Soil science

Pack 2

Soil structure

Pack Code: SS2

This pack you will help you to understand:

- the effect of soil structure on soil fertility
- the importance of organic matter
- different soil textures and how to identify them
- what is meant by the pH value of the soil.

Land Based Colleges
National Consortium
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About this pack

Objectives

When you have completed this pack you should be familiar with how to judge soil structure and texture.

This pack will help you to understand:

- the effect of soil structure on soil fertility
- the importance of organic matter
- different soil textures and how to identify them
- what is meant by the pH value of the soil.

This pack is relevant to the level 3 unit **Understand the principles of soil science,** and in particular to the following outcome:

- Outcome 1: Be able to investigate soil characteristics
- Outcome 2: Understand how soil characteristics affect plant growth and development
- Outcome 3: Understand how soil characteristics affect plant selection

It may also provide useful background for the level 3 unit **Understand Agricultural Organic Production**, Outcome 2.

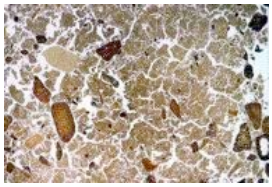
Links to other packs

This is one of a series of learning packs, each tackling an aspect of soil science. They are:

- Pack 1: Types and properties of soil
- Pack 2: Soil structure and organic matter
- Pack 3: Plant nutrients
- Pack 4: Soil treatments and fertilisers
- Pack 5: Plants and soil

Each pack contains several activities which ask you to think the topic through or to apply it to an organisation you know of. In some cases you may be able to work on these activities with other people in your group.

Introduction



Soil structure is the way that the particles and pores in the soil are arranged to provide a good tilth or crumbliness. Well structured soils have more easily available water and increased productivity.

This pack will help you to assess the structure, texture and acidity of soil so that you are able to take the right action to improve it and optimise productivity.

Soil structure

Soil structure is the shape, size and arrangement of individual mineral particles into aggregates and air spaces. The particles which make up the soil are usually bonded together to form soil structures called **peds**. The formation of peds allows more pore space between particles to give a less compacted soil structure. This makes it easier for water, air and living organisms to move.

Well structured soils with stable peds help aeration and drainage and have more easily available water. In the top soil the peds are crumb structured, allowing roots to penetrate to extract nutrients. If you dig a spade into the soil and lift out a spit you should see the natural crumb structure; if there are horizontal cracks this indicates compaction. If roots run horizontally in the soil, this may be another sign of compaction.

The sub soil should contain larger peds, but again with evidence of vertical cracks and root penetration. Good penetration of roots into the sub-soil allows the plant to exploit more of the available soil water. Good structure reduces surface capping and erosion. It also helps ensure sufficient **rooting depth** for the plants you wish to grow. The soil structure is a consequence of the management of the soil – ill timed or inappropriate cultivation can destroy soil structure, which can then take several years to recover.

Activity

When you next do some practical work, examine the structure of the soil you are working with using the guidance above.

Soil pores

Soil pores, which are the spaces between the soil particles, also affect the structure of the soil. The overall pore space and the size of the pores affect the water retention capacity of a soil and its availability to plants. Pores are filled with either air or water. For plants to grow well they need both air and water in soil pores; the large pores are important in allowing rain to penetrate and drain through soil at wet times, but they should drain rapidly after rain and become air filled again to allow the plant roots to breath.

Pores can be divided into three sizes:

- Large (macro) pores which are over 10^{-5} m; water drains under gravity
- Medium (meso) pores which are 10^{-5} m – 10^{-7} m; available water holding capacity diameter
- Small (micro) pores which are less than 10^{-7} m; water unavailable to plants

A soil with a good structure will have all types of pores.

Activity

Draw or describe the structure of a good soil.

How would a bad structure differ?

Check your answers with those at the end of the pack.

Improving soil structure

There are a number of things which a farmer or grower can do to help the formation of a good soil structure.

- Good cultivation – cultivating when soil has suitable water content will avoid compaction while varied cultivation will help avoid plough pans.
- Maintain levels of organic matter.
- Lime regularly to return soil to its optimum pH and to promote flocculation.

The importance of organic matter

True peats contain more than 20% organic matter. Most mineral soils contain between 10% and 20% organic matter. Fresh organic matter is broken down by soil organisms.

Humus is the stable end product of organic matter decay. It is a dark brown-black substance around mineral particles. It is powdery when dry and jelly-like when wet. It has a very variable and complex composition but always contains carbon, hydrogen, oxygen, nitrogen, phosphorus and sulphur.

Organic matter is important to the soil because it:

- provides a valuable source of plant nutrients
- is able to hold and retain nutrients against leaching
- improves the structure of the soil
- increases water retention in sandy soils
- improves soil structure and aeration in clay soils by opening up the pore spaces between soil particles
- is a food source for soil organisms
- darkens soil which aids heat retention and gives earlier warming in spring.

Activity

Can you think of two sources of organic matter suitable for improving soils?

1

2

Check your answers with those at the end of the pack.

Soil texture

Soil texture can be defined as the degree of coarseness or fineness of the particles in the soil and the relative proportions of the various sizes of particles present. The texture of a soil will have a direct bearing on its usefulness because it affects drainage and water retention. Soil texture is a fixed character of the soil and cannot be changed by management practice.

Soil particles

The table below shows the enormous range in the sizes of soil particles from coarse sand to the fine texture of clay.

Type of soil	Size of particles	No. of particles per gram	Surface area covered by 1g
Coarse sand	2.0 - 1.0 mm 1.0 - 0.5 mm 0.5 - 0.25 mm	90 720 5700	11sq cm 23sq cm 45
Fine sand	0.25 - 0.125	46 000	91
Silt	0.125 - 0.063	722 000	227
Clay	0.063 - 0.002	90 260 853	8 000 000

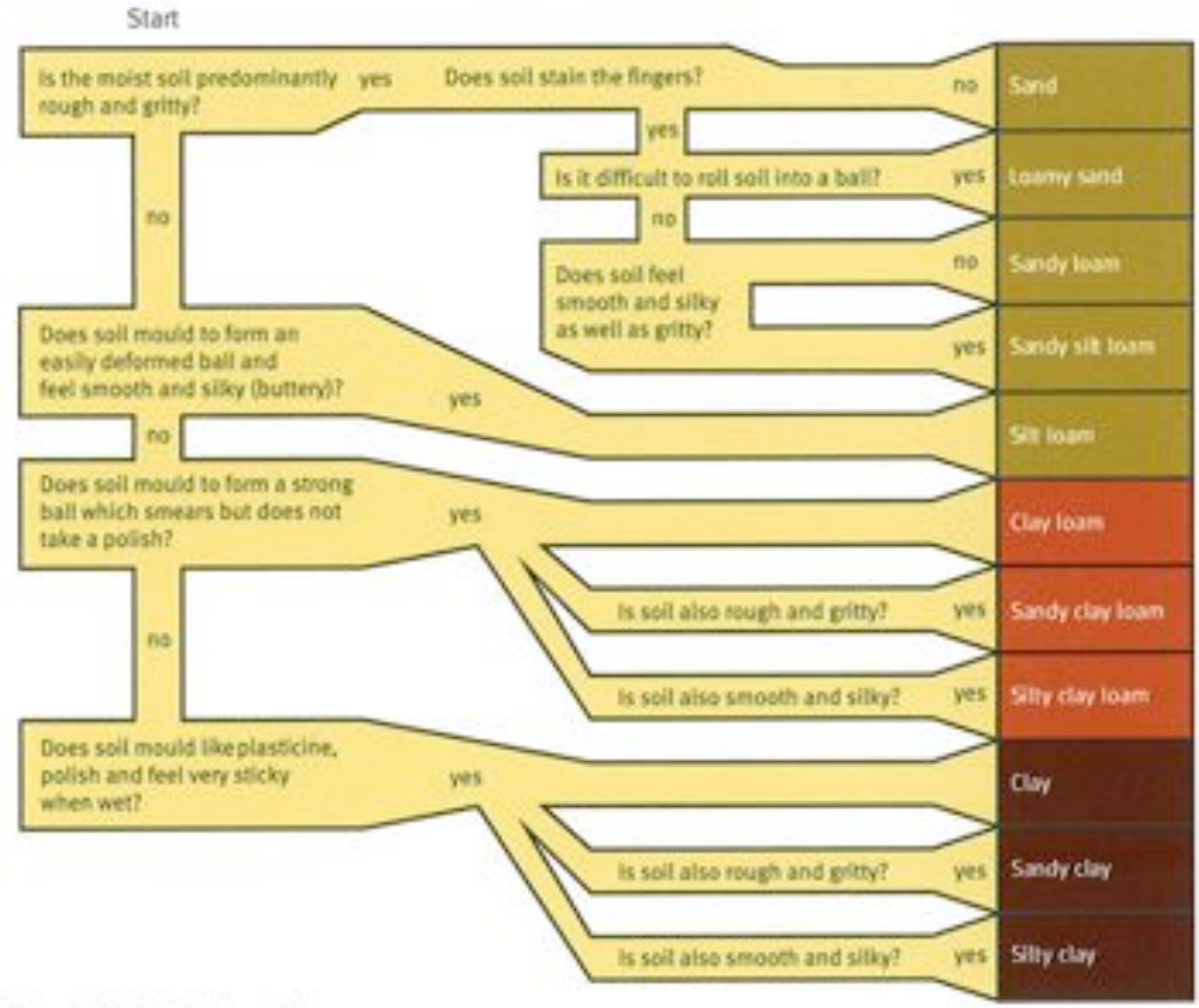
Identifying soil texture

Feeling the soil with your fingers will help you to recognise the texture of soils. For example, sandy soil feels gritty and crumbles easily, silt soil feels smooth and silky, and clay soil feels sticky and you can pinch it into shapes. Most fertile topsoils like the one pictured, eg the loams which are a mixture of sand, silt and clay, fall somewhere between the extremes of texture.

Activity

This activity shows you how to identify soil texture by hand.

Take about a teaspoonful of the soil in your hand. Moisten if necessary with **small** additions of water and work into a smooth paste or putty. Follow the key below to identify the texture of your soil sample



Source: Think Soils, Environment Agency

Judging soil texture will give you indications of how to use and manage the land from which the soil comes.

Soil pH

The pH of a soil describes its degree of acidity or alkalinity. It is measured on a scale of 0 to 14. Normal soils in the UK range from pH4.0 to pH8.5. Acid soils have a pH value of lower than 7.0. For most plants the optimum pH is 6.5 in mineral soils and 5.8 in organic soils.

Soil pH is a measure of the concentration of hydrogen in the soil water. Water is made up of hydrogen (H+) and Hydroxyl (OH-).

- Extra hydrogen would give pH below 7.0 and result in an **acid soil**
- Hydrogen and Hydroxyl in balance would give a **neutral soil**
- Extra Hydroxylwould give pH above 7.0 and result in an **alkaline soil**

Low soil pH indicators

These will show that the soil is likely to be acid.

- Soil pH test below 6.5
- Poor growth of acid-sensitive plants
- Poor decay of soil organic matter
- Appearance of acid-tolerant weeds (eg sorrel) or diseases (eg club root).

Neutralising acid soils

Liming materials are used to neutralise acid soils and increase the range of plants that can be grown. The most commonly used liming materials are:

Material	**Source**
Calcium carbonate	ground limestone or chalk
Magnesium carbonate	ground magnesium / dolomitic limestone
Calcium oxide	burnt or quicklime
Calcium hydroxide	hydrated or slaked lime
Industrial wastes	lime from water softening plants etc., sea sand

You will need to know the pH value of soils so that they can be managed to make the pH fall within the limits of tolerance for the plants being grown.

Typical acid soils are podsols and brown earths. Most cultivated crops will thrive on mildly acid soils. Some plant species, calcifuges such as *Erica* and *Rhododendron* grow in acid soils.

Typical alkaline soils occur where there is natural chalk or limestone or where there has been forest cover. Calciciole plants tolerate alkaline conditions.

The pH to suit a wide range of plants is pH 6.5.

Activity

What is the typical pH of soils on your college estate? What plants are most at home in this soil?

Soil testing

There are a range of tests which can be carried out to test soils.

Field testing

Simple tests, like the activity you carried out earlier which involved feeling the soil or seeing how it responds to rolling into a ball, will help you to decide the texture of the soil. Looking at changes in the colour of the soil will also give you an indication of what minerals are present, the type of parent rock the soil came from and the condition of the soil.

Laboratory testing

Laboratory testing is more complicated than field testing. Laboratory techniques can be used to test, for example

- soil acidity – to get its pH value
- water holding capacity
- the calcium carbonate content – to see whether lime needs to be added to the soil
- the infiltration rate of the soil – to measure how quickly soil can absorb water
- the tilth of the soil – to help you produce the right degree of crumbliness in the soil
- nutrient indices can be used to assess the level of nutrients in the soil.

Glossary

Acid soil	Soil with a pH below 7.0
Alkaline soil	Soil with a pH above 7.0
Peds	Soil structures that allow more space between particles
pH	A measure of the concentration of hydrogen in the soil water – used to describe acidity or alkalinity
Plough pan	A hard layer of soil just below the plough depth created by repeated ploughing to the same depth
Rooting depth	The depth of soil needed by a particular plant
Soil pores	The spaces between the particles of solid matter in the soil
Soil structure	The way that the particles and pores in the soil are arranged
Soil texture	The degree of coarseness or fineness of the particles in the soil and the relative proportions of the various sizes of particles present

Further reading

You will find a number of publications dealing with soil types in the college library. You may find the following helpful:

- Ashman, M and Puri, G (2008) Essential Soil Science Blackwell
- Brady, N and Weil, R (2007) The nature and properties of soil, Pearson Prentice Hall
- Foth, H D (1991) Fundamentals of Soil Science, 8th Edition, Wiley
- Gregory and Nortcliff (2013) Soil conditions and plant growth, 12th edition, Wiley-Blackwell
- White, R (2005) Principles and practice of Soil Science, Blackwell
- Think Soils Manual (2007). Environment Agency. Available at: http://adlib.everysite.co.uk/adlib/defra/content.aspx?doc=263232&id=263233

You can download a number of useful publications from www.soil-net.com/downloads including:

- Nortcliffe, S (1984) Down to earth: An introduction to soils; Leicestershire Museums, Art Galleries and Records Service
- Jarman, M (1984) Groundwork - Practical ways of learning about soils; Leicestershire Museums, Art Galleries and Records Service

Answers to activities

Activity on page 3

An ideal soil structure will be one which:

- has a good, crumbly structure on the surface
- has larger particles below this which allow aeration, water movement and root penetration
- will still have good drainage below about 30cm because of deep hairline cracks in the subsoil and parent rock.

Soils which have a bad structure:

- do not have a good mix of particle and pore sizes and either drain too quickly, hold water for too long or are easily compacted.
- are often made up of blocks or hard layers through which water cannot pass and roots cannot penetrate. For example, repeated ploughing to the same depth can create a **plough pan** – a hard layer of soil just below the plough depth.

Clay is an important factor in holding particles together to form good peds. So is organic matter and chemical cements such as calcium carbonate.

Activity on page 4

Organic matter can come from:

- animal matter such as non-organic nitrogen fertiliser or the dead bodies of animals and insects
- soft green vegetable matter, such as grass cuttings
- fibrous or woody matter, such as hedge clippings or straw
- other decomposing and organic matter which makes humus.

Knowledge quiz

1 The particles which make up the soil bond together to form:

a) pores

b) peds

c) ions

2 Give an advantage of a well structured soil

3 Clay and humus particles carry electrical charges

True / false

4 How might you improve soil structure

5 Soil texture can be defined as:

a) the degree of acidity of the soil

b) the water retention capacity of the soil

c) the degree of coarseness of soil particles

6 What are soil pores and how do they affect the texture of a soil?

7 What does the pH of soil measure?

8 Acid soils have a high pH

True / false

9 How might you neutralise an acid soil?

10 What pH suits a wide range of plants?

Acknowledgements

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For further information please contact the LBCNC project management team at 7 Tyne Road, Bishopston, Bristol BS7 8EE.

Tel 0117 942 3504