DIY Soil Health Tests V1

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1. Introduction

This report describes the main soil health tests that farmers, growers and gardeners can do themselves (DIY). They range from the quick and simple to annual full checkups. All of this information is freely available from multiple sources, particularly on the internet, but, they have not been brought altogether in one place and combined with a short explanation of what soil health is and what drives it. It is therefore only a brief introduction and explanation to each test. If you are interested in understanding the tests in more depth there are links to further information, and, armed with the name and other information about the test you can find lots of information online. The United States through the US Department of Agriculture and Land Grant Universities are particularly good and authoritative sources of information.

This report was originally written for an Aotearoa New Zealand context. It has been adapted to a international context but some of the tests will only be relevant to temperate climates. In all cases if you want to use a test to get more in-depth information getting local advice on doing the tests on your particular soil textures, climate and farm systems is important.

Many thanks to the Bragato Research Institute and Zespri who sponsored this report. They have their own versions of the report customised for wine growers and Kiwifruit growers. To get a copy of their versions for kiwifruit growers please email extension@zespri.com and for wine growers info@bri.co.nz or you can access them through the members sections of their websites.

2. The value of soil health to you and the planet

Soil is literally the foundation of productivity and profitability of agriculture and horticulture. Soils in poor health simply cannot achieve the same level of crop performance as healthy soils regardless of the amounts of fertiliser applied. Healthy soil holds more plant nutrients, both as organic matter and sorbed onto the organic matter. Healthy soils absorb and store more water making better use of rainfall so reducing the need for irrigation. By absorbing water quicker healthy soils reduce the risk of run off and erosion in high rainfall events, and if there is flooding they are more resistant to erosion. Healthy soils are more resilient so keep performing under adverse conditions such as droughts. Healthy soils are more resistant to compaction from people and machines and are less likely to rut from frequent machinery passes. All of these benefits of healthy soil allows plant roots to perform to their best which results in healthy crop plants producing the best yields, quality and profit.

Globally, soils also have a critical role in mitigating many of the environmental challenges we all face, such as climate change, nutrient pollution and biodiversity loss. For example, healthy soils contain more carbon in the form of organic matter reducing atmospheric CO_2 thus helping mitigate climate change. Soils can store many times the amount of carbon than is in the atmosphere. Healthy soils are less likely to loose nutrients or soil particles so protecting waterways from nutrient pollution and eutrophication. Soils are the most biodiverse and important ecosystems on the planet so keeping them healthy is vital for the planet as a whole.

Thus making sure your soils are healthy is a win-win, for your production system, the environment and the planet. Thus knowing the health of your soil is vital, hence this report on DIY soil health tests!

3. What is soil health?

Soil health is defined in many different ways but for our purposes it is a soil that is functioning similar to how it would be under its natural ecosystem, e.g., grasslands or woodlands.

3.1. The three-legged stool of soil health

At a practical level, soil health is like a three-legged stool; there is physical, chemical and biological health.

Physical health is about soil structure – whether it is well aggregated with an open crumbly structure or if it is compacted and too dense (see Figure 4). Soil should be like a sponge – a whole lot of holes of different sizes all joined up together to make soil 'pores' which are soil's highways. The pores are what allow air and water to percolate though the soil and help it hold more water. The key things that damages physical soil health are:

- Compaction from feet (human and livestock), and especially machinery like tractors.
- Tillage / cultivation, the more of it, and the more intensive, the more damage is done.
- A lack of living plants, which are what drives soil biology to create structure – see section 3.2 below.

Chemical health is having optimum levels of nutrients and pH for plant growth - not too little and not too much. It is not just the major nutrients like NPK (nitrogen, phosphorus and potassium), the micronutrients are equally as important. Chemical health is reduced when nutrients are removed (in harvest, and from leaching) and not replaced. Chemical health can also be reduced if nutrients are above optimum. Excess nutrients can create induced deficiencies which will stunt crop growth. Some nutrients, like copper, are toxic to soil biology if they are too high. For example, copper is toxic to earthworms so high copper levels suppress earthworms which reduces soil heath and therefore crop performance.

Biological health is having a large and diverse range of organisms in your soil. Soil is the most complex ecosystem on the planet with organisms from the simplest, like bacteria, to the most complex such as mammals (Figure 1).

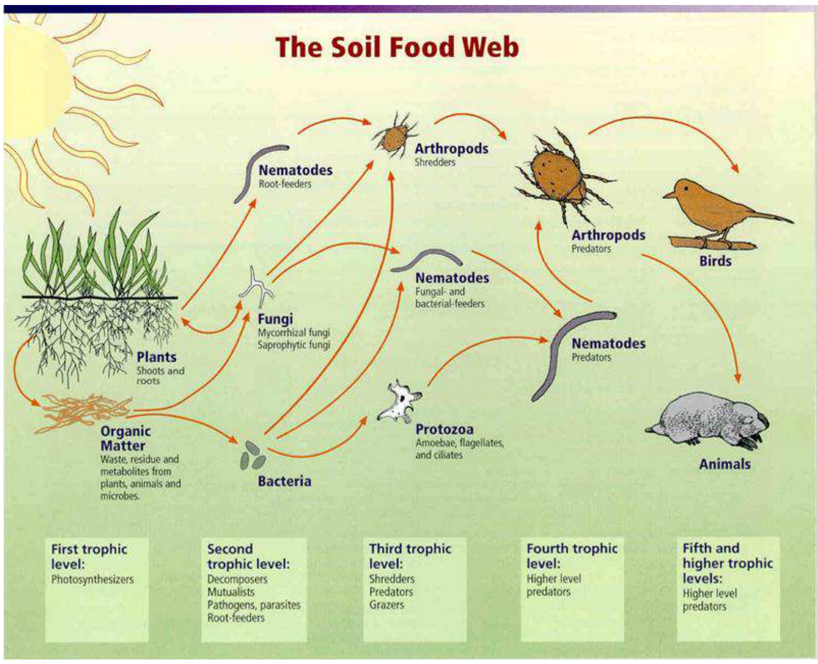

Figure 1. Relationships between soil food web, plants, organic matter, and birds and mammals. Image from USDA Natural Resources Conservation Service.

Just like a three-legged stool all three forms of soil health support each other. If the legs of the stool are not all the right length the stool cannot function properly. The same with soil health, all three 'legs' of soil health - physical, chemical and biological - need to be correct for overall soil health to be optimal. If one leg of soil health is not the correct length the other legs cannot compensate.

3.2. What drives soil health?

Soil organic matter (SOM) is at the heart of soil health, as good SOM levels are a result of and reciprocally underpin soil health. Scientific understanding of soil health and SOM formation has undergone a revolution in the last decade (Figure 2).

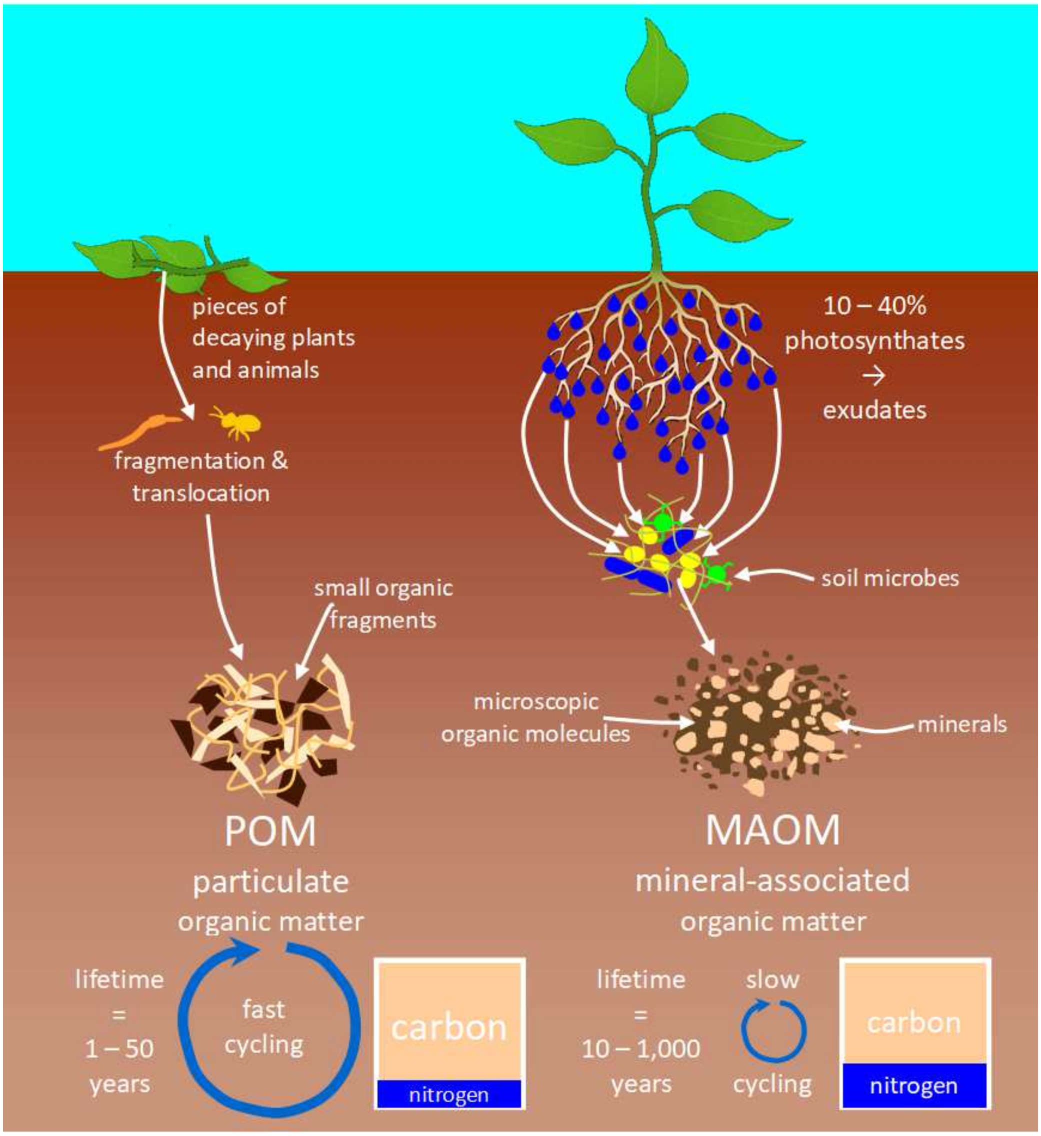

Figure 2. The two main soil organic matter (SOM) formation routes: particulate (POM) and mineral-associated organic matter (MAOM). After Jocelyn Lavallee (Cotrufo *et al.*, 2022)

It used to be thought that it was plant and animal residues, such as leaf litter, compost, manures, etc., deposited on the soil surface that drove the creation of organic matter. It is now realised that it is simple compounds called 'exudates' such as sugars, lipids and proteins that are pushed out from living plant roots that drive organic matter creation.

In Figure 2 there are two SOM creation paths. On the left-hand side is the path that creates particulate organic matter (POM) from plant and animal residues. This is where above ground residues are fragmented by larger soil organisms such as worms before being further decomposed by microbes such as fungi and bacteria. It was thought that the tougher organic material, like lignin (the main compound in wood), was turned into humus and that it could persist in the soil for centuries to millennia. It is now know that the POM is completely broken down much faster – a few years to a few decades at most, and most newly deposited above ground residues are completely decomposed in the first few years. POM is mostly carbon.

The right-hand side of Figure 2 shows how organic matter is created from plant root exudates. Between 10 to 40 percent of the photosynthates plants make from sunlight are turned into root exudates. These feed the beneficial microbes that live in a thin layer of soil around the roots called the rhizosphere. The microbes return the favour by helping the plants access water and nutrients and help protect the plant against harmful organisms. The plants can change the type of compounds they excrete to favour particular species of microbes when they need their particular help. Different plant species also put out different kinds of exudates which feed different species of microbes. Some of the exudates are decomposed by the microbes tuning them into SOM. The microbes then put some of the SOM inside soil particles, especially clay particles, which protects the organic matter from further decomposition. This organic matter inside the soil particles is called mineral associated organic matter (MAOM). This means that it is MAOM that now lasts from centuries to millennia. MAOM is also mostly carbon but is higher in nitrogen than POM so is the more important store of soil nitrogen which is nearly all in the form of organic matter.

Up to 80% of the organic matter in a soil is formed by the MAOM not the POM route. Thus maximising the creation of MAOM is therefore vital to maximise soil health. Thus it is living plants via their root exudates that drive soil health, not plant residues and compost. Indeed not only are plant root exudates directly feeding the majority of soil microbes, (populations of which are incredibly high in the rhizosphere) they are the only source of energy for all soil biology, as it is only plants that capture the energy in sunlight.

The very worst thing for soil health is bare soil – even if it has dead mulch on it. For example, an experiment by Plant & Food at Lincoln studied the impact of converting long term pasture into arable cropping under three tillage regimes (no-till, min-till and full tillage (ploughing)) and herbicide fallow. In the herbicide fallow the soil was not cultivated, driven over, or crops grown in it: just any time that any plants established they were sprayed off i.e., like the herbicide strip in perennial crops (Curtin *et al.*, 2015). After 11 years, the three tillage treatments all lost the same amount - 28 tonnes / ha of organic matter (2.5 tonnes /ha / year). The herbicide treatment lost 42 tonnes / ha over the same period (3.8 tonnes / ha / year) due to a lack of exudates from living plants. The resulting lesson therefore is that to maximise soil health you need to maintain 'living roots year-round' i.e., the soil needs to be covered in a diversity of living plants and bare soil avoided at all times.

4. The DIY soil health tests

The following DIY soil health tests allow you to monitor a range of aspects of your soil's health.

The tests vary between being useful for a quick analysis and, as discussed below, comparing different parts of a property but the test results are not easily comparable over time or different soil types. Other tests, particularly VSA (see section 12) gives an absolute score, that is designed to be comparable over time and contrasting places / soil textures.

4.1. Test in multiple locations due to soil variability

It's also important to test in more than one location. Many soils are variable, even over distances of tens of meters. Therefore, one test site may not be representative of a whole field or farm. So, depending on the test, do at least a handful in any one field. And if you know there are different soil types or other variation in the soil, make sure you test in all the different areas.

4.2. Do 'fenceline' tests for a baseline measurement

Some tests give numerical results, e.g., infiltration and worm counts. Examples are provided of what are generally considered poor to good ratings. However, due to multiple confounding factors such as soil texture, climate, farming system, etc. these example figures are very crude and may be completely unrepresentative of your soil. It is therefore recommended to do what is called a 'fenceline' test. This means testing an area of soil that is not impacted by the farming system (e.g., tilled, driven over, mown, eaten or walked on by livestock) and that has permanant undisturbed vegetation covering it, e.g., long pasture / grassland. Often this is under a fenceline, but can include areas such as woodland. Tests on these areas will indicate what a good soil health measurement should be. You can then use that as a baseline to compare with numerical test results but also any test. For some tests (e.g., infiltration, penetrometer) the baseline test wont change much, so once you have done several baseline tests around the farm they will be a good reference for several years. But for others (e.g., worm counts, decomposition) the baseline varies considerably over short periods of time (often driven by weather) so you will need to do a baseline test every time you do a field test.

4.3. Comparing contrasting locations - especially in perennial crops

Building on the 'fenceline' test, in perennial crops (trees, vines, etc.) comparing the middle of the crop row, the tractor wheelings, between the tractor wheelings as well as the 'fenceline' can also be highly informative. If the soil is bare underneath the crop, e.g., through herbicide or cultivating, then its health is likely to be poor due to the lack of plant cover (the crop is rarely enough). The tractor wheelings will be compacted and dense. Assuming the area between the tractor wheelings is under pasture or other permanent vegetation it is likely to be in reasonable to good health, and the 'fenceline' should have the best results of all.

4.4. Soil moisture

Many tests require the soil to be sufficiently moist to be able to dig a hole for the test to work. If you are on a silt or clay soil which can go very hard when dry you need to wait until the soil is moist or irrigate. Some tests you can wet the soil up where the test is to be done.

4.5. The nine DIY soil health tests - quick overview

Table 1 lists the nine DIY soils health tests, what they are measuring and when best to do them.

Table 1. The nine DIY soil health tests, what they measure and when to do them.

Test	Measures?	Time of year	Page
Spade	Quick diagnostic of multiple soil conditions	Any time	5
Soil probe	Density, compaction, pans	Any time	6
Penetrometer	Density, compaction, pans	Any time	6
Decomposition test	Biological activity	When moist	7
Ring infiltration test	Infiltration rate and soil structure	When moist	8
Slake test	Aggregate stability and overall soil health	Any time	9
Earthworm counts	Earthworms – indicator species of overall soil health	Winter, when moist	10
Hot water extractable carbon (HWEC)	Good proxy for microbial biomass and overall soil health	Any time	11
Visual soil assessment (VSA)	Comprehensive score-based measure of soil health - the gold standard	When moist	12

5. The S.P.A.D.E test - your all round test

When to do it: Anytime.

Where to do it: Anywhere and particularly where you think there may be a problem that needs a quick initial diagnosis.

What it tells you: Quick diagnostic of a range of soil health problems.

Equipment needed: A spade.

Time required: A few minutes.

The **S**oil **P**edology **A**ctive **D**iagnostic **E**valuator, better known as a spade is the most important soil diagnostic tool there is. You should have one with you at all times – on all vehicles and tractors. Any spade will do, though a post hole or ditching spade with a longer blade allows you to dig deeper (Figure 3).

Figure 3. Standard spade left and post hole / ditching spade right.

Having a spade with you at all times means you can do a quick (and dirty) diagnostic where you think there may be soil problems or just to check on your soil's condition. This will also help you to become familiar with what good and bad soil health look like (see Figure 4). Many of the other soil tests described in this booklet, e.g., VSA in section 12, also need a spade to do them.

For a quick and simple check, dig a hole about the width of the spade, to a minimum of the depth of the spade's blade, and ideally down into the top of the subsoil. Either take a slice of soil out or have a look at sides of the hole you have dug, as well as looking at the pile of excavated soil.

Key questions to ask are:

- How easily did the spade go into the soil? If it slides in with hardly any pressure, that's great, if you had to jump on it, that's really bad.
- Did it start easy and then get hard, or other way around? This indicates compaction at different levels: hard to start with indicates surface compaction, easy to start with and then harder indicates a soil pan.
- What does the soil structure look like? Is it:
  - A healthy dark colour - due to organic matter - or is pallid and unhealthy?
  - Is it well aggregated, i.e., have a nice crumbly structure and have lots of holes like a sponge?
- Does it smell fresh and earthy like a forest floor (healthy), or sour or smelly, particularly a sulphurous rotten egg smell (unhealthy).
- Any earthworms to be seen? None, not great (but see section 10) one or two (OK) or several handfuls (great).
- Any pests, such as leather jackets?

All of these indicators will give you a rapid idea of your soils health. Figure 4 shows examples of healthy and unhealthy soil.

Figure 4. Examples of healthy (left) and unhealthy (right) soil (a silty loam). In the healthy soil note the darker colour, the crumbly structure, and good numbers of roots and earthworms. In the unhealthy soil note the paler colour, the platy blocky structure and few roots and earthworms.

5.1. Further resources

This is a very comprehensive spade test video from FiBL in Switzerland, in Swiss with subtitles. https://youtu.be/f-kigHj3vbw

This video from Iowa State University Extension and Outreach compares among soils in neighbouring paddocks with different cropping histories https://youtu.be/VB7BAdP8uGs

6. Soil probes and penetrometers for density and compaction

When to do it: Anytime but typically when soil is moist on silt and clay soils which will otherwise be too hard.

Where to do it: Anywhere you think there could be problems and as a comparison among different areas.

What it tells you: How dense (tight) your soils are and if you have any compact layers (pans).

Equipment needed: A soil probe or penetrometer

Time required: A few seconds per spot.

Soil probes and penetrometers are used to measure soil density and compaction. A soil probe is a stiff steel rod, about 12 mm / ½" thick, a meter / yard long on a handle (Figure 5). The tip is pointed and slightly wider than the rod so it is easier to push in and pull it back out of the soil. A penetrometer is the same as a probe but it also measures how much force is required to push the rod into the soil (Figure 6).

6.1. Soil probe

Soil probes (Figure 5) are nearly as useful as a spade for soil diagnostics. They are (comparatively) cheap or you can make you own, they are robust, so should last for ever and are simple to use. Every vehicle should have one, same as with a spade.

Figure 5. Soil probe.

To use a probe simply push it into the ground to 'feel':

- How dense the soil is – does it slide in easily or does it take some effort? This indicates what the soil structure is like – if it goes in easily structure is good, if it's hard work to push the probe in, the soil structure is poor and there may be unhealthy levels of compaction.

- If there compact layers – the pressure to get the probe into the ground will change as you push the probe down. If it starts easily, then goes hard, then soft again, this a sure indication of a soil pan i.e., a thin (~5 cm / 2”) layer of particularly dense soil that is likely to be to hard for roots and other soil organisms, such as worms, to penetrate. Some natural pans are so hard you wont be able to push through them.
- If there are changes in soil layers / stones, through changed resistance and also the sound of the probe hitting or scraping past the stones.

A key advantage of a probe over a spade is it’s really quick to push into the ground so you can do many more tests and also get much deeper than is practical with a spade. The two tools are thus excellent complements for each other, for example a probe can be used to find areas with a pan and then the spade used to excavate to find out more about the pan.

You can also use a probe to find buried items like irrigation mains. N.B. check there are no electrical cables in the area as the probe could push through the insulation and electrocute the user. Electrically insulated probes are available.

6.2. Penetrometers

The key limitation with a probe is that you only have the resistance felt from pushing the rod into the ground to tell you what the soil density is. With experience you can get a feel for what is too much resistance, but to get the most accurate information you need penetrometer (Figure 6). The disadvantage of a penetrometer is they are much more expensive and delicate, so they need to be kept in their protective case and not thrown around in the back of a vehicle. They are thus best reserved for when a more purposeful investigation of soil density is needed.

Figure 6. Soil penetrometer.

Soil density determines how easily or not plant roots can penetrate soil. Roots push through soil in a similar fashion to the penetrometer, so the penetrometer gives you a good indication of whether soil can be accessed by plant roots or not. The ability of roots to penetrate soil reduces linearly from 0 to 200 PSI / 0 to 15 bar reading on a penetrometer. Between 200 and 300 PSI / 15 to 20 bar root penetration will be very limited and above 300 PSI / 20 bar roots cannot penetrate soil at all.

Most penetrometers have an analogue dial, and are the less expensive option and generally more than sufficient for most agricultural and horticultural situations. Digital versions have additional functions, such as measuring depth and pressure at the same time, plus recording multiple measurements for studying later on a computer or smart phone.

Getting an accurate reading from a penetrometer takes a bit of skill. Pushing too hard or fast will give an artificially high reading – you need to push at a steady and constant rate and pressure, see the video links below for examples. Soil moisture has a big impact on resistance; the most accurate readings will be achieved when the soil is well moistened. Clay content also affects soil resistance, so it can be helpful to calibrate your penetrometer on some nearby areas of soil that are in good condition, e.g., a vegetated fenceline, to give you a baseline resistance reading for your soil.

6.3. Further resources

A detailed video from University of Wisconsin Integrated Pest and Crop Management https://youtu.be/Zq_785JqRq8

More detailed information from Penn State University Extension "Diagnosing Soil Compaction Using a Penetrometer (Soil Compaction Tester)" https://extension.psu.edu/diagnosing-soil-compaction-using-a-penetrometer-soil-compaction-tester

7. Decomposition tests – 'don't soil your undies'! - for soil biological activity

When to do it: When the soil is warm and moist – autumn is good.

Where to do it: Anywhere, particularly to compare different areas (fenceline vs. field center).

What it tells you: How much soil biological activity you have.

Equipment needed: Either un-dyed thick cotton sheet like calico or white cotton underwear.

Time required: A couple of minutes per items buried, then up to two months waiting time, followed by several minutes retrieval and assessment.

7.1. Background

Decomposition tests measure the amount of biological activity in your soil by seeing how fast a piece of buried cotton rots away. Some Oregon farmers had the bright idea of using cotton underwear for the test and the great 'Don't soil your undies' challenge was born, which is now a global phenomenon!

Any organic material will work, not just cotton, however, cotton is simple and cheap so it is the favoured option. If you want to save a bit of money and not bury new undies, a piece of calico or a similar thick cotton fabric can be used.

The cotton is food for soil organisms so the faster the cotton decomposes the more soil biological activity there is. The difference in decomposition rates between soil health and locations can be phenomenal. Some undies have been dug up after two months and are as good as new (they could be washed and worn!), while others have only the rubber waist band and plastic stitching thread remaining!

This test works best in spring and particularly autumn, as the soil is more likely to be moist and warm at those times. If soil temperatures are below approximately 8°C it is too cold for soil microbes to function (called biologic zero) so no decomposition will occur at this time, making mid-winter an unsuitable time for this test. If the ground is irrigated then summer is also a good time, but, if the soil is dry then it is not. The amount of available nitrogen in the soil also affects the rate of decomposition.

7.2. The test

For greatest accuracy use unbleached and un-dyed cotton, such as calico, as the bleaching process can leave residues that are toxic to biology, and likewise some dyes are also toxic. Underpants therefore need to be white. This means they are likely to have been bleached, but, this is OK. To be really thorough, wash the cotton on a regular cotton cycle in a washing machine **without** washing detergent before use to remove any manufacturing contaminants. This will give the most consistent results.

Cut the fabric into pieces that are about the size of a spade blade, e.g. 20 × 15 cm / 8” × 6”. If you want to get a numerical result, weigh each dry piece of fabric to 1 g accuracy.

In the field, make a vertical slit in the soil with a spade about 20 cm/ 8” deep. Carefully insert the cotton piece into the slit. Folding the cotton over the bottom edge of the spade and using that to slide the cotton in the slot can help. Leave at least 3 cm / 1” of cotton, or the waist band of your undies, sticking out above the soil surface to help find them again. Push the soil back so there is good contact with both sides of the cotton piece. Clearly mark where the pieces are so you can find them again. Carefully retrieve the cotton pieces by digging them up – don’t just try and pull them up as they are likely to rip.

Three weeks is the minimum time in soils that are biologically active for significant decomposition to occur. Allow up to eight weeks if the soil is less biologically active. If you’re not sure how long to leave the cotton, put several pieces in the soil and then dig them up sequentially, e.g., every fortnight.

7.3. Measurements

If your soil is really biologically active there won’t be any cotton left below the strip or waist band that was above the soil surface. Shorten the test duration next time.

For simple comparisons and a record, take a photo along with details of the location (a small white board on which to write the details and photograph at the same time as the cotton is handy). For a more accurate comparison where you had pre-weighed the fabric, carefully wash the soil off (hand wash is probably best as the cotton may disintegrate in a washing machine), dry and re-weigh. The difference between the weight before and after the test can be used to calculate percent change ((final value – initial value) / initial value) × 100 = percent change, which can be used to compare among different sites and dates.

If you are comparing among different locations e.g., center vs. edge of a field, start all the tests at the same time so they are a true comparison.

7.4. Further resources

Oswego Lake Watershed Council undertook a more detailed look at the effect of vegetation type and surface residues on decomposition. There are also photos of undies with different levels of decomposition. https://www.oswegowatershed.org/soil-your-undies/

USDA Natural Resources Conservation Service – Oregon including video https://www.nrcs.usda.gov/conservation-basics/conservation-by-state/oregon/soil-your-undies-challenge

A web search for ‘don’t soil your undies’ will produce a very large number of results including lots of images of undies in various states of decomposition!

8. Ring infiltration test - how fast water soaks into your soil

When to do it: Anytime when the soil is moist.

Where to do it: Anywhere – this is a great comparative test for different areas - as long as your soil is not too stony.

What it tells you: The infiltration rate of your soil (how fast water can get into your soil) which indicates how good your soil structure is.

Equipment needed: Infiltrometer rings (make your own), piece of wood, lump hammer or mallet, container of water, timing device (watch, phone), water measuring device (optional), glad wrap (optional).

Time required: Varies. A few minutes per ring to setup. Infiltration of the water can range from a few minutes to hours.

8.1. Introduction

Infiltration is the ability of water from rain and irrigation to enter your soil. This depends on your soil's structure and aggregation. If it is well structured, like a bath sponge, then water can infiltrate quickly. Poor structure can result in the water hardly infiltrating at all. The ring infiltration test thus gives an indication of how good or bad your soil structure is as well as a measure of how quickly rain and irrigation water will soak into your soil.

Infiltration rate is simply the depth of water that will soak into the soil in one hour. Infiltration rate thus directly relates to rainfall, both in amount and intensity. Twenty-five millimetres / 1" of rainfall, means a 25 mm / 1" depth of rain has fallen. When you know the rate of rainfall, e.g., 25 mm / 1" in an hour, this directly relates to the ability of a soil to absorb that rate of rainfall and whether all of that rain will infiltrate the soil or if some will run off across the surface.

The ring infiltration test is also a 'proper' soil science test, with purposely designed rings and detailed procedures to ensure accurate and consistent results. The approach described here is a simplified version for farmers, growers and gardeners that still gives good enough results that can be compared across time and location, without the detailed requirements of a science grade test.

Soil texture (type) also has a large impact on infiltration rates with sandy soils draining very freely, silts having medium infiltration and clays the lowest rates (Table 2). If you are comparing results among different soil types this needs to be taken into account.

Table 2. Infiltration rates for different soil types (https://www.fao.org/3/s8684e/s8684e0a.htm)

Soil type	Typical infiltration rate in mm/hour
Sand	less than 30
Sandy loam	20 - 30
Loam	10 - 20
Clay loam	5 - 10
Clay	1 - 5

Table 2 also gives a range of typical (average) infiltration rates for different soil textures. However, this is very generic, and you are best doing a 'fenceline' test (see section 4.2) to get a more accurate baseline measurement for your soil(s). Getting local advice is also important.

There is also the related term ‘porosity’ that describes how well water can travel **within** a soil, i.e., down through the soil profile. Infiltration and porosity are therefore related. Measuring porosity is however beyond the reach of DIY tests.

8.2. Equipment and methods

There is no one perfect design of ring infiltrometer and there are many methods for using them. Some of the scientific methods are really complex so these are not covered here. Directly below is a single simple method using a basic ring made from commonly available materials. Use this approach if your unsure what your best method is or are not worried about the complexities of the technique. This simple method section also gives the overall steps of how to do a ring infiltrometer test - so read it to get an overall view.

The rest of this section goes into greater detail of infiltrometer designs and methods. This is in part because there are many different approaches described online and it can be pretty confusing getting your head around how the different designs and methods relate to each other. It certainly confused me! It is thus hoped that you can pick out a design and method best suited to your needs. However you can skip over it entirely if you just want to use the simple approach.

8.2.1. A simple ring infiltrometer design and method using easily available materials

Get some 80 mm / 3” diameter domestic uPVC guttering downpipe. Cut it accurately at 90° into 100 mm / 4” lengths to make the infiltration ring. Sharpen the **outside** of one end as per Figure 7 (NB the one in Figure 7 is 120 mm long, make yours 100 mm / 4”long). Mark a line 5 cm / 2” from the sharpened end (Figure 7). A mortise gauge is good for this.

Figure 7. Ring infiltrometer made from 12 cm / 5” long, 8 cm / 3” diameter uPVC guttering down pipe, showing sharpened end for driving into soil and inserted into the soil to the depth line at 5 cm / 2”.

Get a container to carry your water in. Each test will use 250 ml so multiply that by the number of tests you plan to do plus some spare, e.g., 10% to work out how much water to take with you. You need to put the water into the infiltrometer ring very gently so depending on the size and outlet of the container you are using to carry your water you may need a small container, like a measuring cup, to transfer water from the main container into each ring.

Clear the test location from as much vegetation and residues, such as twigs and leaves, as possible Figure 8 making sure you don’t stand or walk on the test area.

Figure 8. Ground preparation – clearing as much vegetation and residue from the test location as possible.

Soil moisture has a major impact on the rate of infiltration – dry soil will suck the water in much faster. Also driving rings into dry soil can cause the soil to shatter rendering the results invalid. The test can therefore only be done on soil that is close to, but not completely at, field capacity, i.e., moist. If the soil is not moist enough and a test has to be done, place a few thickness of hessian on the test spots and then place a bucket with a small hole (e.g., 2 mm / ¼") in the bottom, on the hessian and then fill the bucket with water. Leave for at least 24 hours for the water to properly disperse through the soil, i.e., so it is not waterlogged.

As soils are inherently variable even across small distances, several tests should be undertaken for each location. Putting multiple rings in place at the same time so you can run multiple tests in parallel can save time, however, if there are too many rings you wont be able to keep an eye on all of them for timing purposes.

Figure 9. Simple method for driving ring into ground – wooden batten and club hammer.

Drive the ring into the ground using a thick wooden batten and a mallet or club hammer (Figure 9), making sure it goes in absolutely vertically and without wobbling side to side as it goes in. If it does go askew, remove it and start on a new location. If the ring wobbles as it is driven it, it creates gaps in the soil down the side of the ring, where the water will preferentially drain, invalidating the test. Drive the ring into the ground until the line marked on the outside is exactly level with the soil surface. There should then be 50 mm / 2" of pipe (the 100 mm / 4" length of the ring - the 50 mm / 2" it has been driven into the ground) sticking out of the ground. This will give you 50 mm / 2" depth of water when the pipe is filled.

Gently fill the ring with clean water to the brim (Figure 10) e.g., tap water. Time how long it takes for all the water to infiltrate (drain away) - the soil surface should just be 'glistening' when the water has just finished infiltrating. This could be as little as a few minutes to hours.

If you are just interested in comparing among a number of locations then you can simply fill each ring to the top and time how long it takes for all the water to soak into the ground to the point that the surface is glistening. You can then compare the times taken for the different test locations and also at different dates. However, this does not tell you what your actual infiltration rate is.

To calculate the rate of infiltration divide 60 (i.e., 60 minutes in an hour) by the number of minutes it took for the water to drain away. Multiply that number by 50 (the number of millimetres depth of water in the ring) That will give you your infiltration rate in mm / hour. For example, if it took 20 minutes for the water to fully drain away then the infiltration rate is (60 ÷ 20) × 50 = 150 mm infiltration per hour.

Figure 10. Infiltration ring filled with water.

8.2.2. Information on different ring infiltrometer designs and methods

As noted above there are a multitude of different designs and methods of ring infiltrometers which can be particularly confusing for novices trying to make sense of all the different approaches. This section is designed to help you understand these different approaches and decide on one that works for you. This means there is also a lot more information than for the other tests. The good news is you can skip right over is and just use the simple approach described above if you don't want to get into the myriad details.

8.2.2.1. Infiltrometer ring construction

Materials

Rings can be made of metal or plastic. Research grade rings are made of metal, such as galvanised or stainless steel for toughness and corrosion resistance. For non-research purposes, hard plastic (like uPVC) is fine unless you have stones and / or plan to do a lot of testing, as the edge on a plastic ring will get damaged. It is important that the wall of your chosen ring is not too thick, 3 mm / ¼" is about the maximum, otherwise the soil will be disturbed too much when the ring is driven into the ground and the water will leak down the ring edges. Thicker also makes it harder to drive into the soil. An advantage of metal rings is they can have thin but strong walls. Domestic guttering down-pipe (Figure 7) and other forms of thin walled, hard plastic pipe, e.g., drain / sewerage pipe work well .

Diameter

The pipe can be a range of diameters. Research rings are some 15 to 30 cm / 6” to 12” in diameter. The larger the diameter the more soil is enclosed and therefore the more accurate the result. Bigger also means more water is required which has to be carried to the test site(s). Eight centimetres / 3” is considered to be the minimum viable diameter (Figure 7). About 15 cm / 6” is a good middle-of-the-road diameter.

Length

Ring length is also not fixed. 10 cm / 4” is about the minimum ring length to allow enough of the ring to be driven into the soil and leave enough above the soil to fill with water. 15 to 20 cm / 6” to 8” is ideal. Longer allows more of the ring to be driven into the soil and more water to be used, both to improve accuracy, especially when the water drains quickly.

Bevelled edge

Sharpen / bevel one end of the ring on the **outside** as shown in Figure 7. This makes it easier to drive the ring into the soil and minimises the **soil inside** the ring being disturbed by the bevel.

Fancy driver

A fancier approach to just using a block of wood and a mallet as in Figure 9 involves using a hole saw to cut a circular slot into a piece of wood that the infiltrometer ring fits snugly into (Figure 11). This keeps the wood stable on the ring as it is driven into the ground, making it easier to get the ring in vertically without wobbling. Use the hole saw in a drill press to ensure the slot is exactly vertical. Depending on the height of the ring and the depth it needs to be driven into the soil, the circular slot can be cut to a depth such that as the ring is driven into the soil when the wooden block touches the soil the ring is at the right depth. For longer rings use multiple blocks of wood, drill a slot in the top one and drill the center completely out of the others then glue or screw them together using a ring to align them.

An even fancier approach is to add a shaft to the piece of wood so the ring to be driven in from a standing position. This not only saves older knees and backs, but it helps to make sure the ring goes in perfectly vertical (Figure 11). You can then also slide the rings onto the handle for transport!

Figure 11. ‘Fancy’ ring driver, with a circular slot cut in a wood block with hole saw that the ring fits snugly into and with a wooden shaft to allow ring to be driven from standing position.

8.2.2.2. Adding water to the ring

It is important to use clean water for the test. Where a high level of accuracy is required and the water has impurities such as iron or calcium, distilled or rain water is best.

It is important to pour the water into the ring gently, so as not to stir up the soil. Putting the water into fast or from too greater height can result in stirred up soil clogging soil pores and invalidating the test. If the test is being done where there is vegetation covering the soil and holding it together, such as pasture, then the water can just be gently poured into the ring. Where the soil is bare, and especially where it has been cultivated and is lose, more advanced techniques are required. Scientific ring infiltrometers have diffusers to minimise water impact. In America the plastic wrap (food wrap, glad wrap, cling film, Saran wrap), technique is popular: a piece of plastic wrap is put inside the bottom of the ring and up and over the sides, the water is then poured onto the plastic wrap, which is then carefully pulled away to start the test. See the videos in the further resources section below for demonstrations.

The depth of the water in the rings also impacts the rate of infiltration; a greater depth of water will exert more pressure. Having more than 15 cm / 6” depth of water is not recommended.

To get the most precise results, a ring is filled multiple times, even if the ground has been pre-wetted as described above. Often the first batch of water will soak in quite quickly and then subsequent batches slow down. Where this occurs first batches will be over-estimating infiltration rate. Some approaches recommend doing a fixed number of batches, e.g., two or three, others require that the infiltration time for batches to stabilise, i.e., two consecutive runs have take the same time. While providing greater accuracy this can become very time consuming, especially on low permeability soils. See below about rings with multiple lines for slow infiltration rates.

8.2.3. Measuring infiltration

To measure your infiltration rate then you need to use a known amount of water. There are three approaches:

1. Putting a pre-measured amount of water into the ring - **measured method**;
2. Putting a known depth of water in the ring - **depth method**;
3. Measuring how much the water has dropped over a fixed time period - **time method**.

8.2.3.1. Depth method

For the depth method, the simplest approach is to fill the ring to the top and time how long the water takes to drain away until the surface is glistening. However, ensuring the ring is filled accurately and deciding exactly when the last of the water has drained away leaving a glistening surface introduces inaccuracies. To be more accurate lines at known distances are marked on the inside of the ring as water level markers. This improves accuracy as it is easier to see exactly when the water level is at the marked lines. Confusingly there are multiple approaches using internal lines:

- A ‘filling line’ close to the top of the ring, a known distance from the soil surface / the outside soil depth line;
- A ‘finishing line’ close to the soil surface, a known distance from the top of the ring or a higher line;
- Two lines a known distance apart one close to the soil the other near the top of the ring, i.e., both a filling and finishing line;
- Multiple lines a known distance apart.

Having a filling line reduces timing inaccuracies when filling the ring, especially if the water is draining quickly. The ring is typically filled above the line (often to the top of the ring) and timing starts when the water level reaches the line.

Having a filling line also allows for 'extra' water to be put in the ring above the line to 'prime' the soil, which may reduce or eliminate the need to do multiple runs as discussed above.

Having a finishing line eliminates the guess work of when the water has finished draining and reached the glistening stage - especially when the water drains slowly and the point that all the water finally drains could vary by several minutes.

With double lines timing starts when the water passes the first line and stops when the water passes the second line which minimises starting and stopping timing inaccuracies.

Multiple lines allow multiple timings, so that changes to the rate of infiltration can be measured with one fill. Multiple lines also allows flexible measuring time, for example if infiltration is very quick then the top and bottom lines are used for timing so the greatest amount of water is measured for greatest accuracy, while if infiltration is very slow (it can be hours) then the height drop between two consecutive lines is used, so the time taken to do the test is minimised. Further, the time for the water to pass each line can be used to see if the rate of infiltration has stabilised, i.e., if the time taken to pass each line is getting longer, infiltration has not stabilised, while if the time to pass each line is the same, infiltration has stabilised.

The minimum depth of water needed for accuracy is around 25 mm / 1". The maximum depth is around 15 cm / 6" because the greater the depth of water the more pressure it experts on the soil and starts pushing the water into the soil rather than it just infiltrating under gravity. Where multiple lines are used these are typically 1.5 cm / ½" to 2.5 cm / 1" apart. If there are lots of lines they need to be numbered with their depth to minimise mistakes.

For all depth methods the rate of infiltration is 60 (i.e., 60 minutes in an hour) divided by the number of minutes it took for the water to drop between the measuring points multiplied that by the depth the water dropped. For example, if the depth the water dropped was 25 mm and it took 20 minutes then infiltration rate is (60 ÷ 20) × 25 = 75 mm infiltration per hour.

The advantage of the depth method is the infiltration ring doubles as the water measure so no additional measuring equipment is needed, and with start and finish lines it has a high level of accuracy. If only a start line is used or the ring is just filled to the top then the getting depth of the ring in the soil correct is critical for accurate measurement.

8.2.3.2. Measured method

With the measured method a pre-measured amount of water is put the ring and timed for how long it takes to infiltrate and reach the glistening stage. This appears to be the preferred approach in America. The same as for the depth method the amount of water used needs to equate to a minimum depth of 25 mm / 1" and maximum depth of 15 cm / 6" in the ring. To work out how much water to use based on the size of your ring, measure the **internal** diameter of your ring in centimetres (using centimetres means your answer will be in cm^3 i.e., millilitres). The volume of a cylinder is calculated as depth × π × $radius^2$ = volume. For example, for an 8 cm dia. ring the radius is 4 cm (i.e., half the diameter); 4 cm squared is 16; π = 3.141. The calculation is thus:

$$\text{depth} \times \pi \times \text{radius}^2 = \text{volume}$$
$$2.5 \times 3.141 \times 16 = 126 \text{ ml}$$

A simple way to double check your calculation is correct is to measure the water depth when you put it in the ring.

Time how long the water takes to completely disappear, and leave a glistening surface. The calculation for hourly infiltration rate is the same as for the depth method.

The advantages of the measured method is that the amount of water can be accurately measured, e.g., using a measuring cylinder or by weight. Multiple pre-measured amounts can also be put into individual containers prior to going out to the field to save time and having to measure water out in the field. The accuracy of the measured method is not effected if the depth of the infiltration ring is not 100% inaccurate (within reason, e.g., out by a few mm / 1/8") because the amount of water added is pre-determined and not dependent on the lines on the ring being at the right height above the soil. However, deciding when the water has drained and the surface has reached the glistening stage can be difficult, especially if infiltration is slow. A solution to this is to have a finishing line (as per the depth method) but then the depth of the ring in the soil needs to be accurate so the finishing line is an accurate distance above the soil. You also need to add extra water to compensate for the finishing line being above the soil surface.

8.2.3.3. Time method

The third approach is to run the test for a fixed amount of time and measure how much the water has dropped in the ring over that time. This often uses a start line (from the depth method) allowing for soil priming, a more accurate starting time and easier measuring. An engineers ruler where the markings start right at the end of the rule is best, as the end can be placed so it just touches the waters surface and the distance to the starting line near the top of the ring can be easily sighted.

The advantage of the time method is you know how long the test will take. The main disadvantages is accurately measuring the height the water level has dropped, particularly as the rings are at ground level, so you need to get your head low enough to take an accurate reading. Also if infiltration is very slow the water may hardly drop in the allocated time so will be difficult to accurately measure. More time will thus need to be allocated. The hourly infiltration rate calculation is the same as the other methods.

8.3. Further resources

Murray Catchment Management Authority short video demonstrating ring insertion and water filling, using the between the lines timing technique https://youtu.be/YsEYs3YfkKE

Tennessee State University Extension detailed video showing using the glad wrap and measured method https://youtu.be/9KSdTFHA_E4

University of Nebraska – Lincoln detailed video using the glad wrap and measured method https://youtu.be/iz415J3AOI4

University of Wisconsin College of Agriculture and Life Sciences have a comprehensive video on both infiltration and slake tests https://youtu.be/d1M7EFqqsMM

Australian Wine Research Institute - Vineyard activity guides: Measuring the infiltration rate of water into soil using the ring infiltrometer method https://www.awri.com.au/wp-content/uploads/v_activity_infiltration_rate.pdf

An internet search for 'soil infiltration test', 'ring infiltrometer' and variations thereof will yield a lot of results.

9. Slake test for aggregate stability - overall soil health

When to do it: Anytime but soil needs to be reasonably dry or be artificially dried.

Where to do it: Out in the field, or in the shed.

What it tells you: How stable you soil aggregates are.

Equipment needed: Largish transparent jars with wide mouths, some approx. 1 cm / ½" hole wire mesh, water to fill the jar and soil clods that fit inside the jar mouth.

Time required: Minutes to a few hours.

In 2022 the Soil Health Institute (SHI) soilhealthinstitute.org, a not-for-profit soil science organisation based in North Carolina, USA, in conjunctions with over 100 scientists across the US, undertook an project to find the minimum number of practical, affordable tests for soil health. They found just three were required!:

- Organic carbon concentration;
- Carbon mineralization potential (burst of CO_2);
- Aggregate stability.

This shows the importance of aggregate stability as a really valuable overall measure of soil health.

9.1. The slake test

The slake test is really impactful as it quickly and visually shows you how stable your soil aggregates are i.e., how resistant they are to breaking apart.

It's also a quick and simple test – much less work than ring infiltrometers for example. The equipment required is a transparent jar (glass or plastic) with a reasonably wide opening (Figure 12). One option is to cut the top off a clear plastic drink bottle. You need as many jars as the number of soil samples you want to test in one go. Some wire mesh with approximately 1 cm / ½" sized holes (holes can be any shape) which is used to make a small basket in the mouth of the jar – deep enough to hold a lump of soil up to 5 cm diameter (Figure 12). Then fill the jar with water so when you put the lump of soil into the wire basket it is immersed in the water.

Dig up some soil from the areas you want to test. You then need to pick out a single piece of soil that's between three to five centimetres in size, the exact size does not matter, it just needs to fit into the wire basket in the jar and be fully underwater. The soil needs to be relatively dry – moist soil does not work. So, if the soil is moist, air dry it first at ambient temperatures for several days. Then carefully put the soil clod into the wire basket and watch with wonder.

If you have healthy, well aggregated soil, virtually nothing will happen – a few pieces may fall off the clod, and the water will remain clear. If your soil is in really poor health, then the clod will disintegrate before your eyes into a murky soil soup as in Figure 12. The videos in the further resources below show this really well.

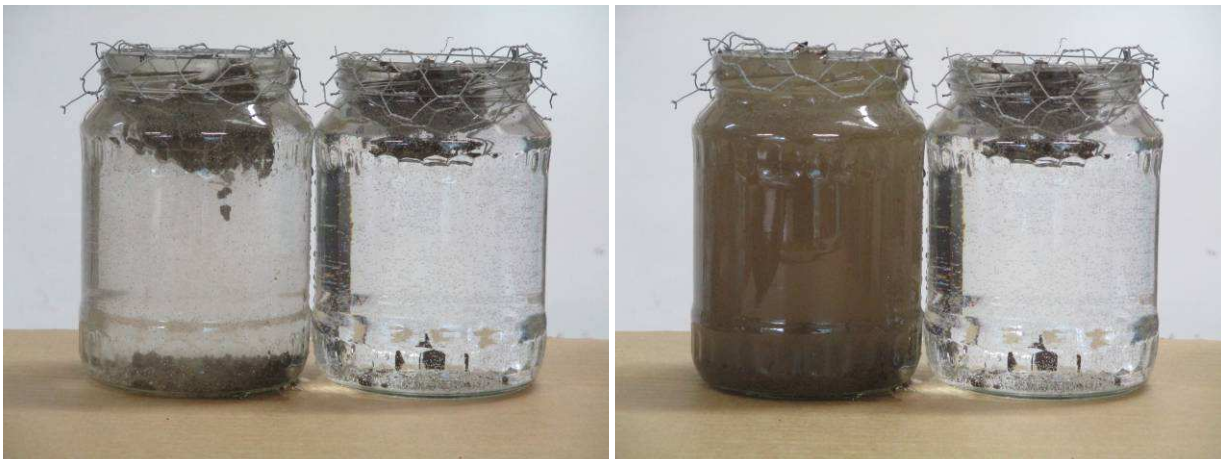

Figure 12. Slake test of unhealthy soil (left jar) and healthy soil (right jar) at start (left photo) after one hour (right photo).

9.2. Further resources

University of Wisconsin College of Agriculture and Life Sciences have a comprehensive video on both infiltration and slake tests – the latter starts at 2 minutes 22 seconds.
https://youtu.be/d1M7EFqqsMM

USDA Natural Resources Conservation Service one page slake test handout with links to videos
https://www.asec.purdue.edu/soilhealth/downloads/SlakeTest%2CNRCS.pdf

University of Wisconsin College of Agriculture and Life Sciences one page handout with links to additional videos https://fyi.extension.wisc.edu/danecountyag/files/2020/02/Slake-test-handout.pdf

10. Earthworm counts - overall soil health

When to do it: During late winter to early spring when the soil is moist and worm populations peak.

Where to do it: Anywhere: both production and undisturbed comparison sites.

What it tells you: Earthworms are an 'indicator' species, high numbers indicates healthy soils, low, or no worms indicates less or unhealthy soils.

Equipment needed: Spade, small plastic container wet on the inside (can use a moist paper towel).

Time required: About 10 minutes per hole.

Farmland earthworms are only native to certain parts of the world, for example they are exotic to Northern America and New Zealand. However, they have been introduced, accidentally and deliberately to many places they are not native. They are thus not everywhere - you may just be naturally lacking in them. You should therefore get specific advice on worm tests for your area. This information is also mostly relevant to temperate climates as arid and cold climates are not hospitable to worms. .

There are three main types of earthworms found on agricultural land:

- Dung / surface dwellers / epigeic – these inhabit the surface layer without forming permanent burrows. They feed on dung, decaying roots & leaves and other organic residues and detritus.
- Topsoil / endogeic – live in the top 20 – 30 cm of the soil (i.e., the topsoil as the name indicates!). They burrow through the soil, eating it and digesting the organic matter in the soil they eat.
- Deep burrowers / dwellers / anecic – these have permanent vertical burrows up to three meters deep. They feed by coming to the surface to collect organic matter like dung and leaves and pull this down into their burrows where they eat it.

Earthworms are really important to soil ecology and health. They are often called 'ecosystem engineers' due to the pivotal role they play. They help decompose organic matter, releasing nutrients to plants and cultivating or tilling the soil as they go. Earthworms also help aerate the soil and improve its structure and aggregate stability.

10.1. Doing the counts

Dry soil conditions make digging difficult and many worms hibernate at depth when it's dry, so earthworm counts need to be done when the soil has been wet for some time. In comparison, cold temperatures do not bother them so much, unless it's freezing. It's also best to do worm counts at the same time each year as populations also vary a lot over the seasons. Late winter to early is thus the best time unless the soil is frozen. Earthworms prefer medium-heavy loam to loamy sand soils and don't favour heavy clay or dry sandy soils, so soil texture will also impact your counts.

If you are wanting accurate results to compare across your property and over time, rather than just a quick look, you need to choose a representative area of the property and dig several holes.

Gently dig up a 20 × 20 × 20 cube of soil – it does not have to be intact as you are going to break it up (a standard spade is 18 cm across). Put the soil on a sheet or board so you don't lose any worms. Then carefully break the soil apart with your fingers and sort through it and lift out the worms. Put them in a container with a thin layer of water, or wetted piece of paper towel in the bottom to keep the worms moist. Then count your worms, and afterwards carefully put them back in the hole with the soil. One 20 × 20 cm hole is $1/25^{th}$ of a square meter, i.e., 25 holes would equal 1 m^2. Multiply the number of worms in each hole by 25 to get the number of worms per m^2.

Due to the huge variability of worms due to multiple factor such soil texture, climate, soil moisture, farming system (pasture vs. cropping), geographical location etc. figures on what would be poor to good populations is very general. As very ball park figures if you have less than 10 worms per m^2 then it is not ideal, 200 worms / m^2 is good and above 400 worms /m^2 is probably exceptional. But these are very general figures. Better still would be to get local information on what to expect, taking into account farm type as well. To get the most accurate measure of your best worm populations, sample some undisturbed ground covered with permanant vegetation, e.g., a fenceline with pasture. You will need to do this baseline sample every year / time you sample due to worm populations varying over time.

Figure 13. Examples of some earth worms: left Grey worm (*Aporrectodea caliginosa*), center Pink worm (*Aporrectodea rosea*),right Yellow tail (*Octolasion cyaneum*).

10.2. Further resources

AgResearch's 'The great kiwi worm hunt' has New Zealand specific information and good pictures of the different species https://www.bhu.org.nz/the-great-kiwi-earthworm-survey-species-id-sept-2020/

FiBL in Europe have a comprehensive earthworm handbook https://orgprints.org/id/eprint/30567/

The Foundation for Arable Research have details on worm counts in their 'Soil Quality on Southland Cropping Farms' booklet https://www.far.org.nz/assets/files/blog/files//070f33ba-e94c-534b-a73f-6c6cc771b420.pdf

11. Hot water extractable carbon (HWEC) - estimating microbial biomass / biological activity

When to do it: Anytime – as part of your standard soil nutrient tests.

Where to do it: Take a representative sample from across the field – as part of nutrient tests.

What it tells you: A proxy for microbial biomass, i.e., how biologically active your soil is.

Equipment needed: Standard soil test corer, bag or bucket for soil samples.

Time required: About twenty minutes for a 10 hectare field

The hot water extractable carbon test (HWEC) is not a DIY field test, it is a laboratory test, but it's such a valuable and inexpensive test that it's included here so more people are aware of it. It is done as part of standard nutrient soil testing so just needs an extra tick on your soil test order form.

The test gives an indirect measurement of soil microbial biomass which is the living part of soil organic matter and the most important. It is soil microbes, often called soil biology, that create soil health. Unlike total soil organic matter which changes quite slowly in reaction to changes in management (e.g., using cover crops, reducing tillage), microbial biomass responds much more quickly to management changes. Regular testing will thus give you an early indication if soil health is changing for good or bad.

Directly measuring microbial biomass is difficult and expensive but a considerable amount of research has found that organic carbon compounds in soil that are soluble in hot water give a good approximation of microbial biomass. The hot water extractable carbon test involves soaking a measured amount of soil in hot water for a specified time and then measuring the amount of carbon that is in the water.

HWEC results also strongly correlate with other soil health indicators such as mineralisable nitrogen (min-N), carbohydrates, and physical indicators such as aggregation. It is therefore also a good measure of overall soil health. As it's a lab test it's also highly standardised and comparable across different soils, times of year, etc.

So, next time you are getting soil nutrient tests done ask your laboratory if they do the HWEC test and if so add it to the tests being done. If they don't ask them to provide it.

11.1. Further information

Hill Laboratories information on HWEC https://www.hill-laboratories.com/about-us/news/more-value-from-hot-water-soil-tests/

12. Visual soil assessment (VSA) - the gold standard

When to do it: When soils are moist.

Where to do it: Several representative locations across the field, or as a comparison of different areas.

What it tells you: It gives you a scored assessment of your overall soil health as well as a valuable education about your soil.

Equipment needed: A spade, plastic basin, hard board that fits in the bottom of the basin, thick plastic bag, knife, water bottle, tape measure, VSA field guide, score cards. A new version of the test is being brought out which has a reduced equipment list and streamlined testing procedure.

Time required: Twenty five minutes per site.

Visual soil assessment (VSA) is the gold standard of all in-field soil testing. VSA was developed in Aotearoa New Zealand in 1999 by Mr Graham Shepherd to provide farmers and growers with a rigorous way of assessing their soils. VSA was validated by researchers at Manaaki Whenua – Landcare Research and several other New Zealand research organisations. It is now used globally, particularly in temperate climatic areas, and is supported and recommended by the Food and Agriculture Organization (FAO).

VSA is a suite of integrated tests and includes some of the tests listed earlier in this booklet such as worm counts. VSA has also been customised for different production systems.

A VSA involves digging up a section of soil with a spade, the same as for the worm count test (see above). Then you work your way through a score card listing a range indicators such as soil structure, porosity, colour and mottles, earthworms, rooting depth and so on. The test also involves looking at the field as a whole for issues such as ponding, crusting and wind / water erosion. Crop plant performance is also part of some tests. The scores are weighted and when added up give an overall soil health score. There are detailed instructions with pictures for each assessment. The way the tests are done also addresses issues such as soil textures affecting test results (as noted for many of the tests in this booklet) so that scores are comparable among quite different production systems, soil types etc. There are also crop-specific test booklets for some crops.

So, if you want to do the most thorough, comprehensive and accurate DIY soil health, a VSA is what you need. See below for links to VSA resources.

12.1. Further information

For more information on VSA visit Graham Shepherd's website https://www.bioagrinomics.com/visual-soil-assessment where you can order hard copies of the field guides or you can download PDFs from the FAO's website https://www.fao.org/3/i0007e/i0007e00.htm

13. References

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