Environment Agency

think soils

Examining soil structure

A practical guide to digging a hole

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Published by:

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February 2010

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Introduction

Taking time to look at soil structure is essential for profitable farming, soil health and the environment.

Diagnosing the state of soils isn't always easy. Soil condition can vary considerably across a field and at different depths, and can vary throughout the year depending on land management. Different soil types are at risk to different types of damage. Every field is unique.

This handbook is a practical guide to 'digging a hole' and examining soil condition. It draws on material in the more comprehensive *think**soils*** soil assessment manual, but focuses on the practical techniques needed to effectively assess soil structure.

Problems caused by poor soil structure, including compaction, are getting worse in some areas. This results in increased runoff, washing sediment and sometimes precious nutrients and pesticides off your land. These problems are made worse by changing weather, and the time and financial pressures faced by farmers.

This guide should help farmers and their advisors know how to examine their soils, and what you should be looking for.

Soil structure

Soil structure refers to the arrangement of soil particles in the soil. Clay content, organic matter (and in some soils calcium and iron compounds) help to bind the soil together into structural units, aggregates or peds.

Well structured soil allows the free movement of air and water through fissures (or cracks) between the structural units. Pores within the units also allow the movement of air and water. A soil with poor soil structure has a high risk of generating runoff. The risk of runoff is greatest when poor soil structure is near the soil surface.

Soil structure deteriorates when structural units are deformed producing a dense single mass of soil (or large soil units). This occurs when pressure is applied to a wet and soft soil. Pressure squeezes the soil units together and reduces pore space within the units. A dry soil can withstand pressure without deforming soil structure.

Some soils are unstable when clay, calcium or organic matter content is low. Unstable aggregates disperse when wet, forming a solid mass as the soil dries. Where this occurs at the immediate soil surface, the soil may form a cap or crust.

Soils can restructure due to natural fracturing processes when clay shrinks and swells, and by cultivation. Biological activity also restructures soil.


Good soil structure
Poor soil structure

the topsoil

- Preparing a hole for examination
- Preparing a section of topsoil to be examined
- Looking at pores and fissures
- Looking at structural units
- Looking at shape, size and colour of soil structural units
- Assessing the packing density of soil

Preparing a hole for examination

Normally at least three holes need to be dug in a field to obtain a representative picture. More holes will be needed in large fields and where there are a range of soil types. Areas prone to compaction and possible sources of runoff should be examined (for example, headlands and wet spots), and areas where crop growth is poor should also be looked at.

Mark out the edges of a square hole to be dug. Each edge needs to be about 50cm so that a sufficiently deep hole can be dug. (Depth of the overall hole would normally be at least to 40cm.)

Preparing a section of topsoil to be examined

Dig out soil from one half of the square to a depth of about 20cm within the cultivated layer. The remaining soil is the section of topsoil to be examined, so do not trample on this half and do not smear the face with the spade.

Looking at pores and fissures

Lever out a spadeful of soil from the undisturbed half of the square so that soil structure can be examined.

The first step when examining soil structure in a spadeful of soil is to look for spaces (either fissures between soil structural units, or pores within the units).

Soil with good structure has abundant pores and fissures allowing good drainage, aeration, root growth and biological activity.

Soil with poor structure is where there are few pores and fissures, or where there are horizontal fissures.

Looking at structural units

The second step to examining soil structure is to look at the soil structural units. This is most easily done when the soil is moist.

Carefully tease the soil apart along its lines of natural weakness, breaking the soil into structural units.

A structureless soil is without any aggregation of soil particles. It is massive when soil particles are bonded together into one single mass, or single grain when soil breaks to individual soil particles.

A soil has structure when soil is aggregated into units. Structural units that are naturally formed are called peds. These are formed by shrinking and swelling of clay, producing angular shapes, or by biological processes that produce more rounded faces. Calcium also helps to bind clay particles together.

Cultivation produces artificial aggregates and these are less permanent than peds and often do not persist through cycles of wetting and drying. These aggregates are termed clods (or fragments if they are less than 10cm).

A strongly developed ped structure is where peds are clearly evident, separating cleanly from one another when the soil is disturbed. Conversely a weakly developed ped structure is where peds are less obvious and there is much unaggregated material.


Peds are naturally formed structural units that separate cleanly from one another when gently teased apart

Looking at shape, size and colour of soil structural units

Spherical structures are termed granular. Square shapes are called blocks. Flattened structural units are called plates.

Where blocks have mainly curved /rounded faces they are termed subangular. Where faces are mostly flat the blocks are termed angular.

Small blocks are called very fine when they are <5mm, fine when they 5-10mm and medium when they are 10-20mm. Large blocks are called coarse when they are 20-50mm and very coarse when they are >50mm.

Soils with coarse and very coarse angular blocks, and those with plates, have poor drainage and aeration because blocks and plates can fit tightly together. Conversely, fine granules and fine subangular blocks allow good drainage and aeration.

Soil colour is a good indicator of the degree of waterlogging. When soil is poorly drained it has less oxygen, and iron is reduced, producing a grey colour. Conversely, a well-oxygenated soil is brown in colour. Repeated cycles of oxygenation and reduction produce grey and rusty mottled colours.

Granular soil structure

Very coarse subangular blocks

Medium and coarse angular blocks with rusty mottles

Platy soil structure

Assessing the packing density of soil

Porosity of soil is affected by the packing density of soil particles. Soils with high packing density have lower porosity.

Packing density can be estimated by assessing the strength of soil and comparing this with size, shape and degree of development of peds.

Soil strength is determined by applying pressure to a 3cm cube of soil using an extended forefinger and thumb. The cube can either be a ped or part of a ped, or a block fashioned from massive soil. The cube should be orientated according to how the soil is found in the profile.

Where a moist cube cracks under gentle force it is described as friable. A soil is generally at least risk from compaction when in a friable state. Where a moist cube fails under the maximum pressure that can be applied by extended thumb and forefinger it is described as very firm.

Where a moist cube fails under pressure that is much less than the maximum that can be applied, it is described as firm.

A friable soil has a lower packing density and is more porous than a firm and very firm soil of the same texture.


WITHDRAWN
A very firm soil with high packing density and low porosity

the subsoil

- Preparing a hole for examination
- Preparing a section of subsoil to be examined
- Looking at pores and fissures
- Looking at structural units
- Looking at shape, size and colour of soil structural units
- Assessing the packing density of subsoil

Preparing a hole for examination

Subsoils should be examined when the soil is moist.

Dig out half of the soil in the pit to a 30-40cm depth. Take care not to smear the face or trample the soil in the remaining half of soil to be examined.

Preparing a section of subsoil to be examined

Dig into the remaining half of soil and cut out a block of soil.

Lever out a block of soil with the spade and hold the soil with the hand to stop it falling and carefully remove from the hole.

Looking at shape, size and colour of soil structural units

Subsoils with natural soil structure tend to have larger peds than structural units in the topsoil. This is because the natural processes that form peds (such as swelling and shrinkage of clay during wetting and drying cycles) are not as frequent in the subsoil. There is also less biological activity, root growth and organic matter in the subsoil.

Subsoils can have continuous pores created by earthworm channels.

Abundant fissues and pores allow for good rooting and water movement (where the water-table allows).

When examining the subsoil it is important not to confuse a change in soil texture with structural degradation. There is often a boundary between the tilled and untilled soil, and this change should not be mistaken for degraded soil structure.

Looking at structural units

Carefully tease apart the subsoil, breaking it along its natural lines of weakness. Assess the degree of ped development, and the size, shape and colour of peds.

A structureless subsoil can either be natural, for example where the clay content is low and the soil has naturally slaked (slumped), or it can be formed by compression of moist soil by farm traffic and cultivation.

A strongly developed ped structure is where the peds are clearly evident and easily break apart into well-defined units.


A strongly developed subsoil structure

Looking at shape, size and colour of soil structural units

Subangular blocks, angular blocks and prisms tend to be found in subsoils.

Prisms are where the peds have long vertical faces. Prism size range from very fine (‹10mm width), through to fine (10-20mm width), medium (20-50mm width), coarse (50-100mm width) and very coarse (›100mm width).

Root and water movement is more likely to be restricted where the peds are coarse (large) and where they are angular, prismatic or platy.

Subsoils that are mottled indicate poor drainage, and a high risk to structural damage.


Structureless
massive subsoil


Very coarse plates


Medium prism
with rusty
mottles


Coarse
subangular
blocks

Assessing the packing density of subsoil

Packing density can be estimated by assessing the strength of subsoil and comparing with size, shape and degree of ped development. Apply pressure to a 3cm cube of soil using an extended forefinger and thumb. The cube can either be a ped or part of a ped, or a block fashioned from massive soil. The cube should be orientated according to how the soil is found in the profile.

Where a moist cube fails (cracks) under gentle force it is described as friable. Where a moist cube fails under the maximum pressure that can be applied by extended thumb and forefinger it is decribed as very firm. Where a moist cube fails under force that is much less than the maximum it is described as firm.

A friable soil has a lower packing density than a firm and very firm soil of the same texture. Soils with low packing density are more porous than soils with high packing density.

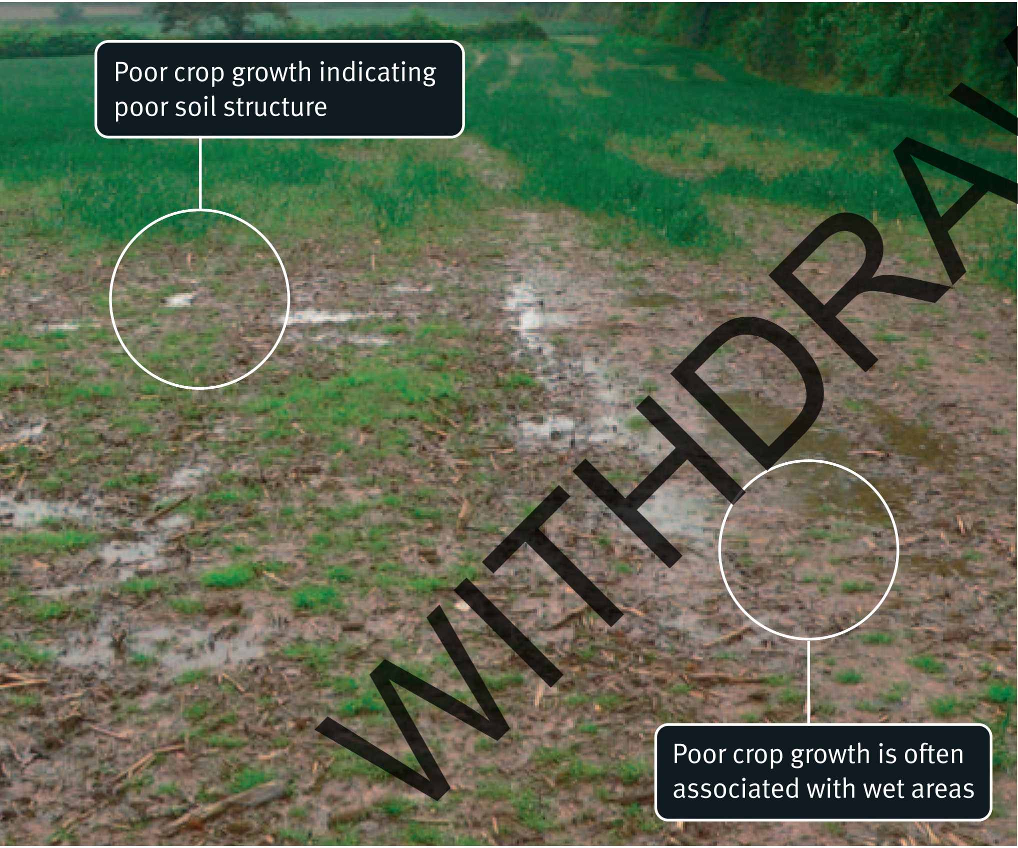
Sandy and light silty soils with a friable soil strength are moderately or very porous even though they may be structureless.


A friable soil cracks under gentle force

plants and plant roots

- Using plant growth as an indictor of poor soil structure
- Looking at root growth as an indicator of soil structure

Using plant growth as an indictor of poor soil structure



Crop and grass growth can be affected by poor soil structure.

Plant growth is most at risk on headlands, near gateways, and wet areas in the field (where soil is prone to structural damage by vehicles or stock). These areas are also potential sources of runoff and erosion.

Wet areas in the field can either be natural, for example where the water table is high, or they can be caused by poor soil structure.

Soil structure is often degraded in wet areas, which further compounds problems of waterlogging and poor crop growth.

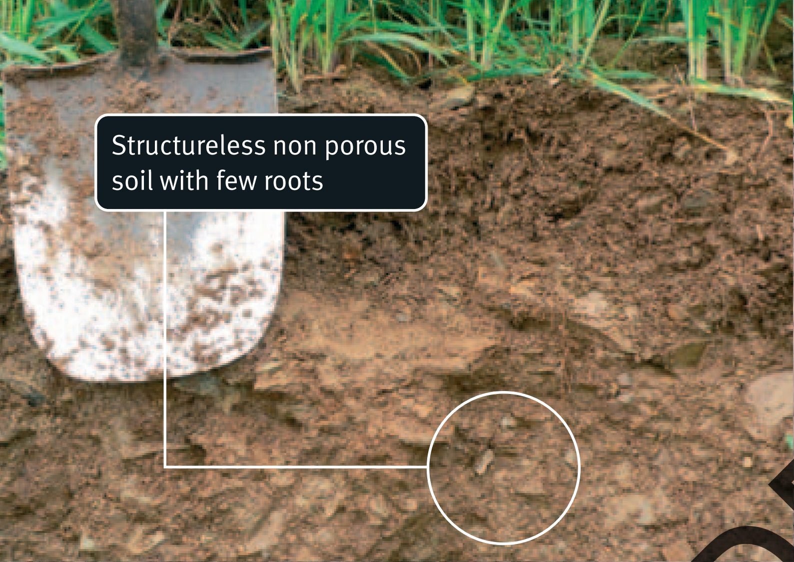
Looking at root growth as an indicator of soil structure

Roots are very sensitive to soil structural condition, wetness and aeration. They can extend 2m deep in the soil, and autumn sown crops often have roots deeper than 1m by the following spring.

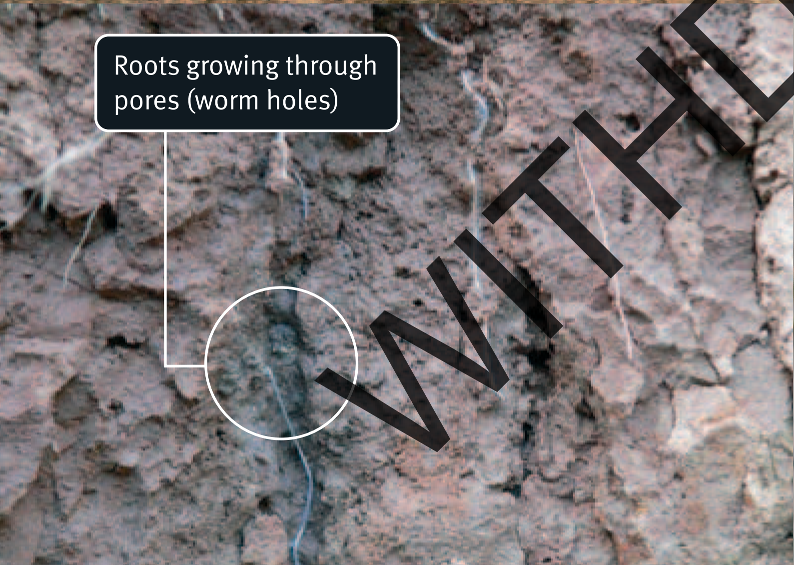
The soil should be examined to determine root abundance, root depth, direction of growth, and whether roots have penetrated structural units, or are confined to fissures.

Roots will take the path of least resistance and hence are good indicators of soil structural conditions and porosity. Ideally, they will grow vertically through fissures or cracks and pores present in a well structured soil. On encountering zones of compaction they are likely to be impeded vertically and so will grow horizontally. This will limit the depth and hence volume of soil from which the roots can extract water and nutrients for the growing crop.

Roots can grow in poorly structured soil provided there are pores for the roots to grow through (e.g. worm holes). In some soils, roots can not penetrate into dense structural units, and are confined to fissures where they may find moisture and nutrients.


Structureless non porous soil with few roots


Many roots growing in a well structured porous soil


Roots growing through pores (worm holes)


Roots confined to a fissure between coarse angular peds

What next?

Good soil structure has many benefits. It allows the roots of crops to go much deeper into the earth, providing a better supply of water and allowing the crops to access the full range of benefits from the soil.

Land with good soils structure will drain more quickly in the spring and take longer to wet up in the autumn, giving you a longer safe working period on the land.

Poor soil structure can lead to increased surface water runoff, poor yields and excessive use of nutrients and pesticides. There are many ways to tackle poor soil structure. These need to be tailored to the unique needs of each field.

Once you have assessed soil structure in your fields you need to plan how to manage your soils.

The Department for Environment, Food and Agriculture (Defra) ask farmers to complete a Soil Protection Review (SPR). The purpose of the SPR is to tackle degradation threats to soil.

Some additional sources of advice, guidance and financial assistance to help improve soil structure are listed on the opposite page.

More information is available from:

Department for Environment, Food and Rural Affairs (DEFRA)
www.defra.gov.uk
Defra provides a range of publications on soil and have published the Code of Good Agricultural Practice for the Protection of Soil
www.defra.gov.uk/environment/lan/soil/pdf/soilerosion-lowlandmanual.pdf

Catchment Sensitive Farming
The England Catchment Sensitive Farming Delivery Initiative provides advice and limited capital grants to 50 priority catchments across England. More information about the initiative can be found on the Defra website at www.defra.gov.uk/foodfarm/landmanage/water/csf/index.htm

Environment Agency
www.environment-agency.gov.uk
The Environment Agency provides a range of publications including *Best Farming Practices* and the *think**soils*** manual *Soil assessment to avoid erosion and runoff* which accompanies this booklet.

Natural England
www.naturalengland.org.uk
Natural England provides a range of publications on soil, and information about environmental stewardship schemes.

Netregs
www.netregs.gov.uk
The Netregs website helps farmers to understand regulations affecting their environmental obligations.

South West Rural Enterprise Gateway
www.sw-ruralgateway.info
The South West Rural Enterprise Gateway provides information about advice and capital grants available via the Rural Development Programme for England. This includes the South West Agricultural Resource Management programme which is made up of two strands: Resources for Farms and Soils for Profit.

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GESW0210BRTS-E-P