Chapter A3. Features of soil

PURPOSE OF THIS CHAPTER

To introduce the general features of soils

CHAPTER CONTENTS

- texture
- structure
- slaking and dispersion
- infiltration and permeability
- organic matter, pH and acidity
- bulk density
- the soil profile

ASSOCIATED CHAPTERS

- Parts B and D

FEATURES OF SOIL

Soil is made up of solid, liquid and gas components:

- the solid part consists of mineral particles and organic matter
- the liquid part is water and nutrients
- the gas part is air.

The solid components are minerals derived originally from weathering rock and organic materials derived from plants and micro-organisms. In many areas of New South Wales, the mineral elements of soil have been transported and deposited by the action of old streams and rivers.

The liquid component of the soil is made up of water, with varying amounts of nutrients and other soluble substances dissolved within it. The water and nutrients are used by plants to grow. Water may be lost by evaporation to the atmosphere, or by deep drainage through the soil. Water that is drawn out of the soil by plants and released into the atmosphere is called transpiration.

The gas component of the soil refers to air. Soil is generally porous, containing many air spaces. Oxygen in the air is required in the soil for the growth of most plants. When the soil becomes saturated with water, with no air left in the pores, the soil is said to be waterlogged. (See Figure A3–1.)

TEXTURE

Texture can be measured by the behaviour of a small handful of soil when it is moistened with water, worked into a ball and then pressed out between thumb and forefinger. It is used as a guide to the proportions of gravel, coarse sand, fine sand, silt and clay in the soil. Texture is important, because it affects the movement and availability of water and nutrients in the soil.

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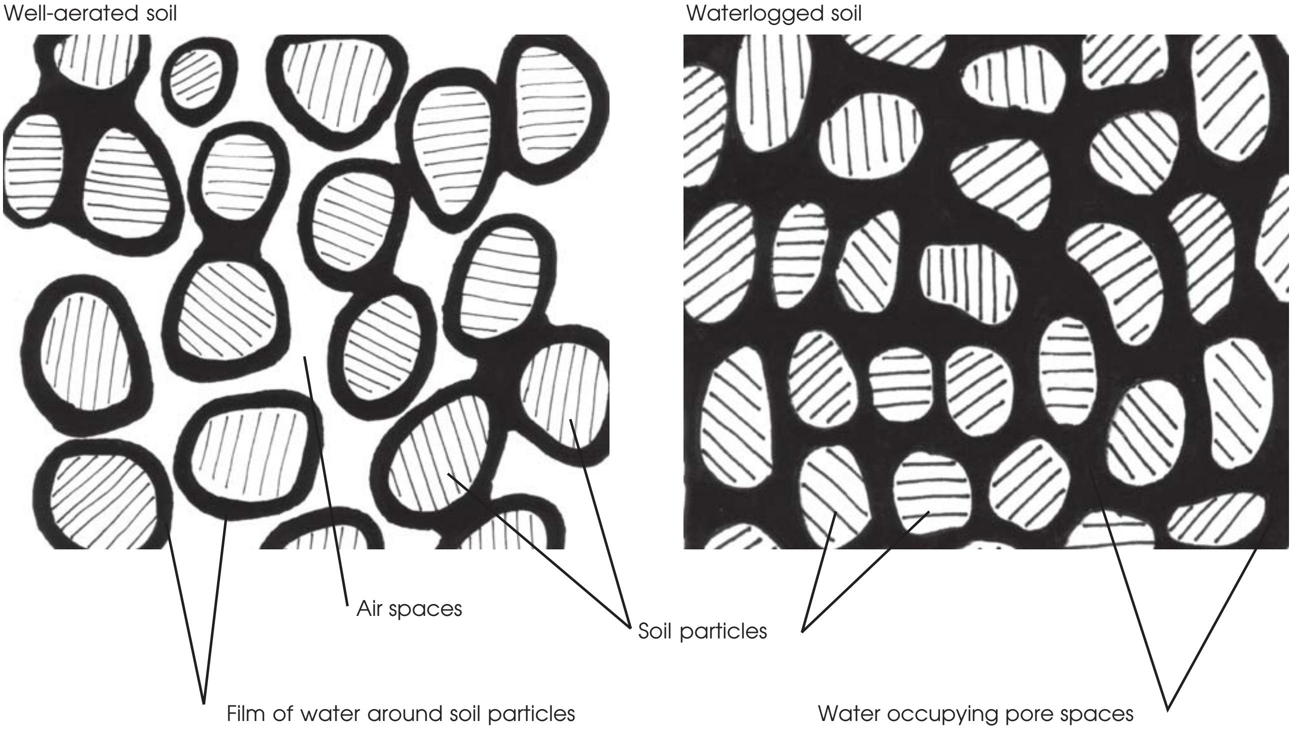
Soil particles are grouped into five main size ranges: gravel, coarse sand, fine sand, silt and clay.

A soil with a relatively even mix of particle sizes is called a loam.

Figure A3–1. Well-aerated and waterlogged soils



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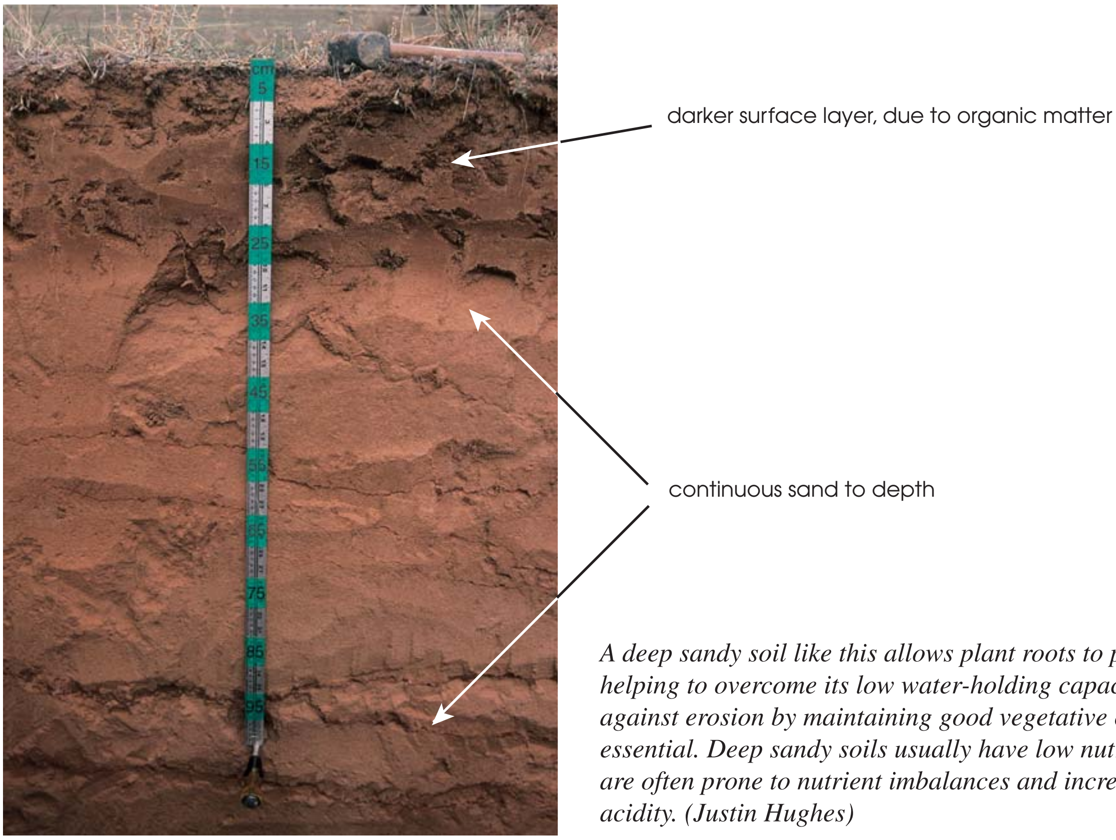
See Chapter D2 for more information on testing soil texture.

The word 'loam' refers to a relatively even mix of particle sizes in a soil. For example, a sandy loam is a soil that has a mix of particle sizes but that is dominant in sand. Likewise, clay loam has a mix of particle sizes, but has more clay than a loam textured soil. Figure A3–2 shows the importance of texture in a sandy soil.

Figure A3–2.



A deep sandy soil like this allows plant roots to penetrate easily, helping to overcome its low water-holding capacity. Protection against erosion by maintaining good vegetative cover is essential. Deep sandy soils usually have low nutrient levels, and are often prone to nutrient imbalances and increasing soil acidity. (Justin Hughes)

STRUCTURE

Soil structure refers to the arrangement of sand, silt and clay particles and organic matter, and the spaces between them. Individual soil particles and organic matter usually stick together to form aggregates (similar to a clod), leaving air spaces or pores between the aggregates. It is rare for soil particles to exist as single units in the soil (except in sands). Therefore, the soil generally consists of many distinct soil aggregates. The size and shape of the aggregates vary (Figure A3–3). The arrangement and size of the aggregates, along with the pores or spaces between the aggregates, is known as structure.

A well-structured soil, as well as having many small aggregates, has ample space within and between the aggregates to allow good penetration of water, air and plant roots (transmission pores). It also has adequate small pores to store water for use by plants (water storage pores). (See Figure A3–4.)

Individual soil aggregates may have differing shapes. Some aggregate shapes indicate better soil structure from a plant-growth point of view.

Platy structure is likely to restrict air and water movement and thus reduce plant growth. Crumb-type aggregates allow good plant growth because there is good water and air movement. Soils with a crumb structure allow good root growth for vegetables, as the soil is less compact than other structure types. Blocky structure is also generally favourable to plant growth.

> *Soil particles are held together to form soil units called aggregates. Aggregate size and shape, and the air spaces between, largely determine structure. A well-structured soil has many small aggregates, and a good balance of large and small pores. Small pores act as water storage areas for plants. Large pores allow relatively easy movement of air, water and plant roots.*

Figure A3–3. Some different aggregate shapes

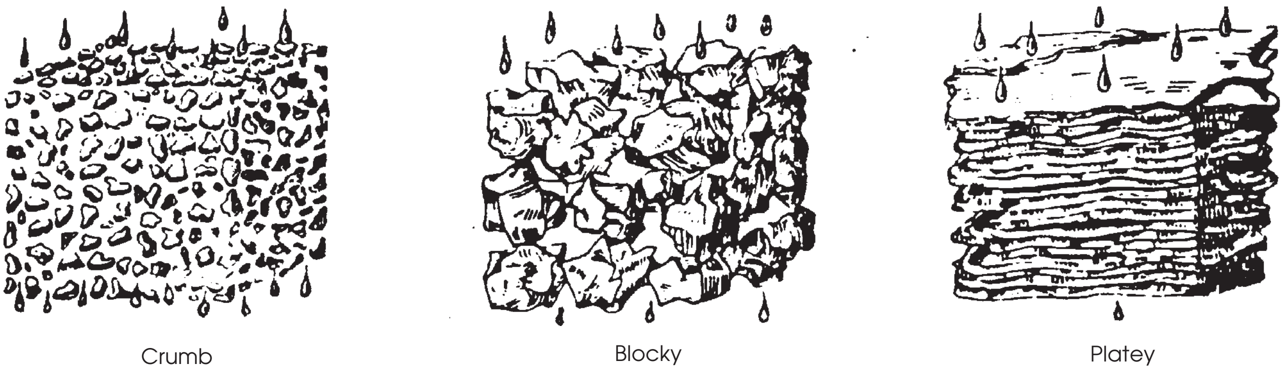


Figure A3–4. Well structured and poorly structured soils

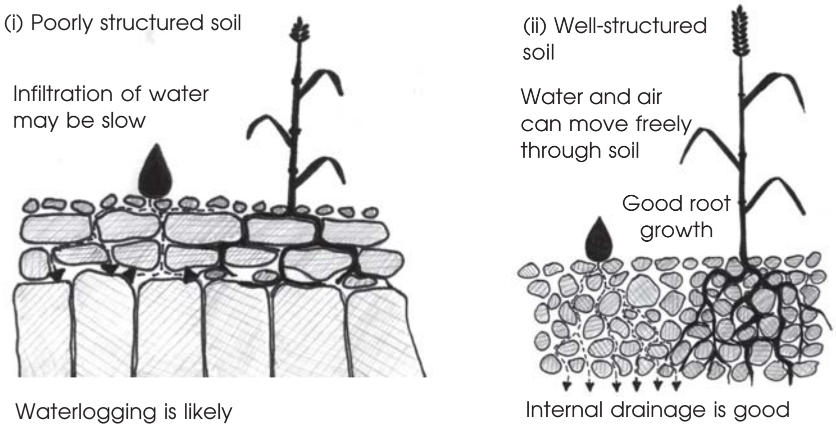


Figure A3–5.

Cultivated vegetable soil (clay loam) without gypsum (above) and with gypsum (below) at 2t per ha. (Col Begg)

Structure can be rated as good or bad from a plant-growth point of view. Poor structure does not allow good movement of water and air, and hence plant growth is poor. Soil that consists of large blocks with few pores or air spaces in the soil is said to have a 'massive' structure. This condition is poor for plant growth.

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When water is applied to most soils, the clods 'melt', or break down. This process is called slaking. After irrigation or rainfall a slaking or dispersing soil may become hard and compact on drying. This condition is often called hardsetting.

SLAKING

When water is applied to most soils, the aggregates within the soil tend to 'melt', or break down. This process results in the original soil clod disintegrating into very small fragments often referred to as microaggregates. The process of slaking is common in most soils. It results in problems such as crusting and hardsetting, particularly in soils with loamy surfaces, such as the red brown earths.

Soils that are low in organic matter are likely to slake excessively. In cracking clays, slaking leads to self-mulching, which is desirable.

DISPERSION

Dispersion is the process following slaking in which soil microaggregates further break down into their component particles (sand, silt and clay) on the application of water.

Clay dispersion is mainly caused by high levels of sodicity, that is, high amounts of exchangeable sodium in the clay fraction of the soil, and low levels of soluble salts. Dispersion increases when organic matter levels are low. Additionally, if soils are worked when they are too wet there will be increased dispersion.

Gypsum is often applied to sodic clay soils. Gypsum is a type of salt containing calcium. It acts by increasing the level of soluble salts and replacing sodium with calcium. The combination of these two factors reduces swelling and prevents dispersion, therefore helping to maintain soil structure (Figure A3–5). Organic matter that helps to bond soil particles together can help reduce dispersion.

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When water is applied to clay soil with a high sodium content and low soluble salts, the aggregates may break down into individual particles. This is called dispersion. Dispersive soils are generally poorly structured. Gypsum is often applied to dispersive soils to improve their structure.

INFILTRATION AND PERMEABILITY

Infiltration refers to the entry of water into the soil. A soil with low infiltration is one into which water does not enter very quickly; a shallow wetted zone may result.

Permeability is the soil characteristic that governs the rate of air and water movement. The permeability and the infiltration rate are influenced by the size and distribution of pores in the soil. The more large pores in the soil, the higher its permeability and infiltration.

Soils with low permeability are not suited to vegetable growing, since the movement of water through the soil profile is low. This is because water entry is restricted, resulting in low water storage at each irrigation. Waterlogging is also likely on these soils, because they have poor internal drainage. Low permeability is often associated with poorly structured soils, usually due to slaking and dispersion.

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Infiltration refers to the movement of water into a soil. Permeability refers to the ability of a soil to allow the movement of water and air through it. Soils of low permeability are well suited to rice, but not to other crops.

ORGANIC MATTER

Organic matter in soils consists of all living and dead plant and animal matter. Organic matter includes seeds, leaves, roots, earthworms and manure, as well as bacteria, fungi and humus.

Soil structure is highly dependent on organic matter content, particularly in loamy and sandy textured soils. The higher the organic matter, the better the soil structure tends to be.

Organic matter tends to be concentrated in the upper part of the topsoil, since this is where plant production takes place. Decayed plant material becomes a dark material called humus. Humus is responsible for the darker colour of topsoil in many soils.

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Organic matter is made up of living and dead plant and animal matter. It strongly influences soil structure, particularly in loamy and sandy soils. Soil organic matter (as measured in a soil test) is the humus content of the soil, and does not include plant residues and trash.

PH

Soil pH is a measure of how acid or alkaline the soil is (Figure A3–6).

The standard method of measuring soil pH in the laboratory is with a suspension made from air-dried soil mixed with five times its weight of dilute solution (0.01 M) of calcium chloride ($CaCl_2$). The result is designated the pH ($CaCl_2$).

Distilled water is sometimes used in place of calcium chloride, in which case results are reported as pH (water). Values for pH ($CaCl_2$) are about 0.5 to 0.8 lower than for pH (water).

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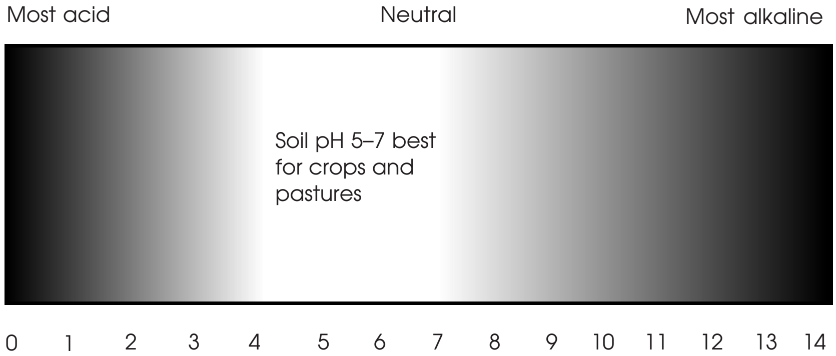
Soils with pH below 7 are acid. Soils with pH above 7 are alkaline. Growth and yield is reduced in most plants below a pH ($CaCl_2$) of 5. Soil acidification is increased by many agricultural practices.

Figure A3.6. The pH scale*



* values measured in 0.01 M $CaCl_2$

ACIDITY

All soils below pH 7 are acid. However the growth and yield of most plants are unaffected until the pH ($CaCl_2$) reaches about 5. As the pH level drops below 5 and soil acidity increases, plant growth and yield decline. Yields can be affected directly by acidity, or indirectly by a change in the availability of some important nutrients. For example, as the pH decreases below 6, the availability of phosphorus and sulfur may decrease. At the same time, aluminium and manganese become more available and may cause yield reductions through aluminium and manganese toxicity. At pH levels above 7 other elements such as zinc may become deficient.

Many soils are naturally acid, but agricultural practices have contributed to the increasing acidification of many neutral to slightly acid soils. These practices include:

- use of some ammonium fertilisers, particularly ammonium sulfate
- the production of legumes that fix nitrogen, if that nitrogen is leached, rather than being taken up by plants
- the removal of nutrients in the form of produce.

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The bulk density is the mass of oven-dried soil per unit of volume, expressed in megagrams (Mg) per cubic metre (1 megagram is equivalent to a tonne). Bulk densities generally range from 1.2 to 2.0 Mg/m³. High bulk densities can restrict root development and plant growth.

BULK DENSITY

Bulk density is defined as the mass of oven-dried soil per unit volume of soil. Soils with high bulk density have a smaller volume of pore spaces. Very high bulk density is therefore undesirable for plant growth, since infiltration, aeration (supply of air to roots) and root development are likely to be below optimum.

Bulk density is measured in megagrams (Mg) per cubic metre. Bulk density values are typically < 1.0 for topsoils high in organic matter, 1.0 to 1.4 for well-aggregated loamy soils, and 1.2 to 2.0 for sands and compacted subsoil horizons in clay soils. For example, on the Riverina soils, bulk densities range from 1.2 to 1.4 in well-structured clay soils, to 1.4 to 1.8 in the sandy loam soils.

Soil layers with a high bulk density are often very hard when dry. The pale, bleached layer just under the surface in some sandy loam soils is an example of a soil horizon with a high bulk density. Compacted soil layers have a high bulk density.

THE SOIL PROFILE

A soil profile is a vertical section of the soil. It allows you to examine the layers of the soil from the surface down to the rock or sediment from which the soil was formed (parent material). In the inland vegetable-growing environment, most soils have parent material consisting of sediments or soil particles carried into the area by wind or water.

The layers in the soil are called horizons. These horizons are obvious in some soils, because changes in soil appearance are abrupt as you move down the soil profile. However, in many other soils the change is more gradual and horizons are hard to distinguish (Figure A3–7).

O horizon (surface organic litter)

This is the layer of organic matter sitting on top of the soil. It tends to be deepest in undisturbed forest environments.

A1 horizon (topsoil)

This is the surface soil, referred to as topsoil. It has the most organic matter and biological activity of any of the horizons. The decayed organic matter (humus) darkens the soil colour.

A2 horizon (topsoil)

This layer is not present in all profiles. It frequently has a pale, bleached appearance and is poorly structured. Bleaching is an indication of periodic waterlogging often due to formation of a ‘perched’ watertable above a relatively impermeable subsoil.

B horizon (subsoil)

This horizon frequently has more clay than topsoil. In clay soils, the difference in clay content between the A and B horizons is less than those for other soils, such as the red brown earths, where the topsoil is loamy or sandy.

C horizon (weathering rock)

This layer may be very deep, and may not be present in the root zone of many vegetable-growing soils.

Figure A3–7.

Soil researchers preparing soil monoliths used in an extension activity to identify soil profiles. (Graham Johnson)