 6OH$$

→ 4) Loss of Nitrogen gas (N_2)

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Phosphorus – a special case!

Phosphorus in soil is found as phosphate, which looks like this:

PO^{3-}

Fe^{3+} Iron (Ferrum)

$\rightarrow Fe_3(PO_4)_2$

Aluminium and Iron become more available at low pH. Therefore P-fixation is worsened by low pH

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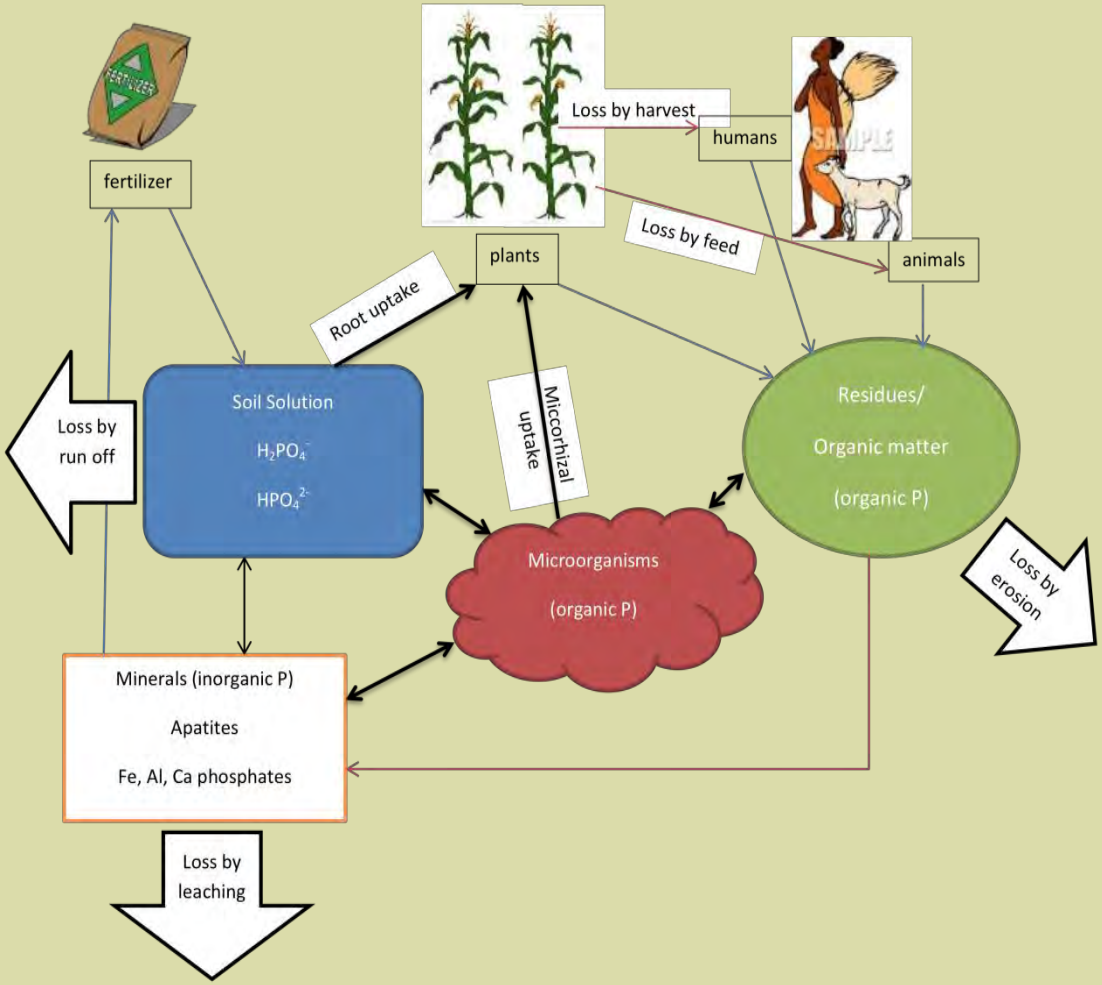
Phosphorus Cycle



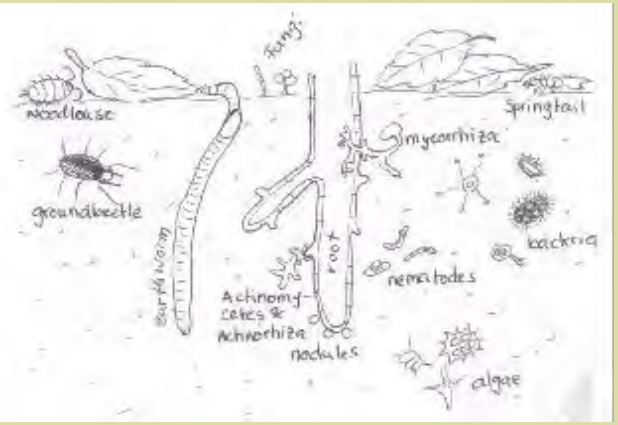
Microorganisms – the living soil

Arthropods: species of soil organisms that can be seen by the naked eye. They are the primary de-composers; cutting up larger particles of plant and animal residues and bringing it into contact with other soil organisms that further decompose it. Others are beneficial in fighting plant diseases: Springtails e.g. eat mostly fungi. Their waste is rich in plant nutrients but these are only released after other fungi and bacteria decompose it.

Fungi: exist as different species, sizes and shapes in soil. They aid plants by breaking down larger pieces of organic matter or by releasing nutrients from soil minerals. Some fungi also produce plant hormones, antibiotics or trap harmful nematodes.

Actinomycetes: fungi-like bacteria that help decompose organic matter into humus, releasing nutrients. They also produce antibiotics to fight root diseases.

Mycorrhizas are close associations between fungi and roots and act to extend the reach of root hairs into the soil. They increase the uptake of water and nutrients and protect roots from root-feeding nematodes, pro-duce hormones and antibiotics, which enhance root growth and provide disease suppression.



Root nodules are close associations between bacteria and roots

Actinorhizas are close associations between actionmycetes and roots.

Algae: improve soil structure by producing a kind of glue that helps holding soil together in water-stable aggregates.

Bacteria: Most numerous among soil organisms. Each species plays a specific role in helping plants take up nutrients from organic matter (especially in the nitrogen cycle) in breaking down soil minerals and releasing potassium, phosphorus, magnesium, calcium and iron. Still others produce natural root growth hormones. They also increase the solubility of nutrients, improve soil structure, fight root diseases, and detoxify the soil.

Nematodes: of the great number of nematodes only a few species are harmful to plants. The harmless species eat decaying plant litter, bacteria, fungi, algae, protozoa and other nematodes speeding up the nutrient cycle.

Protozoa: move in the water between soil particles. They are predatory, eating other microbes. Through digesting bacteria, protozoa speed up the nitrogen cycle and make nutrients, more available to plants.

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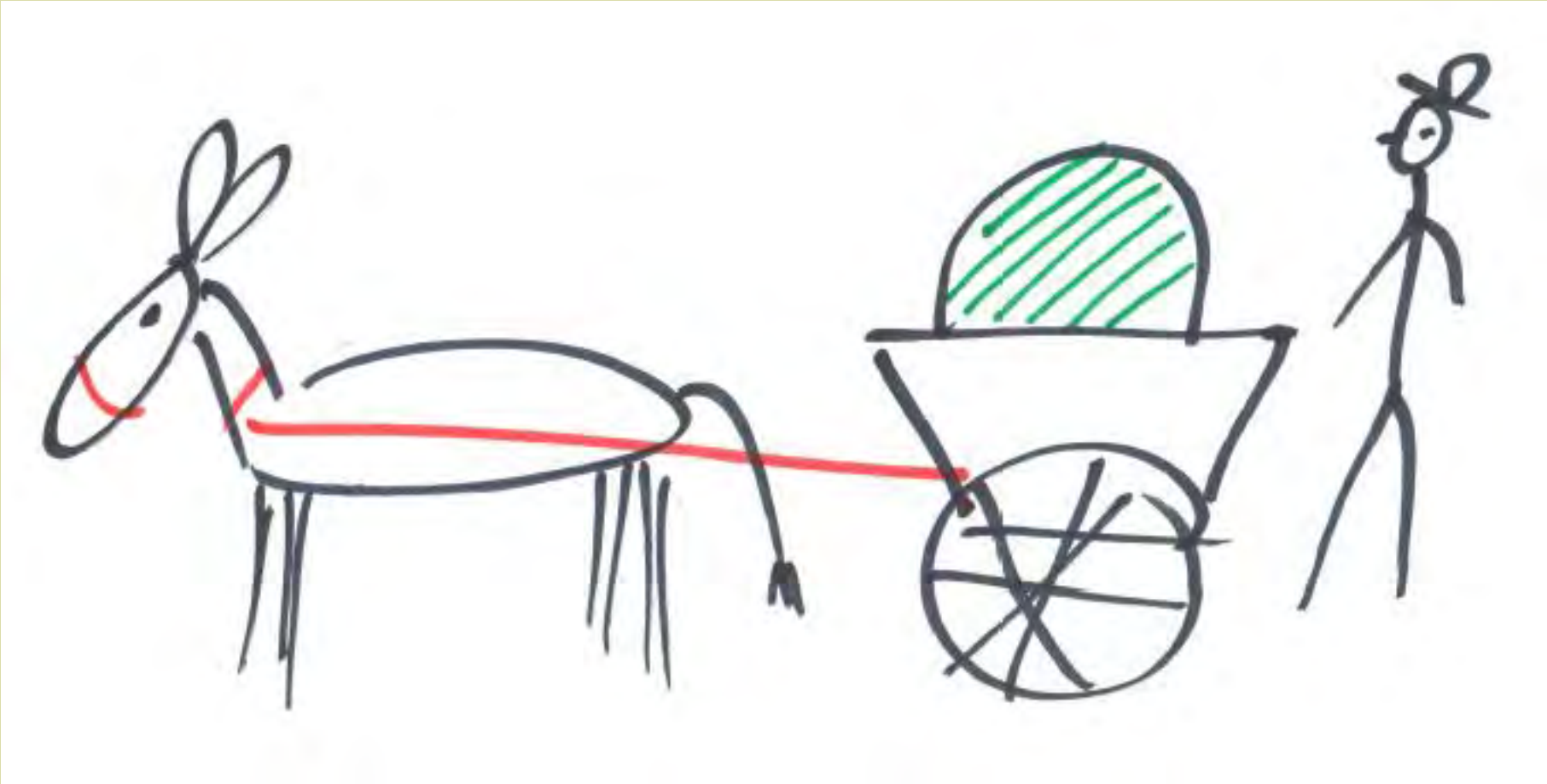
The missing link



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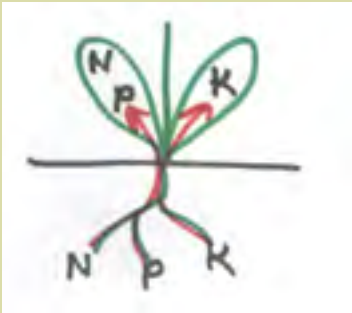
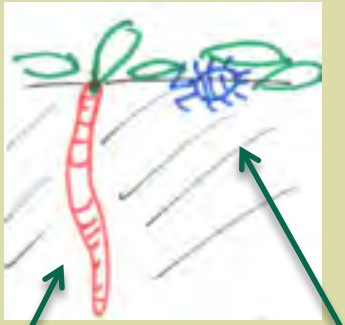
How does it work?



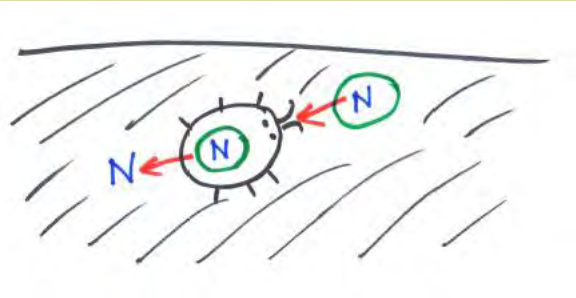
Nutrients are taken up by the plant and stored in the leaves

Dead leaves on the soil surface



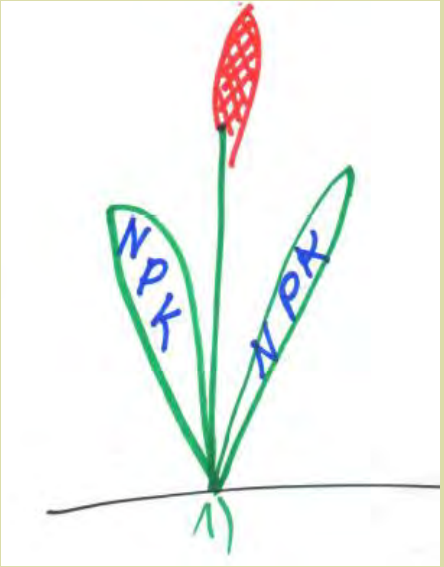
Earthworm and springtail

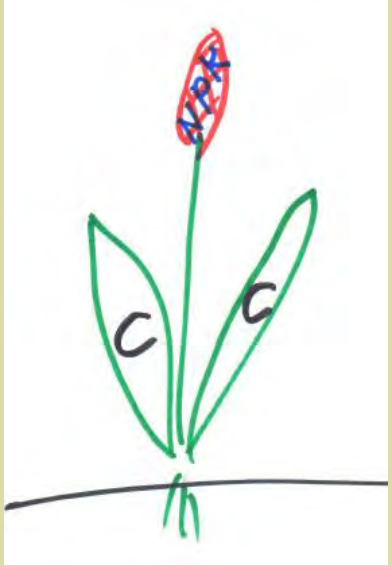
Smaller pieces of organic matter in the topsoil



Nutrients being eaten by microorganisms and eventually released into the topsoil

fact to know about microorganisms to understand soil fertility





When a plant goes into seed, the nutrients move from the leaves into the seed. After that the plant dies back. It turns yellow or brown. What remains in the stalk and the leaves is something we call **Carbon ,** which is written as: **C**

When we harvest our maize, we remove the seeds and the only thing that is left is the carbon of the dead leaves.

Carbon is just the same as charcoal or paper. It is just the structure of organic matter but it doesn't contain any nutrients.

When we incorporate harvest residues into the soil that is like adding PAPER!

When we feed them to our cows it is the same as feeding them PAPER!

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Is God crazy?

Why does he leave us with PAPER???

God is not crazy!

He knows exactly what he is doing.

Science helps us to understand God's ways!

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Nitrogen-Carbon-Balance

- Microorganisms need Carbon to digest Nitrogen and they also need Nitrogen to digest Carbon.
- To make 1 Nitrogen available for plants microorganisms need to take up 20 Carbon at the same time. Or to decompose 20 Carbon they need 1 Nitrogen.
- They cannot digest the one without the other.
- This is called the **Nitrogen-Carbon Balance:**

1N:20C

- In soil fertility C and N are useless or even harmful without each other!

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New Approach in Soil Fertility Management

- Know the status of your soil
- Make an informed decision about its (input) management
- Choose appropriate methods and technologies to reduce organic matter losses
- Ensure balanced and appropriate nutrient levels while keeping your soil healthy and rich in humus
- Monitor your crop to minimize interventions that are damaging to important microbial life in the soil.

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Thank You!

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