

Chapter 4

Soil fertility and crop production

Soil fertility is a complex quality of soils that is closest to plant nutrient management. It is the component of overall soil productivity that deals with its available nutrient status, and its ability to provide nutrients out of its own reserves and through external applications for crop production. It combines several soil properties (biological, chemical and physical), all of which affect directly or indirectly nutrient dynamics and availability. Soil fertility is a manageable soil property and its management is of utmost importance for optimizing crop nutrition on both a short-term and a long-term basis to achieve sustainable crop production.

Soil productivity is the ability of a soil to support crop production determined by the entire spectrum of its physical, chemical and biological attributes. Soil fertility is only one aspect of soil productivity but it is a very important one. For example, a soil may be very fertile, but produce only little vegetation because of a lack of water or unfavourable temperature. Even under suitable climate conditions, soils vary in their capacity to create a suitable environment for plant roots. For the farmer, the decisive property of soils is their chemical fertility and physical condition, which determines their potential to produce crops.

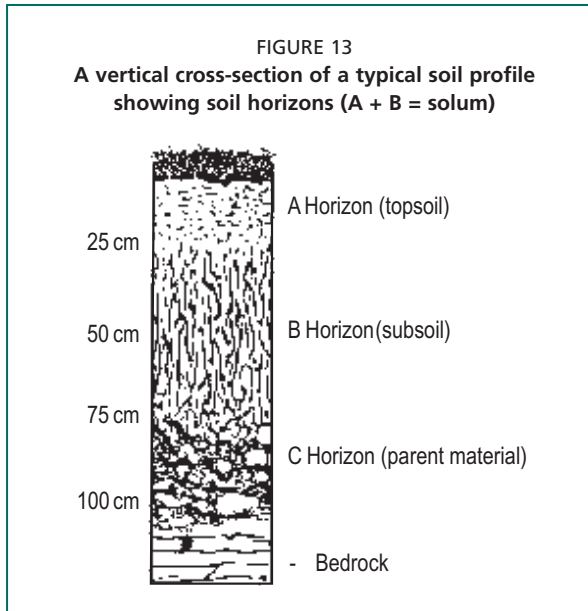
Good natural or improved soil fertility is essential for successful cropping. It is the foundation on which all input-based high-production systems can be built.

SOILS AS A BASIS FOR CROP PRODUCTION

Soil, the natural medium for plant growth

Crop production is based largely on soils. For large-scale and low-cost crop production, there is no substitute for natural soils as a substrate for crops in the foreseeable future. Soils are the uppermost part of the earth's crust, formed mainly by the weathering of rocks, formation of humus and by material transfer. Soils vary a great deal in terms of origin, appearance, characteristics and production capacity. Well-developed soils generally show a distinct profile with different layers. The uppermost layer, called topsoil or A horizon, is richest in organic matter, nutrients and various soil organisms. Plants mainly use the topsoil as rooting volume to obtain water and nutrients, but they can also use the subsoil (partly corresponding to B horizon) or even lower layers up to 1 m or even deeper (Figure 13).

Major types of soils are formed from rocks by weathering processes over long periods extending to more than 1 000 years. During weathering, physical disintegration of rocks and minerals occurs, and chemical and/or biochemical soil forming processes lead to their decomposition. The result is the synthesis of new products, e.g. clay minerals and humic substances. Mineral or organic



substances can be moved downwards or upwards within the profile, but they may also be lost by transportation to other places by water and wind erosion. Some of the most productive soils are the result of distant long-term geological soil erosion.

Soils vary largely with respect to their natural fertility and productivity resulting in plant growth ranging from practically zero (no growth at all on extreme problem soils) to abundant luxuriant growth of natural vegetation. However, only a small proportion of world's soils has a very good level of fertility. Most soils have only good to medium

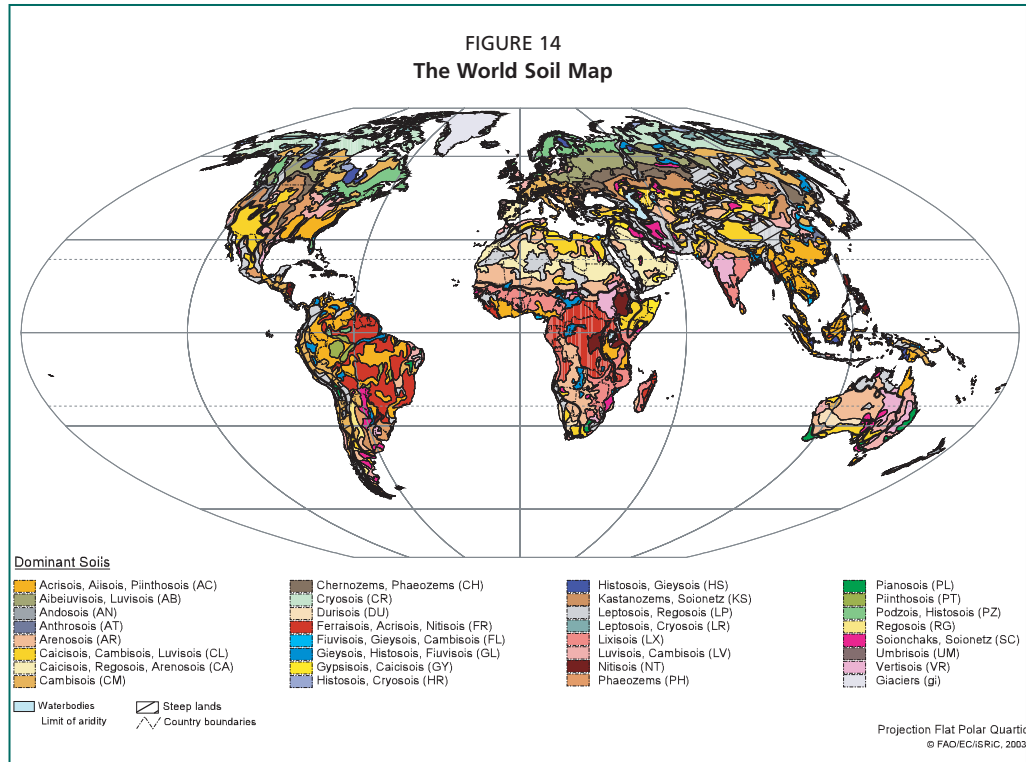
fertility and some have very low fertility, and are often referred to as marginal soils. Such areas should not generally be used for cropping but only for grazing in a controlled manner. However, under natural vegetation in a suitable climate, even soils of poor fertility may produce luxuriant vegetation where the nutrient cycle is closed, e.g. the Amazon forests.

Well-known fertile soils are deep alluvial soils formed from river mud, organic-matter-rich soils on loess material, nutrient rich Vertisols and volcanic soils. In most countries with large food demand, cropping cannot be restricted to the most fertile soils because of the large population and general shortage of usable land. However, soils with medium fertility can be improved considerably as has been demonstrated in many countries. Naturally poor or degraded soils can also be restored to a satisfactory fertility level. Under poor management, soil fertility can be seriously depleted and soils may become useless for agriculture.

Classification of soils

Soil scientists classify soils by different classification or taxonomic systems. Formerly, the classifications at national level were based on easily recognizable features and relevant soil properties for cropping. Soil-type names were generally well understood by farmers. Even on a higher classification level, the division into zonal soils (mainly formed by climate), intrazonal soils (mainly formed by parent material or water) and azonal soils (young alluvial soils) was easy to understand.

Modern and global-scale classification systems are based on developmental (pedogenic) aspects and resulting special soil properties. A common one is the system of soil types developed by FAO and the United Nations Educational and Scientific Cooperation Organization (UNESCO) used for the World Soil



Source: FAO, 1991.

Map (Figure 14) or the international classification based on the soil taxonomy developed by the United States Department of Agriculture (USDA). The major soil units depicted are listed in Table 8, which contains the modern FAO/UNESCO classification (28 major soil groupings, composed in 9 sets) and USDA equivalents.

The total land surface of the world is covered by the following major soils:

- soils of humid tropics, e.g. Ferralsols (Oxisols), etc.: 20 percent;
- soils of arid regions, e.g. Calcisols (Calcids), etc.: 18 percent;
- mountainous soils, Leptosols (Umbrept): 15 percent;
- soils of steppe region, e.g. Chernozems (Udolls): 7 percent;
- Podzols (Spodosols) and similar soils: 7 percent;
- clay soils of subtropics, Vertisols (Vertisols): 3 percent.

As agriculture develops, the natural properties of soils, especially of the topsoils, become more and more similar and adapted to crop requirements. This means that most cropped soils tend to become Arthrosols.

SOIL CONSTITUENTS

A soil consists of mineral matter, organic matter and pore space, which is shared by air, water and life forms. In addition to the above constituents, the soil also contains a large and varied population of micro-organism and macro-organisms