The Fundamentals of Agronomy and Agroecology

Key Lessons from the Training Conducted at Ceffel in Madagascar

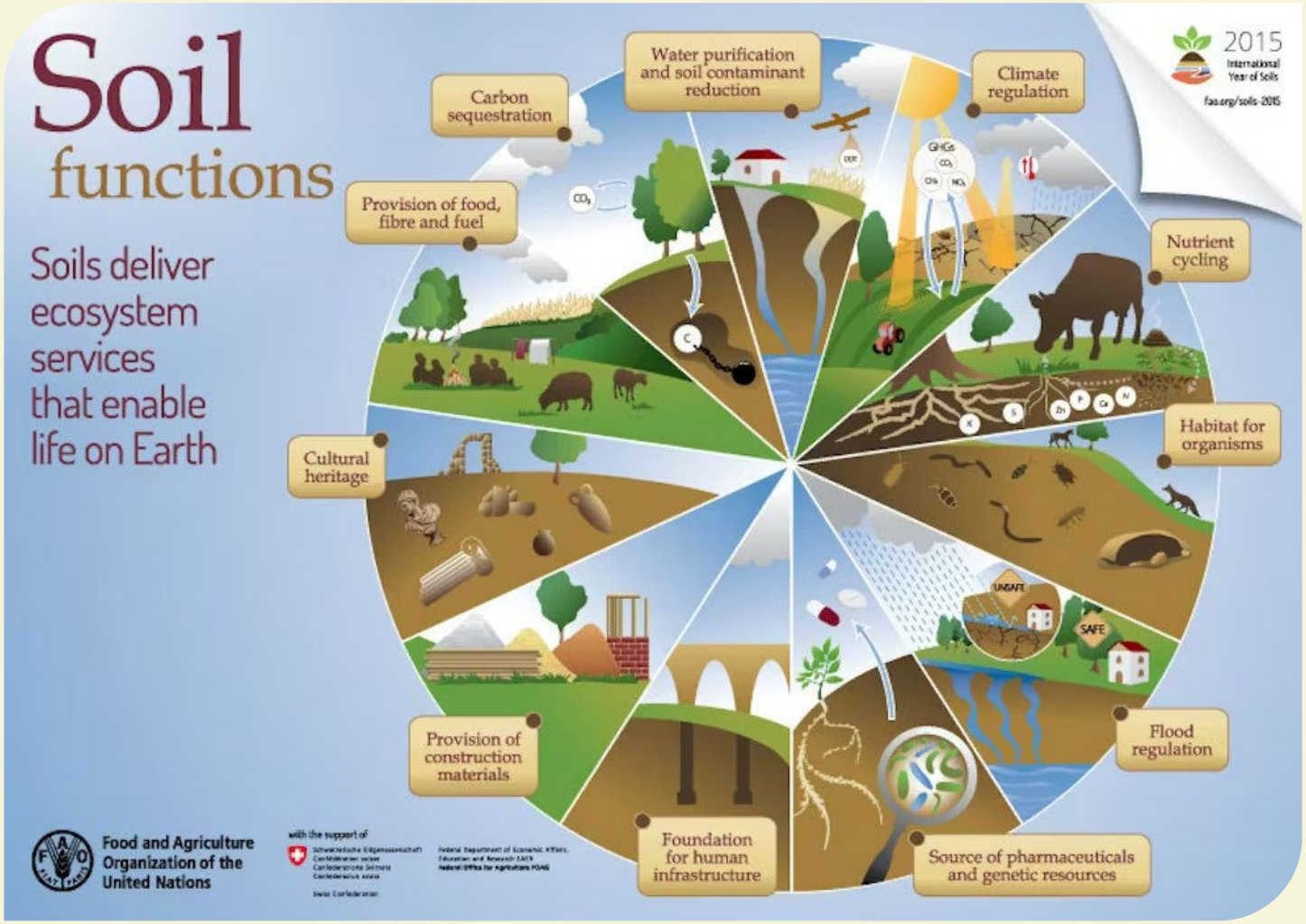
Soil Health and Fertility | Plant Nutrition | Plant Health

1 Key Factors

Paying close attention to soil health and fertility is essential to ensure efficient and sustainable agricultural production. **A better understanding of the physical and chemical properties of the soil**, such as its pH, organic matter content, structure, and nutrient levels, makes it possible to identify its specific needs. This information helps farmers choose the most appropriate farming practices and adapt the application of soil amendments and fertilizers in a targeted manner, thereby avoiding unnecessary expenses.

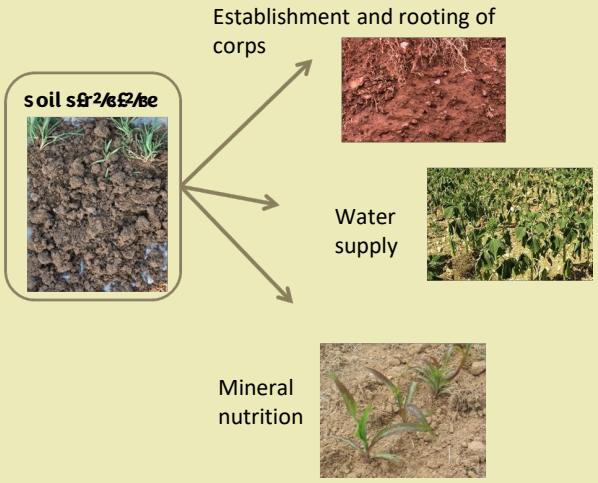
A healthy soil also enables better yields **and improved production quality** by ensuring optimal conditions for crop development.

Maintaining soil fertility is also part of **a sustainability approach**: preserving natural resources and maintaining the productive potential of the soil over the long term, for the benefit of future generations.



2 Agronomic Considerations

Soil structure: this determines water and air circulation as well as root development. It can be observed by making a soil profile using a knife to distinguish the different layers and check whether the soil is compacted or aerated.



Organic matter and soil life have three major roles:

- providing nutrients from the decomposition of plants and living debris, made assimilable by the action of microorganisms (mineralization)
- improving soil structure through the clay--humic complex, the creation of tunnels, and the stability of aggregates
- improving the soil's ability to retain water and infiltrate it efficiently. Biological activity can be assessed using the slip test, which allows direct observation of soil organisms' activity.

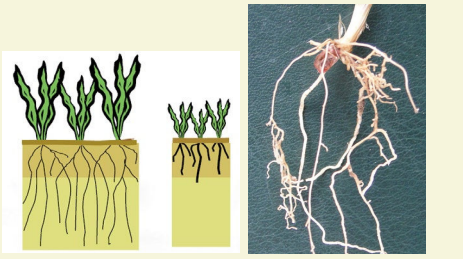
Soil texture: this influences water retention, aeration, and nutrient availability, and therefore guides choices in terms of irrigation, nutrition, and crops. It can be determined using the texture triangle or by manually testing the soil (fine, sticky, sandy, etc.). Poor texture can be compensated by appropriate practices (adding organic matter).

Plant health depends directly on soil quality, particularly on its ability to provide the nutrients essential for the growth of the plant.

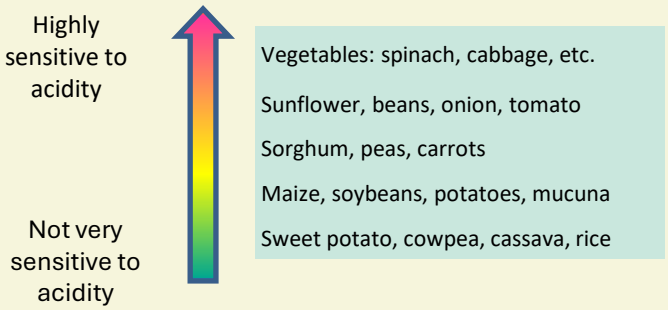
Soil pH: this influences the availability of nutrients for plants. It is measured using a pH meter but can also be estimated in the field by observing the color of the soil, spontaneous vegetation, or by simple tests using vinegar and baking soda (effervescent reaction).

When the pH is below 5.5, phosphorus is less available because it is trapped by iron and aluminum oxides.

Root function is affected
The roots become thick and poorly branched. They are no longer able to provide plants with minerals and water.



Tolerance to aluminum toxicity varies depending on the crop.



Acidity is the primary limiting factor, so correcting it is the priority, before considering nutrients!

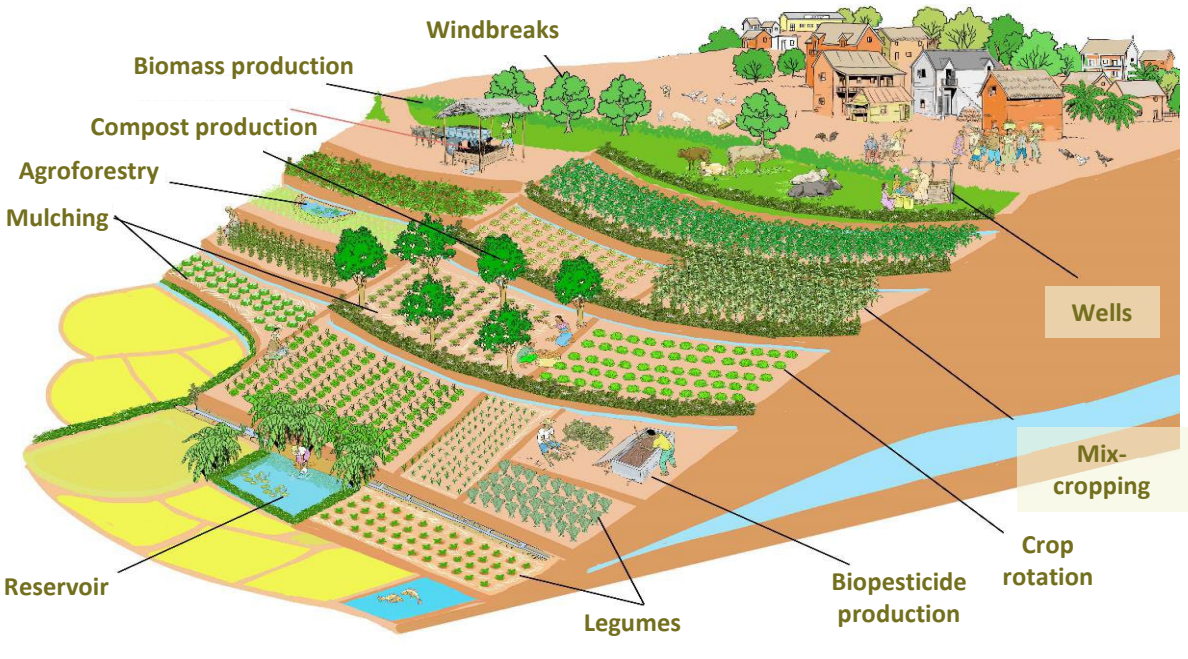
Conversely, in a soil that is too alkaline (pH above 8), often calcareous, certain other essential nutrients such as iron, manganese, phosphorus, zinc, and copper become less soluble and therefore inaccessible to plant roots.

3 Observe et Diagnose

- **Location of the plot, topography:** slope, elevation and erosion risks.
- **Farming history:** previous crops, yields obtained, farming practices (soil improvement, nutrition, treatments, land preparation method, export/burning of straw and other crop residues, etc.).
- **Soil characteristics:** texture, structure, presence of organic matter, beneficial insects and other biological indicators, signs of waterlogging.
- **Vegetative state of existing crops:** vigor, rooting, color, possible symptoms of stress or deficiencies.
- **Local climatic conditions:** rainfall, temperature, sunshine, etc.

4 Main Strategies

- **Implementation of agroecological farming practices adapted to the local context and soil type:** choice of crop type, crop rotation, minimum tillage, plant nutrition applied at the right dose and under the right conditions, etc.
- **Land management, particularly on slopes, to limit erosion and promote water infiltration:** terraces, half-moons, erosion control strips, grass strips/mulching, etc.
- **Increasing organic matter supply:** regular application of compost or green manure, keeping straw and crop residues on the plot, controlling grazing, using plant varieties with high biomass production (aerial and/or root).
- **Correction of soil pH** when necessary. Acidity can be corrected by adding limestone amendments (lime, dolomite, etc.), or, failing that, by adding large quantities of organic matter over a long period of time. In very alkaline soil, choose tolerant crops (wheat, millet, cowpea, cabbage, etc.) and fertilizers in which phosphorus is directly assimilable (DAP, superphosphate, etc.). As a last resort, peat or elemental sulfur can be buried.



- **Planting trees and using agroforestry practices** to stabilize the soil and create a microclimate.
- **Using cover crops or mulch,** depending on availability and climatic conditions, to maintain moisture, protect and enrich the soil. Cover crops can also pump water away from the next crop in areas with low rainfall.
- **Planting of hedgerows,** preferably based on legumes (such as Tephrosia or Cajanus cajan), to reduce erosion and produce biomass for compost or biological control.
- **Supply of beneficial organisms** (EM, vermicompost, nitrogen-fixing bacteria), paying attention to limit the use of chemical inputs.
  ⚠️ These organisms can only be fully effective on soils that are already well regenerated.

5 Key Elements to Consider

🎯 Consider priorities:

- The soil nourishes the plant, so it is essential to take care of it.
- Before investing in inorganic nutrient input, it is essential to address priorities: limiting erosion, correcting the pH if necessary, etc.

⏳ Be patient:

Restoring degraded soil takes time, especially in hot, rainy climates or cold climates.

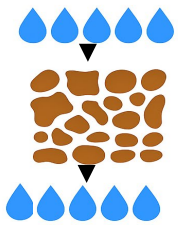
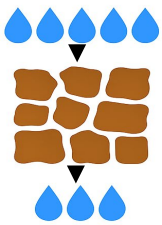
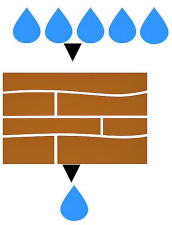
👁 Adopt a systemic approach:

To meet the challenges faced by farmers, fertility management must be part of a comprehensive approach to farming: complementarity between agriculture and livestock, water management, grazing, etc., being careful not to increase the workload.

⚠️ Special caution:

- If the pH is too acidic, efforts to ensure good nutrition will be in vain, as acidity reduces the effectiveness of inorganic inputs.
- Organic fertilizers can also favour or offer shelter to pests (diseases, weed seeds, soil pests, etc.). Composting is therefore a good way to limit these risks.
- Poor soil structure (see diagram on the right) has a negative impact on rooting, water infiltration and retention, and plant nutrition. Quick action is needed: through appropriate tillage method and/or by adding organic matter.

Different types of structure with their water infiltration/retention capacity

Fine/ granular	Blocky	Compact
		
Highly permeable soil, risk of erosion	Good water retention and stability	Low infiltration, risk of waterlogging