Agriculture Notes

What is Soil?

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Soil is the loose surface material consisting of inorganic particles and organic matter that covers most of the land surface. Soil provides the structural support and the source of water and nutrients for plants used in agriculture.

Soils vary greatly in their chemical and physical properties which depend on their age and on the conditions (parent material, climate, topography and vegetation) under which they were formed.

Processes such as leaching, weathering and microbial activity combine to make a whole range of different soil types, each of which has particular strengths and weaknesses for agricultural production.

This Agriculture Note provides a brief introduction to soils and the major soil components.

Inorganic Component

Inorganic material is the major component of most soils. It consists largely of mineral particles with specific physical and chemical properties which vary depending on the parent material and conditions under which the soil was formed. It is the inorganic fraction of soils which determines soil physical properties such as texture and has a large effect on structure, density and water retention.

Soil Texture

The texture of soil is a property which is determined largely by the relative proportions of inorganic particles of different sizes.

In Australia the following five size fractions are used to describe the inorganic fraction of soils:

- **Gravel** - particles greater than 2 mm in diameter.
- **Coarse sand** - particles less than 2 mm and greater than 0.2 mm in diameter.
- **Fine sand** - particles between 0.2 mm and 0.02 mm in diameter.
- **Silt** - particles between 0.02 mm and 0.002 mm in diameter
- **Clay** - particles less than 0.002 mm in diameter.

Sand

Quartz is the predominant mineral in the sand fraction of most soils. Sand particles have a relatively small surface area per unit weight, low water retention and little chemical activity compared with silt and clay.

Silt

Silt has a relatively limited surface area and little chemical activity. Soils high in silt may compact under heavy traffic and this affects the movement of air and water in the soil.

Clay

Clays have very large surface areas compared with the other inorganic fractions. As a result clays are chemically very active and are able to hold nutrients on their surfaces. These nutrients can be released into soil water from where they can be used by plants. Like nutrients, water also attaches to the surfaces of clays but this water can be hard for plants to use.

There are many different types of clays. The ability of clays to swell and to retain a shape into which they have been formed, as well as their sticky nature, distinguish them from sand and silt.

Soil Textural Class

The relative proportion of sand, silt and clay particles determines the physical properties of soil including the texture. The surface area of a given amount of soil increases significantly as the particle size decreases. Consequently, the soil textural class also gives an indication of some soil chemical properties.

The exact proportions of sand, silt and clay in a soil can only be determined in a laboratory but a naming system has been developed to approximately describe the relative proportions of sand, silt and clay in soil. This classification of soil can be undertaken in the field where particular properties indicate possible textural classes.

To estimate texture in the field, crush a small sample of soil (10 to 20g) in one hand. After removing any gravel or root matter, work the soil in the fingers to break down any aggregates which may be present. With the sample moist but not sticky, the textural class can be estimated by the feel of the sample between the fingers

Classes of Texture - in order of increasing clay content (Adapted from Leeper and Uren, 1993)

Textural Class Description

- **Sand** - A sand has a loose gritty feel and does not stick together. Individual sand grains can be seen or felt.
- **Loamy Sand** - In a loamy sand particles barely stick together and a moulded piece of soil just holds its shape.
- **Sandy Loam** - A sandy loam sticks together more than a loamy sand but can be easily broken. Individual sand grains can be felt and heard if a wet sample is rubbed between the index finger and thumb and held close to the ear.
- **Silty Loam** - A silty loam is like a loam but has a smooth silky feel when a moist sample is pushed between the index finger and thumb. On drying a sample can form a hard lump but this may be broken by hand.
- **Loam** - A loam breaks into crumbs but will tend to stick together. Sand grains cannot be felt in a moist sample which when squeezed will retain its shape when handled freely. Loams are usually soft to the feel.
- **Sandy Clay Loam** - A sandy clay loam is like a clay loam but sand grains can be felt (and heard - see Sandy Loam)
- **Silty Clay Loam** - A silty clay loam is like a clay loam but silty as well and smooth to the touch.
- **Clay Loam** - More easily moulded into a shape than a loam, a clay loam rolls out to a thin ribbon between the palms while a loam will break-up. When dry a clay loam will form a lump but is not as tough to break as a clay.
- **Sandy Clay** - A sandy clay is like a clay but sand grains can be felt (and heard - see Sandy Loam).
- **Silty Clay** - A silty clay is like a clay but smoother.
- **Clay** - Clays are tough and can be moulded into shapes when moist. Clays form a long flexible ribbon when rubbed between the palms and the ribbon can often be bent into a "U" shape without breaking. Clays dry into very hard clods.

It should always be remembered that soil texture often varies with depth and that the properties of the topsoil are affected by the properties of the subsoil.

Structure

Structure is the arrangement of soil particles and the pore spaces between them. A soil with structure which is beneficial to plant growth has stable aggregates between 0.5 and 2 mm in diameter. Such soils have good aeration and drainage.

Chemical properties

The inorganic minerals of soils consist primarily of silicon, iron and aluminium which do not contribute greatly to the nutritional needs of plants. Those in the clay fraction have the capacity to retain nutrients in forms which are potentially available for plants to use.

Organic Component

The organic matter of soil usually makes up less than 10% by weight of soil. It can be subdivided into the living and the non-living fractions. The non-living fraction contributes to the soil's ability to retain water and some nutrients and to the formation of stable aggregates.

Organic Matter

The organic matter fraction of soils comes from the decomposition of animal or plant products such as faeces and leaves. Soil organic matter contributes to stable soil aggregates by binding soil particles together.

Plants living in soil continually add organic matter in the form of roots and debris. Decomposition of this organic matter by microbial activity releases nutrients for the growth of other plants.

The organic matter content of a soil depends on the rates of organic matter addition and decomposition. Soil micro-organisms are the primary agents responsible for the decomposition of organic matter such as plant residues. Initially, the sugars, starch and certain proteins are readily attacked by a number of different micro-organisms. The more resistant structural components of the cell wall are decomposed relatively slowly. The less easily decomposed compounds, such as lignin and tannin, impart a dark colour to soils containing a significant organic matter content.

The decomposition rate of organic materials depends on how favourable the soil environment is for microbial activity. Higher decomposition rates occur where there are warm, moist conditions, good aeration, a favourable ratio of nutrients, a pH near neutral and freedom from toxic compounds.

Soil Organisms

The soil contains numerous organisms ranging from microscopic bacteria to large soil animals such as earthworms. The soil micro-organisms include bacteria, fungi, actinomycetes, algae, protozoa and nematodes.

The diversity of soil organisms can both assist and hinder plant growth. Beneficial activities include organic matter decomposition, nitrogen fixation, transformation of essential elements from one form to another, improvement in soil structure through soil aggregation, and improved drainage and aeration.

Under some circumstances soil organisms compete with plants for nutrients.

Bacteria are the smallest and most numerous micro-organisms in the soil.

They make an important contribution to organic matter decomposition, nitrogen fixation and the transformation of nitrogen and sulphur.

The fungi and actinomycetes contribute beneficially to organic matter decomposition. The group of large soil animals includes earthworms, which incorporate organic matter into the soil as well as improving aeration and drainage by means of their channels. Some soil fungi, nematodes, and insects feed on roots and lateral shoots to the detriment of plants.

Further Reading

LEEPER, G.W. and UREN, N.C. (1993) *Soil Science, An Introduction*. 5th edition, Melbourne University Press.

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