FACTSHEET

GREATSOILS

Soil structure and infiltration

Figure 1. Mini Disk Infiltrometer measuring effect of compost on soil infiltration

This factsheet outlines a simple method for measuring infiltration in the field. It also explains how adding organic matter to soil can improve soil structure and water infiltration.

Action points

- **Improve soil structure to increase the ability of soil to absorb and retain water**
- **The use of organic materials such as compost and green manures can improve infiltration and the ability of soil to absorb increasingly intense winter rainfall**
- **Use the drainpipe test as a cheap and simple way to measure the infiltration of water into soil. When combined with the spade test, the causes of reduced infiltration (eg compaction at depth) can be quickly identified**
- **Improved infiltration of rainfall helps to reduce soil erosion and the loss of nutrients from land to water**

Challenges

Although average annual rainfall for England and Wales hasn't changed significantly since records began in 1776, all regions of the UK have experienced an increase in heavy rainfall events in winter. These events are not restricted to winter: the spring of 2012 saw exceptionally wet weather which affected all of England, Wales and eastern Scotland.

An increase in the intensity of single-day rainfall events could lead to an increase in soil erosion and the associated loss of nutrients such as phosphate to drains and rivers. Managing soil health, in particular maintaining good soil structure, is an essential part of the strategy to improving resilience to changing rainfall intensity. Improving the ability of soil to absorb water during intense rainfall events (infiltration) reduces the risk of erosion. Improved infiltration also retains more water within the soil rooting zone for use by crops and reduces the risk of subsurface flow and leaching.

There are several ways to assess the rate of infiltration of water into soil (the hydraulic conductivity), with the more sophisticated methods giving more detailed information. For example, a Mini Disk Infiltrometer (Figure 1) not only

measures the rate of water flow in saturated conditions (when macropores and micropores are channelling water) but can also be used to measure infiltration under unsaturated conditions (when macropores are not in action).

Drainpipe test to measure infiltration of water into soil

This test measures the rate at which water can infiltrate into soil when macropores and micropores are channelling water. It is therefore mainly an indication of the extent of earthworm channels and old root channels in the soil.

A video demonstrating this test can be found at: **ahdb.org.uk/greatsoils**

You will need: two short lengths of pipe 10cm in diameter and 20cm long, a hammer, a stopwatch (eg on your phone), 5 litres of water. The same depth of water should be used for each test (10cm is suggested).

1. Drive the pipe halfway into the ground using a hammer, to leave 10cm standing above the ground.
2. Pour in water (approximately 800ml) to a depth of 10cm.
3. Start the stopwatch immediately and measure the time taken for the water to drain into the soil.
4. Repeat at several different locations eg in a bed, in a wheeling between beds (Figure 2).
5. For soil in good health, the water should drain away within 2–5 minutes for light or medium soils, whereas a heavy clay soil with poor structure could take 20 minutes or longer.
6. After the test, check for any compaction in the soil eg by digging adjacent to the infiltration test. A video demonstrating the spade test and instructions for grassland and arable soils can be found at: **ahdb.org.uk/greatsoils**

What is good soil structure?

A soil with good structure for crop growth needs to have aggregates of soil particles 1–10mm in diameter which remain stable when wet. These aggregates should have a mixture of large (greater than 75µm diameter) pores, macropores, to allow air movement and rapid drainage and small (0.2–30µm diameter) pores (micropores) to retain water for plants to use. Aggregates are made up of a combination of sand, silt and clay particles, together with organic matter.

Causes of poor soil structure

The structure of soil can be damaged by heavy rainfall and by inappropriate and/or poorly timed cultivation. The impact of cultivation depends upon the condition of the soil and the type of equipment used. There is a relatively narrow window of soil moisture content which allows good tilth formation and selection of appropriate power requirement, tractor weight and tyre loads will minimise the risk of compaction. Rainfall can damage the soil surface by the direct impact of the raindrops on soil particles, which may weaken or shatter soil aggregates. As the soil wets up, the aggregates may not be strong enough to resist the pressure exerted by air trapped inside the pores, causing the aggregates to break into finer particles (slaking).

Clay particles within the small aggregates may start to disperse and become separated from the aggregate during heavy rain and irrigation. Dispersed clay particles can then block the pores that are needed to transmit or store water.

When slaking and dispersion occur together then the soil surface can become capped as the soil dries out, forming a hard crust (Figure 3). This problem can be particularly severe in fine sand/silty soils with low organic matter content. The presence of this hard crust on the soil

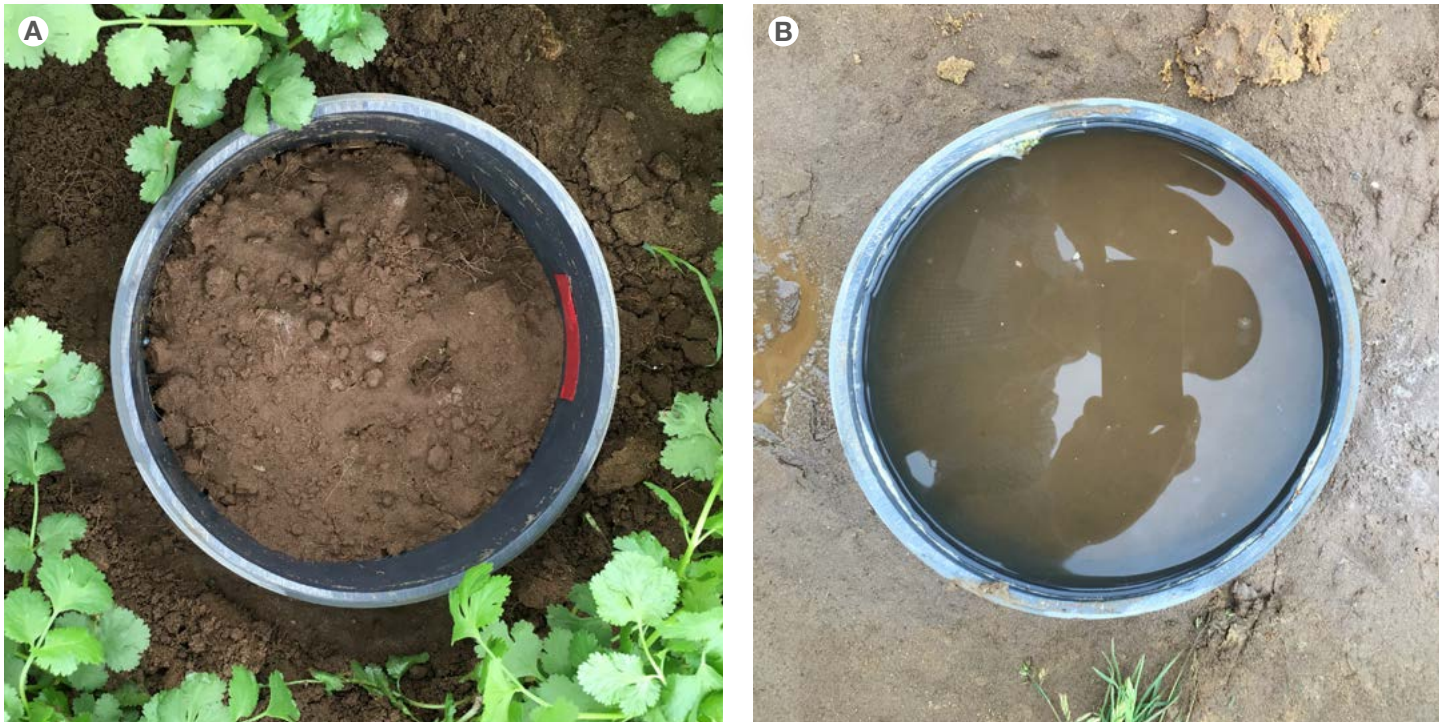

Figure 2. Simple infiltrometer using drainpipe to demonstrate difference between A) good infiltration in a bed used to grow coriander, and B) poor infiltration in the adjacent wheeling

Figure 3. Poorly managed soil showing surface slaking and cracking

surface causes problems for seedling emergence and may require further mechanical operations to break the crust.

Improving soil structure

Good soil management should encourage flocculation (clumping together) of clay particles in order to counteract their tendency to disperse under heavy rainfall and irrigation. The application of gypsum (calcium sulphate) to some types of clay soils can help by supplying calcium ions which increase the strength of aggregates and encourage clay particles to flocculate and form micro-aggregates.

The stabilisation of these micro-aggregates is important for soil to function properly and for crop growth, as it determines the water and air relationships for that soil. In most soils, organic binding agents are involved; they may be decomposition products of plants, animals or microorganisms, microbial cells or products of microbial metabolism.

The addition of organic matter such as compost or green manures to soil will lead to improvements in soil physical conditions by increasing soil organic matter, stabilising aggregates, stimulating microbial activity and helping to break up compaction. A more stable material such as compost will have a longer-lasting effect than a fresh green manure.

What is green manure?

Green manures may broadly be defined as crops grown for the benefit of the soil eg by adding organic matter, nitrogen fixation or improving soil structure. Oats can improve the structure of soil due to their fibrous roots; lucerne, chicory and red clover produce deep tap roots which help break up compacted soil.

Soil biology and soil structure

While smaller aggregates (2–20µm) are bound together mainly by organic chemical bonds, larger aggregates (>2000µm) are held together by a network of roots and fungal hyphae.

Polysaccharides produced by bacteria and fungi are important in aggregate stabilisation, particularly in cultivated soils. The length and linear structure of polysaccharide molecules provide a bridge between soil particles. Bacteria surrounded by clay crystals could form a micro-aggregate, while fungi are probably responsible for binding larger soil particles.

Plant roots increase the stability of the surrounding aggregates, which may in part be due to fungal hyphae associated with the roots (mycorrhizas). Fungi may also form aggregates by bringing soil particles together as they grow. Fungal hyphae retain their strength after they die, allowing a more permanent effect.

Earthworms and plant roots also create a network of drainage channels (macropores) which are stabilised by the secretions of these organisms as they make their way through the soil.

The use of interventions such as compost incorporation or green manures, and regular monitoring of soil using simple techniques such as the drainpipe test and spade test, provide tools that can support improved soil health management to help build the resilience of soils.

> “By encouraging the soil biology to flourish, soil structure improvement will follow.”
>
> Dr Martin Wood, Earthcare Technical Ltd

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Further information

A range of resources to help you with soil health assessment and soil management are available at: **ahdb.org.uk/greatsoils**

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