Reference 3 Different types of soil

Summary

Soil is often the most important asset of smallholder farmers in Sub-Saharan Africa. This technical reference presents the different types of soil, their characteristics and the simple indicators for recognizing them.

Soil is crucial for plants and life in general. It supports plant roots and provides essential nutrients for plant growth. The characteristics of the soil often determine the nature of the natural vegetation and the crops that can be cultivated because they will be adapted to the soil and will provide good crop performance. The soil also determines to a large extent what happens with the water in a watershed—water losses, water availability and water quality are determined by the characteristics of the soil. The soil is also at the basis of recycling: as the micro-organisms living in the soil decompose crop residues into organic material. All soils contain four major elements:

- Air (20–30% of volume).
- Soil solution (20–30% of volume).
- Mineral fractions (45% of volume).
- Organic matter (5% of volume).

The porosity (volume of air and of soil solution) allows roots and micro-organisms to breathe and it also stores water. In a very dry soil, all the pores (the small holes and channels between grains and soil particles) are filled with air. In a flooded soil, these pores are saturated with water. In water-saturated soil, the roots of many crops cannot breathe which may lead to plant death. Rice is exceptional, as its roots can breathe within standing water.

The mineral fraction in the soil supports the roots and slowly releases mineral dissolved salts into the soil solution. These salts are the crop nutrients. The mineral fraction matter can be composed of elements of different sizes. We can distinguish:

- Coarse sand and pebbles.
- Fine sand.
- Loam.
- Clay.

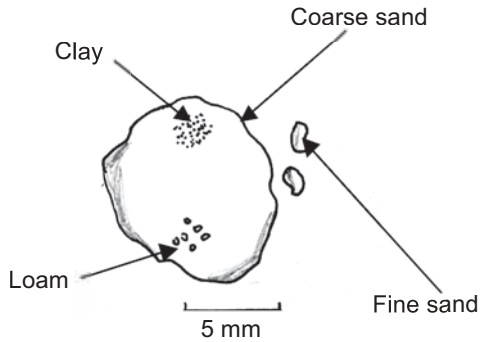

Figure 3.1. Soil texture

Soil contains only a small quantity of organic matter, but that quantity is very important. The organic matter decomposed by micro-organisms releases mineral salts (nutrients) into the soil solution, and also increases the availability of water in the soil. This organic matter, coming from the decomposition of leaves, dead roots and crop residues, accumulates in the upper part of the soil and is dark colored. This is the reason why, when observing the profile of a soil, we can often see different layers: from a black topsoil to lighter colors in the lower layers.

Soil color

The first thing noticed when observing a soil is its color. The soil color is often determined by the color of iron oxides or by the organic matter that covers the surface of the soil particles. The color of organic matter is darker (brown to black) than the color of iron oxides (yellow, red, brown). These colors predominate in topsoil layers, while in the lower layers the colors of iron oxide or manganese oxide (very dark) predominate. Dark topsoil indicates fertile soil. Black soils are generally more fertile than lighter soils because they tend to have a higher organic matter content.

Color changes can provide some indications about the moisture status of the soil, because in dry and aerated conditions the iron oxides have a different color than they do under flooded conditions. The red and brown color of iron in a well-drained and aerated upland soil (high oxygen level) changes to gray, gray-green or blue in a flooded valley-bottom soil (low oxygen level). An intermediate layer (zone) can often be observed, showing variegated colors, including the red and gray of the iron oxides and the black from the manganese oxide. The depth of this layer in the soil indicates the level of the groundwater during the rainy season. These soils are located in the hydromorphic zone of the inland valley. Even in the inland valleys that are flooded throughout the whole year, red coloration can be observed along the roots of aquatic plants such as rice. This is due to the oxygen liberated by the roots when the oxygen content in the soil is low.

Soil texture

The sand, loam and clay contents determine the texture of the soil, which indicates the percentage of coarse and fine particles. A sandy soil contains much sand, a loamy-clayey soil mainly loam and clay.

Soil texture is very important as it determines to a large extent the dynamics of water flow in the soil (Table 3.1). In general, water percolation rates (vertical flow) in sandy soils are much faster than in clayey soils. Together with this percolated water, nutrients flow into lower layers, sometimes out of reach of the plant roots. A sandy soil cannot store much water, but can easily absorb water which is quickly evacuated to the lower parts of the soil. This can be a problem as nutrients can be lost. Sand does not contain a lot of nutrients. A clayey soil can store more water than a sandy soil because the spaces between particles are finer (smaller). Clay is in general fertile, as it easily retains nutrients.

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Table 3.1 Important soil characteristics and their relation to soil texture

Characteristics	Sand	Loam	Clay
Drainage	Fast	Average	Slow
Retention capacity	Low	Average	High
Capacity to stock nutrients	Low	Average	High
Organic matter content	Low	Average	High
Easiness to plow soil in wet conditions	Easy	Average	Difficult
Erosion by run-off	Low (high for fine sand)	High	Low
Wind erosion	Low (high for fine sand)	High	Low

How to observe and determine soil texture

- Take a sample of soil large enough to fill about a quarter of a handful.
- Remove extraneous pieces (roots, seeds, insects, etc.) and any material larger than 2 mm (gravel).
- Add some water to the sample and mix it to form a paste. The soil must be evenly moist without any aggregates.
- First, rub the paste between the thumb and the index and then form a ball or a cylinder, by moving the paste forward from the palm to the fingers and backward to the wrist and vice-versa; this will enable you to determine whether the soil is mostly:
  - *Sandy*: grits can be felt between the fingers and the soil does not stick to the fingers; there is no cohesiveness: the ball breaks easily when it is squeezed between the fingers; a cylinder cannot be formed easily;
  - *Loamy*: the paste partly sticks to the fingers; a ball can be made and it does not break easily when squeezed between the fingers; a cylinder can be formed but cracks appear when it is bent into a U-shape;
  - *Clayey*: the paste is very elastic and sticks to the fingers; it is very easy to roll make it into a ball, to make a hole in it or mold the paste; it is easy to shape a cylinder that does not show cracks when it is bent into a U-shape.

Figure 3.2. Method to determine soil the texture

Soil structure

Soil structure is linked to the organization of primary particles, such as grains of sand, loam and clay in the soil. A good soil structure allows the roots to breathe. In flooded and plowed inland-valley lowlands, the soil often loses its structure and turns into mud. Rice can put up with such a structure because it has channels bringing air from the leaves through the stems down to the roots. In dry conditions, clayey soils show fissures, become compact and form rectangular or hard prismatic blocks. This process hinders root growth as the soil becomes more difficult to penetrate.

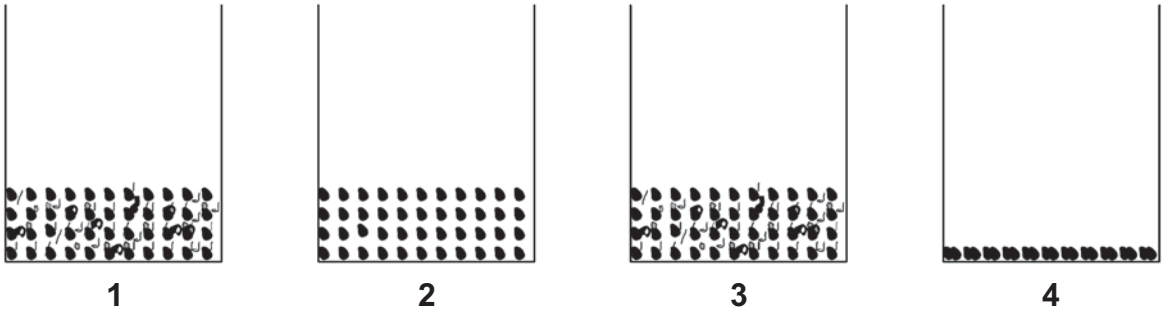

Figure 3.3. Soil aggregates lumps with high organic matter content (1 in dry condition and 3 in moist condition) are more stable than soil aggregates lumps with a low organic matter content (2 in dry condition and 4 in moist condition)

In lighter soils (sandy-loamy), the primary particles are present as in a 'powder,' or in soil aggregates lumps depending on the organic matter content. Organic matter stabilizes soil structure, which is good for the plant. By adding a small quantity of water to a soil with a low organic-matter content, soil aggregates lumps disaggregate into powder. On the contrary, the lumps will not disaggregate in a soil with high organic matter content.

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