UNIT 3 EDAPHIC FACTORS AFFECTING CROP PRODUCTION

CONTENTS

1.0 INTRODUCTION

Soil is the uppermost layer of the earth which supports the growth of higher plants, mainly by providing a medium for plant roots and supplying elements that are essential to the entire plant. The soil is the regulator of water supplies in rivers, lakes and underground aquifers; it recycles raw materials as humus, and a habitat for soil organisms, including beneficial organisms, predators, preys, producers, consumers and parasites. In Nigeria, the variations in the patterns of distribution of soil results in marked regional differences in agricultural specializations. Soil type, fertility and the present and potential systems of soil management have considerable influence on agricultural production. Regional variations in soil types often influence the prospect of growing particular crops in different parts of the country. Also, fertility level influences soil types and traditional soil management techniques used in their maintenance.

2.0 OBJECTIVES

By the end of this unit, you should be able to explain:

- the influence of soil is physical, chemical and biological properties on crop production, and
- the spatial distribution of soil types in Nigeria.

3.0 MAIN CONTENT

Crop productivity is strongly dependent on physical, chemical and biological conditions of the soil.

3.1 Physical Soil Factors Affecting Crop Production

These include the soil's texture, structure, porosity and bulk density.

3.1.1 Soil Texture

This is defined as the relative proportions of the sand, silt, clay and gravel/stone particles (composition) in the soil. The proportion of solid soil particles provides a useful guide to a soil's potential for agricultural crop production, since it exerts a major influence on soil characteristics. The soil texture influences the water-holding capacity (through the clay type and content and capillary conductivity), temperature, drainage and nutrient retention capacity of the soil. Also, soil texture influences the efficacy of soil-applied pre-emergence herbicides and other pesticides. Soils are classified into light (sandy, workable), medium (loamy, most workable) or heavy types (clay, unworkable) on the basis of soil texture, due to its close relationship to the workability (the ease of working the soil with machinery) of the soil.

3.1.2 Soil Structure

This is defined as the arrangement of the particles (sand, silt, clay) in the soil. It influences the soil tilth, root growth and development, gaseous exchange/aeration, drainage, water infiltration into the soil, and efficiency of water and nutrient uptake by plants (through capillary conductivity). "Structural stability" is the ability of the soil to resist deformation when wet. It is influenced by the clay content, presence of lime, iron oxides and humus. However, soil structure is not a stable soil property, and therefore changes with time and weather. Poorly stable soil aggregates slake (collapse) easily while good aggregate structure maintains the shape when wetted for a short time and gradually piece off thereafter. A good structural stability is essential to prevent soil degradation and limited crop growth. Soil structure can be improved by addition of decomposable OM (e.g. farmyard manure, FYM), crop roots and crop residues. Heavy machinery causes damage to soil structure in wet soil, especially heavy clay soils.

3.1.3 Soil Porosity

This is defined as the percentage volume filled with air when the soil is fully drained of saturated water. The pore sizes include micropores (smallest pores containing only water which rarely dries out and is unavailable for crop uptake); mesopores (middle-sized pores containing water available to plants and which allow free aeration of the soil); and macropores (pores greater than 0.1 mm in diameter, can drain easily to allow in air after full wetting of the soil). Soil porosity influences the infiltration of water into the soil, water-holding capacity, drainage and aeration of the soil aggregates; these properties have significant influence on the SOM status. Ecologically, soil aeration plays a significant role in organic residue decomposition; oxidation-reduction of elements, especially nutrients; plant growth; nutrient and water uptake; soil compaction; soil structure; and soil cultivation. Aeration capacity is very high in sandy soils, optimal in loamy soils and very low in clay soils. However, organic matter additions (which increase the number of meso- and macro-pores) can improve the aeration capacity of clay soils.

3.1.4 Soil Bulk Density

This is mass of soil per unit volume of the soil. It is determined by the volume of pore spaces in the soil; the more the pore spaces, the lower the bulk density, and vice versa for high bulk density or soil compaction. Soil bulk density affects the workability of the soil, especially with respect to mechanical cultivation, and especially in dry weather. No-tillage or minimum tillage is also strongly affected by soil compaction.

3.1.5 Soil Water

Water is held in the soil in three forms, namely:

i. capillary water (water held by surface tension forces as a continuous film around the particles and in the capillary pore spaces of the soil);
ii. gravitational water (water held to the soil particles against gravitational forces and suction force of the roots, and which drains under the influence of gravity); and

iii. hygroscopic water (water adsorbed from an atmosphere of water vapour as a result of attractive forces in the surface of the soil particles and aggregates).

Soil water is very critical to root absorption of essential nutrients from the soil, soil temperature, microbial and microbial soil activities, organic matter decomposition, etc. The farm soil needs to be at field capacity always to ensure optimal growth and development.

3.2 Chemical Factors of Soil Affecting Crop Production

The soil chemical characteristics are of primary importance in crop nutrition. They include

3.2.1 Soil Organic Matter (SOM)

This is the proportion of the fresh organic material and humus (partly decomposed and synthesised organic material). These materials exert a profound influence on crop nutrients (through slow nutrient-release mechanism), soil structure and cultivation. Organic matter serves as the soil granulator, being largely responsible for particle aggregation through its efficiency on cohesion and plasticity. It is a rich source of important plant nutrients, particularly nitrogen which is entirely derived from organic matter. Organic matter influences the colour, temperature (by minimizing evaporation from soil surface), water-holding capacity, water retention, infiltration, pH and exchangeable capacity of the soil. It is the main source of energy for heterotrophic soil microorganisms, which stimulates their reproduction and growth, thus facilitating their capacity to make the nutrients in SOM available to the plants. Organic materials in the soil are decomposed by primary decomposers (insects, earthworms, fungi) and secondary decomposers (bacteria, fungi). This, in addition to cultivation and bush burning reduce SOM content. Contrarily, SOM can be maintained by bush fallowing, agro-forestry, no-tillage, crop rotation, mixed farming, ground cover management, alley cropping and incorporation of organic materials into the soil. Important sources of organic matter are FMW, composts, straw, green manure, animal products, cadavers, garbage, industrial wastes (especially food processing wastes), urban liquid wastes, city refuse, peat (Sphagnum moss, sedge), sawdust, leaf mould, sewage sludge, slurry, sewage effluent, leys and mulch.

3.2.2 Soil pH

This indicates the degree of acidity or alkalinity of the soil. It is significant in determining the soil chemical reactions. Soil acidity (low soil pH) is caused by carbonic acid in rainfall water, organic acids (e.g.

humic acids) from microbial breakdown of organic matter (OM), ammonia from nitrification, and loss of calcium in drainage and crop removal. Liming helps to correct soil acidity; liming materials include $CaCO_3$, CaO, $Ca(OH)_2$ and Magnesian limestone. Although crop families can occur at pH 5 and below, it is necessary to analyse the soil pH regularly to determine the lime requirement.

3.2.3 Available plant nutrients

Soil minerals are derived from rock weathering; the primary minerals are derived directly while the secondary minerals are derived from the primary minerals by weathering and synthesis. Plant nutrients are of three main forms, namely macro-, meso-and micro-nutrients. The macro-nutrients (nitrogen, phosphorus, potassium) are primarily important in crop growth, because they are required in large quantities. The meso-nutrients are calcium, magnesium and sulphur. The micro-nutrients are required in minute quantities but are also important for the normal growth of some crops and certain physiological processes, namely enzyme systems, protein and carbohydrate metabolism, nitrogen fixation, chlorophyll formation, pod maturation and production, growth hormones and starch forms. They include copper, molybdenum, chlorine, boron, manganese, zinc and iron. A knowledge of the available nutrients not only guides in determining the suitability of the site (soil) for a particular crop but also in formulating soil fertilizer requirements.

3.3 Biological Factors of Soil Affecting Crop Production

These are complex, and include the soil fauna and flora.

3.3.1 Soil Fauna

This includes both the beneficial and damaging animal organisms. Beneficial organisms are those which break down and incorporate crop residues, and further aid in water movement and aeration e.g. earthworm. The damaging organisms consist of the larval stages of click beetle/wireworms, crane fly, chafer grubs and eelworms/nematodes.

3.3.2 Soil Flora

Pathogens such as bacteria, fungi and viruses are important as sources of soil infections in crop lands.

3.4 Spatial Distribution of Soil Types in Nigeria

About six or more soil types are found distributed across different ecological zones in Nigeria. The soils are:

3.4.1 Alluvials

There are three types of alluvials which are important, namely alluvial of marine deposit found in mangrove areas which are suitable only for coconut growing; the alluvial near the coast which has a high sulphide content and when drained, has the tendency to become acidic, and alluvial on lacustrines and riverine deposit, which constitutes the most useful alluvial soil under controlled drainage conditions.

3.4.2 Ferrasols

These are also called acid sands (pH= 5.0-5.5) and are also reddish-yellow in colour. They cover the southern parts of the forest zone of western Nigeria and extensive areas of mid-Western and eastern states. They are of low fertility or agricultural value but potentially suitable for mechanical agriculture.

3.4.3 Ferruginous Tropical Soil

This is a soil formed from crystalline acid rock, except those developed on sandy, undifferentiated and sometimes hydromorphic soils. It is of high natural fertility but traditional management practices have caused problems for crop utilization. In the forest zone, it is suitable for planting cocoa while in the savanna zone it is suitable for export and food crops e.g. beniseed, cotton, guinea-corn, maize, yam, millet and groundnut. The soil is relatively more suitable for agriculture than any other soil type.

3.4.4 Lithosols

These soils are of local significance and usually associated with ferruginous tropical soils. Agricultural activity is very low but they need to be protected from soil erosion to avoid damaging adjacent and more fertile soil.

3.4.5 Vertisols

These soils have characteristics of considerable agricultural importance. These features include dark colour with large amount of clays of the expanding lattice type (kaolinite); occurrence of deep cracks during the dry season; very limited horizon/less deep development; richness in calcium, especially $CaSO_3$ and $CaSO_4$. Those developed from calcerous rocks have the greatest potential for agriculture. However, they have little use because of difficulty of tillage but dry season guinea-corn is extensively grown in some.

3.4.6 Regosols

These overlay semi-arid brown and reddish-brown soil. Organic matter content is nearly constant to a considerable depth. Many of these soils show an increase in clay content with soil depth.

Generally, organic matter and nutrient contents of soils decline during production or cropping and increase under fallow for varying periods. Therefore, several methods are used by the farmers to maintain soil fertility, including crop rotations, shorter fallows and use of crop residues.

4.0 CONCLUSION

In this unit, you have learned about the effects of soil properties on agricultural crop production and productivity, and aspects of the distribution of soil types and their agricultural value in Nigeria.

5.0 SUMMARY

Agricultural crop production is greatly influenced by soil properties, especially soil type, fertility status and potential management systems.

6.0 TUTOR-MARKED ASSIGNMENT

1) Define the following terms:
   (a) soil texture, (b) soil organic matter,
   (c) hygroscopic water, (d) mesopores, and
   (e) soil structural stability.

2) Enumerate the different types of soil texture.

3) Write short notes on the influence of soil structure on crop productivity.

4) List four ways of improving soil structure.

7.0 REFERENCES/FURTHER READING

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