Practical soil assessment methods for different horticultural systems

The GREATsoils project ran for three years and came to an end in March 2018; it was a collaboration between the Organic Research Centre, the Soil Association and Earthcare Technical, and was funded by AHDB Horticulture. ***Anja Vieweger*** *and* ***Dominic Amos*** *report from their work with horticultural growers across the UK, who have selected, tested, and rated different practical soil assessment tools for their specific growing systems.*

During a two-year field study as part of the GREATsoils project, UK growers from different horticultural systems such as field vegetables, top fruit and protected cropping systems have selected, tested and directly compared a number of promising (to them) soil assessment tools in their own fields. The methods were relatively new to the growers in that they have seldom used them before, but they were seen as interesting new approaches, practical and relatively easy to use, cheap and most importantly seemed to deliver useful results to inform sustainable soil management.

The aim of the field comparison of soil assessment tools was on one hand to (re-)connect growers with their soils, increase their confidence to personally assess and measure the health of their soils, and to evaluate which indicators might be most useful and relevant to monitor in their specific circumstances and horticultural systems. On the other hand, this work aimed to identify if certain horticultural systems, such as field veg, top fruit or protected cropping systems, might require their own specific soil assessment methods, combinations of methods or individual interpretation of results.

The outcomes of this study are a set of recommendations for specific horticultural systems, based on the practical experience of growers who have tested and compared different soil assessment methods in their fields. The recommendations reflect their feedback on each individual tool, as well as the feedback from a larger group of growers and consultants, who have followed the project and participated in field days and system specific workshops over the past two years.

The outcomes clearly show that simple and practical soil assessment tools can be highly useful to growers who:

1. Aim to evaluate the health of their soils themselves,
2. Wish to monitor changes in their soils over time (e.g. structure, fertility etc.), or
3. Aim to assess the effects of certain soil management strategies and activities that they perform.

The study confirmed that different horticultural systems need different soil assessment methods. They also showed that growers can benefit greatly from (continuously) trying out different and new approaches of soil assessment themselves, and over time develop, combine or adapt practical tools that suit their own specific system the best. The three documents of recommendation developed from this work are focused on top fruit, field veg and protected crops as examples of the main horticultural systems in the UK. The documents are also available for free download on the ORC and the AHDB GREATsoils websites, and their content is summarised in the following sections of this article. For more information on different practical soil assessment tools and links to where they are available, please refer to the AHDB Information Sheet 05 - Soil Assessment Methods.

Soil assessment tests evaluated and rated by growers

1 = low, 5 = high rated by growers	Skill required	Time input	Cost input	Suitable for	Not suitable for	Comments from growers	
Spade diagnosis (depth 30cm)	1	1	1	Easy, quick, good indication of soil health, first general impression of the soil status	Subsoil assessment, quantitative nutrient levels	Most common method used, very easy and informative: "spade is always with me"	
Plant health monitoring (current and previous crop, weeds)	1	1	1	Early signs of nutrient deficiencies or compaction	Specific or quantitative information	Seasonal, need some experience and additional tests for details	
Total soil organic matter (SOM) (usually in %)	1	1	1	Total SOM (labile, stable and inert fractions of SOM)	Monitoring labile SOM (providing/releasing energy and nutrients)	No need to do annually, need specific sampling technique	
Visual soil assessment tools (eg AHDB Healthy Grassland Soil methods)	1	2	1	Good overview of a wide range of soil health indicators (roots, worms, soil structure, colour)	Quantitative assessment of nutrients	Assessment speed comes with experience, easy to learn, need the tool only at first	
Standard lab test (macronutrients and pH)	1	2	2	Soil nutrient content P, K, Mg and pH	eg soil life, structure, compacted layers, root development	Regularly done, directly informs fertiliser strategy	
Visual evaluation of soil structure (eg SINJC VESS tool)	2	2	1	Soil structure and compaction detection	Quantitative assessment of nutrients	Some specific knowledge required	
Earthworm counts	2	3	1	Good indicator for soil structure and health, soil life and activity, soil biodiversity	Quantitative assessment of nutrients, subsoil assessment	Seasonal fluctuations, some skill required for species identification	
Micronutrient test	2	2	3	Trace elements/micronutrient levels in the soil	eg soil life, structure, evaluation of compacted layers	Done only if deficiencies suspected in plants	
Soil pit/profile (depth range 30–150cm)	3	3	1	Subsoil assessment, horizons and exact location/depth of compacted layers	No quick results, is a rather destructive method, location of sampling important	Very useful results if done properly, good for structure assessment	
Soil health test	3	2	3	Measures pH, available P, K, Mg, texture, total SOM and respiration rate	In-depth evaluation and meaningful results/conclusions	Skill required for interpretation of overall results, eg respiration rates	
SOM balance modelling tool	5	5	2	Input/output estimation of SOM levels on field or farm level	Beginners in SOM assessment. Basic day-to-day assessment	Not commonly used in UK yet, but might be a promising planning tool	
Soil life suites (eg food web tests, enzymatic activity, basal respiration etc.)	5	2	5	Bacteria and fungi, number, species and diversity (no standards yet)	eg soil structure, compaction evaluation	Skill required for adequate sampling and high skills for interpretation	

INFORMATION SHEET 04 Soil assessment methods

Figure 1: AHDB Information Sheet 05 - Soil Assessment Methods. Soil assessment tests evaluated and rated by growers

Method	Field vegetables	Top fruit systems	Protected crops
Visual Soil Assessment (VSA)			
Earthworm Counts			
Soil Health Laboratory Test			
Simple Infiltration Rates			
Simple Compaction Test			

Table 1: Growers of different horticultural systems rated the following methods according to how useful.

Visual Soil Assessment (VSA)

As there is no VSA tool specifically designed for horticulture available yet, the selected method for this study was the 'Healthy Grassland Tool' developed by Eblex/DairyCo. This tool consists of a two-page glossy soil scoring sheet, with colour pictures to compare the own sampled soil to, as well as a small pocketbook for further detail and information. It provides practical instructions as to how to sample a soil block with a spade and how to assess and compare it with the provided pictures and their scores.

The growers saw this tool as highly useful for more extensive horticultural systems such as top fruit systems. They stated that if the test is used regularly and on several locations in the field, it gives great insights into the general soil health in an orchard. They highlighted that it assesses soil structure, but also root development — pattern and vigour — as well as soil smell and colour; and provides the opportunity to count earthworms etc.; all providing a practical and quick way of getting an impression of the health of the soil and the cash crop. However, many growers in the field vegetable and protected crops sectors were more sceptical about its usefulness in very intensive horticulture systems. Especially when growing on beds (e.g. carrots or lettuce) or in highly intensive rotations for protected crops where the soil is worked very regularly and heavily, and soil structure assessment in the top 30cm is not possible or useful for most of the year. In such situations, timing of assessment is very important: e.g. in early spring, just before the field is ploughed and prepared for planting/sowing, when an assessment of structure is possible after the soil has had a short rest.

Earthworm counts

Earthworms are some of the more common and easily assessable soil organisms and are widely accepted as an indicator for soil fertility, health and organic matter. First, it is crucial to perform the counts in spring and/or autumn, when the worms are most active in the top layers of the soil. And secondly, when heavy tillage machinery and tools are used, earthworm populations can decrease very quickly. Ploughing, for example, will smear or close vertical worm tunnels and might cut some apart, but generally it might do less damage to earthworm populations and their habitat than for example rotating tillage machinery. The OPAL earthworm surveys guide used in this study offers a brief introduction to earthworms and explains its technique for sampling in a short and practical manner.

Many growers were very interested in earthworm counts, but none had any previous experience with this tool. After trying it out, field veg growers stated that the method can be very useful if a good base population of worms is already present in a field, and if an assessment 'routine' can be adopted for long-term monitoring. They also highlighted that expertise needs to be built up over time and the relatively substantial time investment needs to be taken into account. As for many soil assessment methods, earthworm counts are most useful when repeated regularly, maybe twice a year over a couple of years, to get used to the method and get a feel for the 'normal' number of worms and natural fluctuations of populations in the specific field or soil. Finding ten worms in a spade sample can be a lot in some soils, whereas in others it might be a very low result.

Simple infiltration rates

For this test we used a piece of 5cm diameter drain pipe, tightly fixed on the bare soil surface, then 100ml of water are added and the time is measured that it takes for the water to completely infiltrate into the soil. This is repeated at several locations throughout each field or plot. We found that for most soils this is a very efficient method, and growers were excited about this simple test and keen to try it out themselves.

This test was seen by the growers as a very useful tool for assessing soil structure and compaction as it is very easy to use and generates self-explanatory results that are easy to translate into soil management strategies. However, the method requires measuring the time it takes for 100ml of water to infiltrate into soil, and depending on the soil type, structure or moisture content, this can take rather a long time. So, while this tool was seen as highly useful and informative in lighter soils, and for a closer assessment of areas where compaction was previously suspected, in heavier soils it may take over 10 minutes per sample, which tends to stretch a grower's patience and therefore hampers the practical use of this tool in such conditions.

Dominic Amos taking soil samples at Valefresco

Simple compaction test

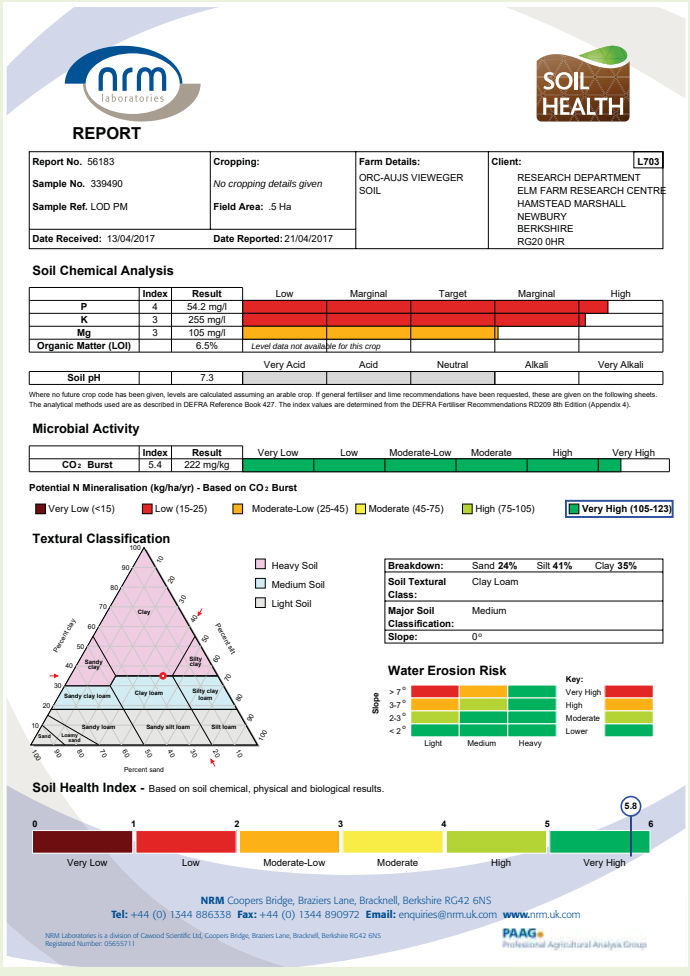
For this test, a blunt knife, soil probe or corer is pressed straight into the soil to get an impression of how much force or pressure is needed to get to a certain depth of the soil. This action is repeated in several locations across the field in an 'M' shape for example, or in different lines leading into a suspected compacted area of a field, or through tramlines into the bed etc., to get a feel for the differences.

This simple test also received very positive feedback from the growers. It was seen as a useful tool for assessing soil structure and compaction, although it is one of the most subjective of the methods compared by the growers. The level of resistance felt when pushing a blunt knife or soil corer into the ground is subject to personal interpretation and cannot be numerically 'measured'. Nevertheless, the growers can calibrate themselves by practising the method and testing it in different fields and soils etc. The test was seen as a very fast, cheap and easy to use method to locate areas of compaction in a field; and with some experience, even the depth of the compacted layer can be estimated.

Laboratory soil health tests, soil health index including respiration rates

These are relatively newly developed laboratory tests, often providing an overall soil health index or soil health score based on chemical soil health indicators (P, K, Mg, pH, total soil organic matter), physical indicators (texture) and biological indicators (respiration), with certain soil management recommendations derived from the results.

This test was included in the study as many growers were very keen on increasing soil organic matter in their soils and are looking for a method to monitor organic matter over time. Total soil organic matter is very difficult to increase in the short term, e.g. during 3-5 years expected changes often do not exceed 0.5%. Total soil organic matter is often analysed by loss on ignition (LOI) or other laboratory methods that measure all fractions of organic matter in the soil, from the highly fixed 'inert fraction' over the easier decomposable 'stable fraction' to the highly reactive and manageable 'active/labile fraction'. It is the latter that farmers and growers are most interested in, as they can potentially see effects of changes in soil management strategies relatively quickly. The active/labile fraction covers all soil biology (fungi, bacteria, etc.) and there are several lab tests currently available to measure this fraction (e.g. food web tests, enzymatic activity, microbial biomass C or basal respiration rates, etc.). These tests are often relatively expensive (e.g. up to £150-200 per sample for food web tests), and interpretation of their results, as well as correct sampling requires great skills and caution. Microbial communities in the soil often vary significantly during different seasons, weather conditions, moisture levels, temperatures and even times of day! So while these tests have great potential to provide useful information for soil management, it is crucial to be aware of the issues above when using them in practice. From a practical point of view, both microbial biomass and respiration rates could 'equally'



nrm laboratories

SOIL HEALTH

REPORT

Report No. 56183	**Cropping:**	**Farm Details:**	**Client:** L703
Sample No. 339490	*No cropping details given*	ORC-AUJS VIEWEGER SOIL	RESEARCH DEPARTMENT ELM FARM RESEARCH CENTRE HAMSTEAD MARSHALL NEWBURY BERKSHIRE RG20 0HR
Sample Ref. LOD PM	**Field Area:** .5 Ha		
Date Received: 13/04/2017	**Date Reported:** 21/04/2017		

Soil Chemical Analysis

	Index	Result	Low	Marginal	Target	Marginal	High
P	4	54.2 mg/l					
K	3	255 mg/l					
Mg	3	105 mg/l					
Organic Matter (LOI)		6.5%	*Level data not available for this crop*				

		Very Acid	Acid	Neutral	Alkali	Very Alkali
Soil pH	7.3					

Where no future crop code has been given, levels are calculated assuming an arable crop. If general fertiliser and lime recommendations have been requested, these are given on the following sheets. The analytical methods used are as described in DEFRA Reference Book 427. The index values are determined from the DEFRA Fertiliser Recommendations RD209 8th Edition (Appendix 4).

Microbial Activity

	Index	Result	Very Low	Low	Moderate-Low	Moderate	High	Very High
CO_2 Burst	5.4	222 mg/kg						

Potential N Mineralisation (kg/ha/yr) - Based on CO_2 Burst

Very Low (<15) | Low (15-25) | Moderate-Low (25-45) | Moderate (45-75) | High (75-105) | **Very High (105-123)**

Textural Classification

Heavy Soil
Medium Soil
Light Soil

Breakdown:	Sand **24%**	Silt **41%**	Clay **35%**
Soil Textural Class:	Clay Loam		
Major Soil Classification:	Medium		
Slope:	0°		

Water Erosion Risk

Soil Health Index - Based on soil chemical, physical and biological results.

NRM Coopers Bridge, Braziers Lane, Bracknell, Berkshire RG42 6NS
Tel: +44 (0) 1344 886338 Fax: +44 (0) 1344 890972 Email: enquiries@nrm.uk.com www.nrm.uk.com

NRM Laboratories is a division of Cawood Scientific Ltd, Coopers Bridge, Braziers Lane, Bracknell, Berkshire RG42 6NS
Registered Number: 05655711

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be used to assess labile soil organic matter fractions. As the NRM soil health test includes a measurement of respiration rates, amongst other highly relevant soil health parameters (P, K, Mg, pH, total %SOM, etc.), and for a relatively affordable price per sample (around £45), this test was chosen in our trials to evaluate its value for growers and to assess its potential to reliably inform soil management strategies to improve soil health and fertility.

Such laboratory tests were seen by the growers as potentially very useful in the future, once more information is available about soil biology indicators, and once useful testing procedures/protocols are developed for routine soil biology testing and monitoring over time. Particularly for intensive horticultural systems such as protected cropping systems it was seen as a very promising soil assessment method.

GREATsoils field labs

Green manures to increase nitrogen availability

This field lab, run in conjunction with Innovative Farmers (IF), aims to compare how different green manures affect the availability of nitrogen and key nutrients to a following spring green crop. A field trial has been set up in Lancashire with Chris Molyneux of Molyneux Kales who was keen to learn more about what different combinations of green manures could bring to his system in terms of nitrogen availability. Chris's motivation was wanting to save money by reducing his nitrogen bills but he has also seen improvements in drainage and the workability of the land. After discussions and planning with the farmer over trial design and set-up, the green manures were drilled in March and terminated in July 2017. A field lab open day took place in July prior to the termination of the green manure, with data on the green manure biomass and nitrogen content collected on the same day. Sampling has continued through the season with most of the results now available and shared with the group. An open day took place in March 2018, with results disseminated and discussions around whether to take the field lab forward with other growers in the area.

Improving soil health across a shared rotation

This field lab, also run with IF aims to improve soil health and organic matter in an arable/horticulture system where different businesses use/rent the same field at some point in their rotations. The collaborating growers and farmers assess the effects of each introducing more cover crops in their rotations on cash crop yield and quality as well as soil health and long-term sustainability. Growers often rent or share land that they may only use for one year of a rotation, meaning that any investments in soil health may not directly benefit them in the short term, especially if others in the rotation don't make similar efforts. Taking a longer-term view and working cooperatively should lead to benefits for all as well as helping to protect and enhance soil health.

The two arable farmers and the horticulture holding are each using a specific field, to conduct this experiment of bringing in more cover crops or adding organic matter to the soil. The cash crops on the three sites are potatoes (using PCN mustard ahead of the cash crop), sugar beet

(using a split field approach with radish cover crop, compost applications and chicken litter applications ahead of the cash crop), and lettuce (using oats as overwintering green manure ahead of the cash crop)

The group met for an update meeting in March 2017 to exchange first results and discussed their experiences during a field day on 17 July 2017 with a wide range of growers and farmers in the region. During autumn and harvest, the participants have collected data on yield and quality of their cash crops (e.g. sugar content of beets, skin finish of potatoes etc.) and these results are now being written up for a report, available soon on the Innovative Farmers website.

Amendments for soil health in fruit

Many growers are already using green waste compost or composted woodchip to add fertility and organic matter to their soils. However, there are also a range of products being promoted to boost the health and fertility of soils. Working out not only which of these will have a positive impact in specific farm systems and environments, but also which give the best value for money, is often difficult. To address this challenge, a group of growers has decided to undertake a field lab to carry out some practical comparison experiments of currently available soil amendments, with a focus on top-fruit systems.

Six growers have started to set up small field experiments to assess the effectiveness of different soil amendments, including enriched biochar, ramial (uncomposted) woodchip, composted woodchip, green waste compost and mycorrhizae inoculant. Each grower chose the amendments or combinations thereof according to their interest and suitability for the system. Individual monitoring programmes have been devised for each site to monitor the effects of the amendments and collect data on soil health and fertility parameters, as well as potential effects on tree/plat health, fruit quality and yield.

The group has just successfully applied for an IF research grant to support the trials and enable growers to carry out more in-depth on-farm monitoring of their trials to confirm the effects of the soil amendments; and fund the involvement of a researcher on each of the six sites to support them in this process, ensuring sound and reliable results.