The Organic Research Centre

Growing Resilient, Efficient And Thriving – GREATsoils

GREAT soils
Resilience, productivity and life

Funded by AHDB Horticulture, project CP107b

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Soil Association

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Earthcare TECHNICAL

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Aims of the project

The project will:

- evaluate soil assessment methods for growers
- improve growers' confidence in 'reading the signs'
- offer the opportunity to practise assessment methods with colleagues and advisors
- engage a wide range of levy payers, growers, advisors and other stakeholders
- Further develop/adapt methods for practical soil assessment to enable confident choice of management

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Evaluation of soil assessment methods

- **What is available out there? Literature study and critical review to evaluate existing methods** with growers.
- **What of it is actually useful? Determine the usefulness, efficiency and practical applicability** of the methods during several grower consultations
- **Comparing the most relevant approaches. On six case study sites/farms we organise field trials** to compare different methods and tools for soil assessment (2016/2017)

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Review of soil assessment methods

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Review of soil assessment methods

What is soil health?

- the '*capacity of the soil to support productivity and ecosystem services*' (Kibblewhite et al., 2008).
- the '*capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health*' (Doran and Zeiss, 2000).
- *the 'fitness of soil for use, based on the soil's inherent capabilities, the desired uses of the soil and the scale of assessment' (Larson and Pierce, 1991).*
- …

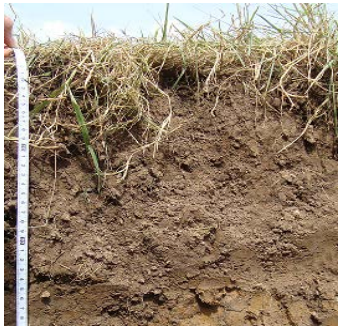
Review of soil assessment methods

Indicators of soil health

- **Biological** (SOM, number and diversity of micro-organisms, AMF diversity and root colonisation, Earthworms number and diversity, respiration rate, total DNA etc.)

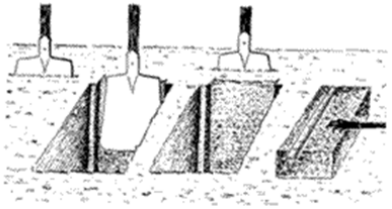
- **Chemical** (Nitrogen e.g. N_{min}, ammonia (NH_4), nitrate (NO_3), other macro nutrients (P, K, Mg etc.), micro nutrients (Fe, Cu, Mn, B etc.), pH level, cation exchange rate, electrical conductivity, salinity etc.)

- **Physical** (Texture, Structure, Compaction, Erosion etc.)



Review of soil assessment methods

Visual soil assessment



1. Spade diagnosis

This very easy and quick method consists of digging a cube soil sample of a spade's width and the topsoil's depth (around 25-30cm)

It assesses:

- aggregate structure (consistence, size, shape, porosity),
- compaction (plough pan, other management horizons),
- anaerobic signs (colour, smell),
- earthworm presence and tunnels,
- root development, amount, shape and distribution

This method assesses a broad spectrum of soil health indicators in the top layer, it is recommended 2 weeks before and 2 weeks after harvest, or before and after the main growing season.

Review of soil assessment methods

Visual soil assessment

2. Soil profile / soil pit

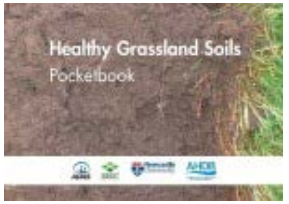
A soil profile or soil pit, is dug either by hand or digger, and reveals lower areas (sub-soil) and different horizons of the soil (up to 70-150cm).

It is possible with this method to examine the sub soil and locate potential compacted layers below the main cultivation depth of 0-30cm, and therefore particularly useful when problems are expected in the sub-soil, or to assess and monitor long-term effects of soil management.

This method is more labour consuming and challenging in very dry conditions or in highly compacted soils; it may require the support of an experienced advisor for the first couple of applications.

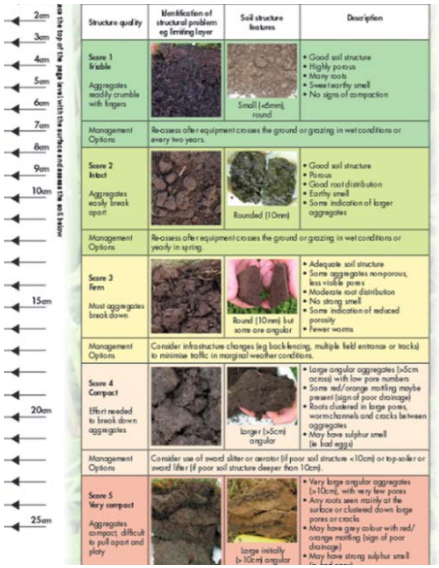
Review of soil assessment methods

Visual soil assessment



3. VSA tools, e.g. Eblex-DairyCo healthy grassland soils tool

There are currently various VSA tools and guides available, which are relatively similar and easy to use.



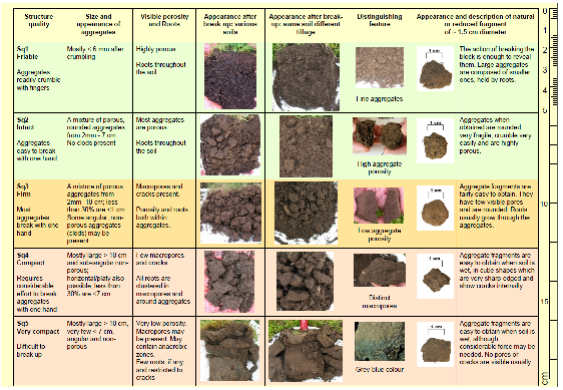
These methods allow a good, rough overview of physical and biological soil quality! If done regularly (e.g. twice a year) and with a bit of practice, this can be a very useful and efficient monitoring tool for soils in all soil-based agricultural systems.

Review of soil assessment methods

Visual soil assessment

4. VESS tools, e.g. Visual assessment of soil structure from SRUC

This method works with a similar principle, (the Eblex-DairyCo tool is based on this method), taking a soil sample with the spade and comparing/rating against colour photos and scales.



This VESS assesses soil structure quality, aggregate size and appearance, visible porosity and root development.

This approach is highly useful for a quick and easy soil structure assessment, particularly for practical long-term monitoring and evaluation in the field. However, as the name already states, this method does not take any biological soil health indicators into account.

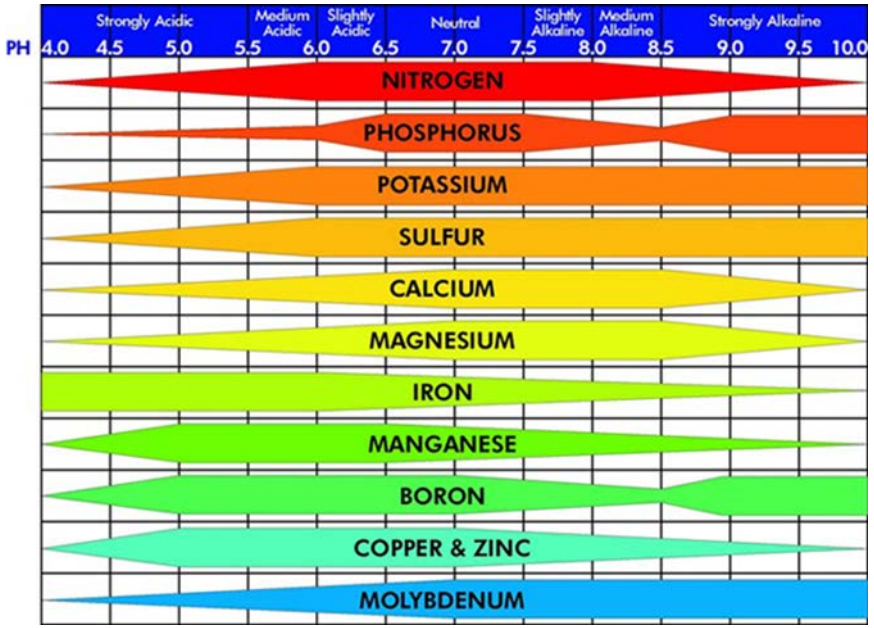
Review of soil assessment methods

Laboratory soil tests

1. Standard soil analysis

The standard soil analysis is offered by various laboratories and services, and usually measures:

- Acidity (pH) as an important aspect of soil fertility, influencing nutrient interactions and release, root development and microbial activity.
- Phosphorus (P)
- Potassium (K)
- Magnesium (Mg)



Laboratory soil tests

2. Soil Organic Matter (SOM)

This analysis is usually offered by laboratories providing standard soil analysis services, and is generally a useful indicator of total N and carbon reserves in the soil.

- **Labile SOM:** providing energy and nutrients for soil micro-organisms that release parts of the nutrients for plant usage.
- **Stable SOM:** less decomposable OM whose main function is its cation exchange capacity, often bound in organic-mineral aggregates.
- **Inert SOM:** least reactive OM fraction, composed of products of humification that are the most resistant to mineralization and affecting the physical properties of the soil.

Review of soil assessment methods

Laboratory soil tests

2. Soil Organic Matter (SOM) – labile SOM (LOM)

Examples of the main LOM indicators proposed by commercial soil laboratories:

- **Microbial Biomass C** represents the fraction of the soil responsible for energy and nutrient cycling (bacterial, fungal and protozoan) and the regulation of OM transformations.
- **Basal soil respiration** O_2 as a reactant or CO_2 as a product of the OM biological oxidation is measured to assess soil microbial activity. The evolution of CO_2 produced over time is called microbial respiration rate.
- **Enzymatic activity** is determined by measuring product formation or substrate remaining during incubation of soil samples. Different enzyme activity can be measured, the more active microbial biomass there is, the higher level of dehydrogenase is produced.

Review of soil assessment methods

Laboratory soil tests

3. NRM Soil Health Test

This is a new service offered by NRM, measuring

- pH,
- available P, K, Mg,
- soil texture,
- SOM and
- respiration rate

The result in from of an overall 'Soil Health Index', when regularly evaluated, may be useful for assessing the general health of the soil over time, but it is not yet clear how the respiration test will inform soil management to directly improve soil health and crop performance.

Laboratory soil tests

4. Soil Food Web Tests (e.g. Laverstoke)

This test measures the microbial biomass and diversity in soils:

- Total bacteria and total fungi
- Active bacteria and active fungi
- Protozoa (single-celled micro-organisms)
- Nemathods
- Mycorrhizal root colonisation
- Leaf organisms

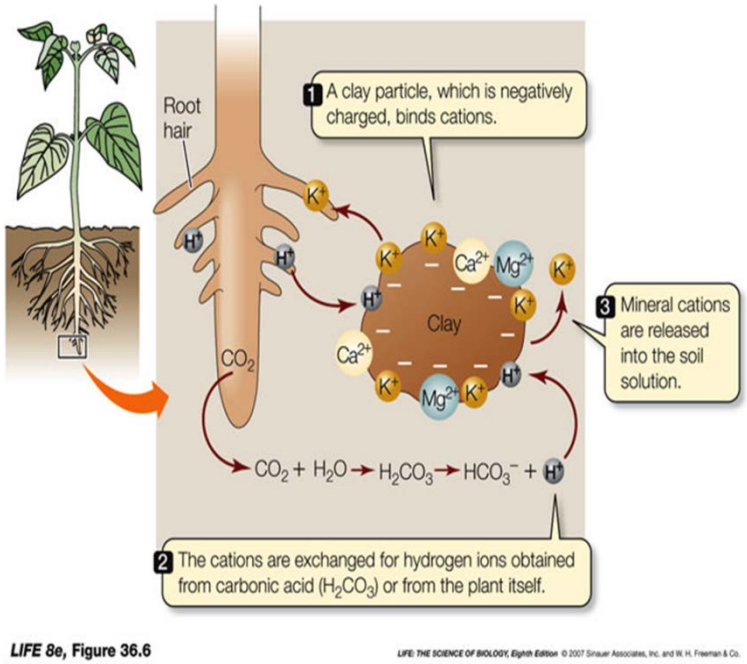
'The laboratory accesses a database with biological results of currently over 100,000 samples from all over the world to compare the clients' results to soils where the plant species are growing in native ecosystems. This information can be used by growers to determine the need for any organic amendment programmes required to correct microbial imbalance in their soils to improve the biological and overall fertility of the soil' [Laverstoke].

Review of soil assessment methods

Laboratory soil tests

5. Base Cation Exchange Capacity (e.g. Albrecht)

This is a service assesses the colloidal clay fraction, cation exchange capacity, and the optimum ratios of basic cations for balanced plant nutrition.



Optimum ratios of
Calcium to Magnesium (4:1 to 7.5:1)
Magnesium to Potassium (15:1 to 38:1)
are at the heart of the interpretation and recommendations of the analysis, which often include the purchase of significant quantities of soil amendments e.g. gypsum on heavier soils.

Modelling tools and other methods

- **Nutrient balance and budget:** the system inputs and outputs of each nutrient are calculated, which allows a modelling of potential nutrient surpluses or deficits. It can be applied across a wide range of different systems and scales, ranging from single fields to whole farm systems or regions, but can only represent an average across the evaluated area (variations in nutrient contents of manure, yield quantity and quality, actual levels of N-fixation, losses in nutrient cycles need to be considered!).

- **Humus balance** this calculation aims to estimate the input-output balance of humus and organic matter in horticulture and arable soils, producing recommendations for optimal fertilisation and soil management strategies.

Review of soil assessment methods

Modelling tools and other methods

- **Soil conditioning index** this planning tool can explain what changes to expect if a farmer decides to change practices to improve SOM. It may take several years to measure an increase in total soil organic matter, but related soil properties, such as aggregation, infiltration, and biological activity, are likely to improve more quickly. The results cannot be used to predict the amount of organic matter or the rate of change.

- **Solvita Test** uses respiration rates to assess soil biology and produces recommendations for soil management practices. The tool kit measures soil CO_2 respiration and reserve organic nitrogen, results are available within 24 hours.

- And many more!

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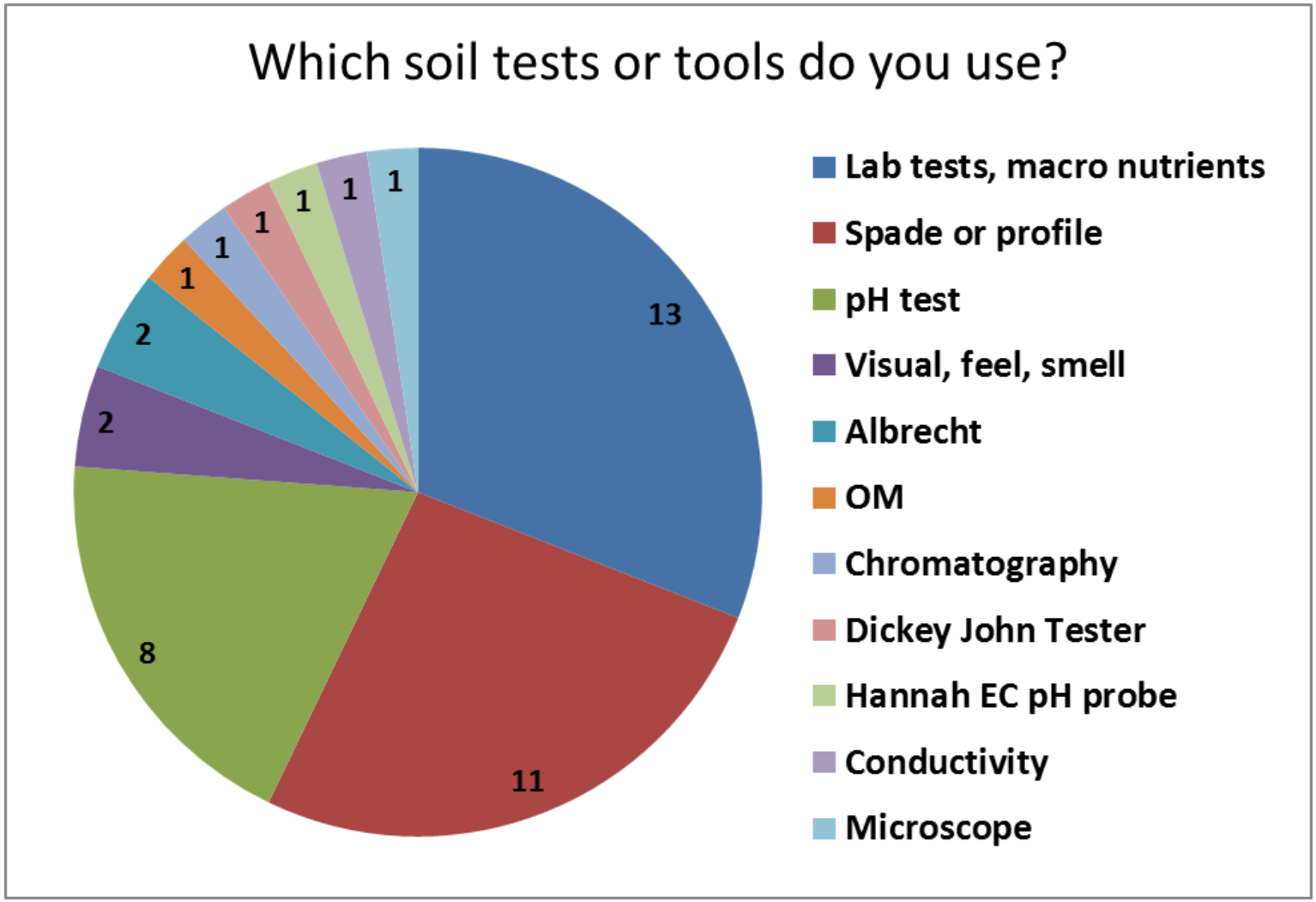
Pre-survey to grower consultations



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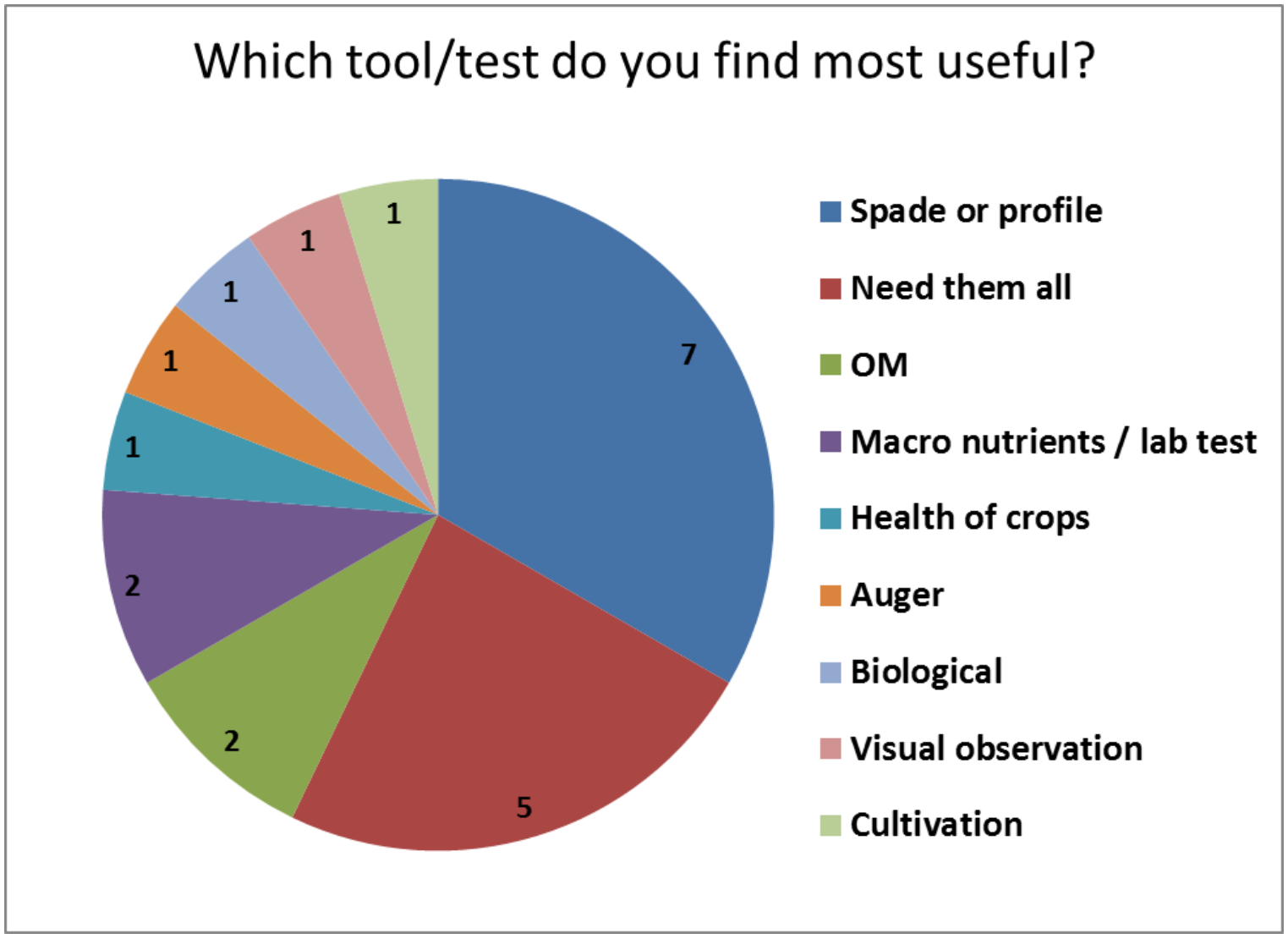
Pre-survey to grower consultations



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Grower consultations across the UK

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Visual soil assessment	Visual soil assessment	Visual	structure assessment by hand	digging a hole to look at compaction	trowel/ spade	spade	spade	soil sampling: spade + bochet, auger	how many seagulls behind the plough	look at soil once ploughed, different colours	ease of working the soil (not empirical)	earth-wor
plant growth, yields	crop growth, yields	previous crop	crop rotation	current crop yield and variation in growth	local knowledge to assess crop suitability	trying out variety of green manures	germ-ination	historic under-standing of field + past results	cultivation techniques	where livestock fits in rotation		
Nutrient analysis (+pH)	nutrient analysis and pH	regular nutrient analysis	NPK soil test	macro nutrient sampling	Albrecht samples	soil nutrient analysis Albrecht	pH	NRM soil health suite	con-ductivity scanning	GPS soil sampling on Quad Bike		
organic matter (total %)	organic matter (total %)	organic matter loss on ignition	organic matter tests	OM %	ability to hold/lose moisture and nutrients							
Microbial biomass, CO2/ respiration rate, PLFA	Microbial biomass	CO2/ respiration rate	PLFA	fungal/ bacterial balance	microbes							
Hand texturing	hand texturing	soil texture	hands									
Micro-nutrient analysis	micro nutrient sampling	micro nutrient sampling	measure-ment of trace elements									
Water-management, moisture probes	water	moisture probes	moisture probes									
soil cores (for sampling and subsoil assessment)	soil cores	soil corer										
pene-trometer	pene-trometer	pene-trometer										
cation exchange capacity	cation exchange capacity											
soil profile (digger, spade)	soil profile (digger, spade), 30cm <											

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Grower consultations across the UK

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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, fast general impression of the soil status	Subsoil assessment, quantitative nutrient levels	Most commonly used method, very easy and informative; 'spade is always with me'	
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	
Visual evaluation of soil structure (e.g. SRUC VESS tool)	2	2	1	Soil structure and compaction detection	Quantitative assessment of nutrients	Some specific knowledge required	
Visual soil assessment tools (e.g. Eblex-DairyCo. Tool)	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	
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	
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	

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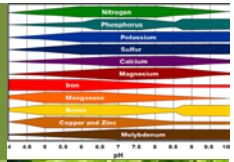
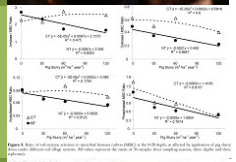
Grower consultations across the UK

1 = low; 5 = high rated by growers	Skill required	Time input	Cost input	Suitable for	Not suitable for	Comments from growers	
Standard Lab test (macro nutrients and pH)	1	2	2	Soil nutrient content P, K, Mg and pH	E.g. soil life, structure, compacted layers, root development	Regularly done, directly informs fertiliser strategy	
Micronutrient test	2	2	3	Trace elements/ micronutrient levels in the soil	E.g. soil life, structure, evaluation of compacted layers	Done only if deficiencies suspected in plants	
Total soil organic matter (SOM) (usually in %)	1	1	1	Total soil organic matter (labile, stable and inert fractions of SOM)	Monitoring labile SOM (providing/ releasing energy and nutrients)	No need to do annually, need specific sampling technique!	
Soil life suites (e.g. Food Web Tests, enzymatic activity, basal respiration etc.)	5	2	5	Bacteria and fungi, number, species and diversity (no standards yet!)	E.g. soil structure, compaction evaluation	Skill required for adequate sampling and high skills for interpretation!	
Soil Health Test (NRM)	3	2	3	Measures pH, avail. P, K, Mg, texture, total SOM and respiration rate	In-depth evaluation and meaningful results/conclusions	Skill required for interpretation of overall results, e.g. respiration rates!	
OM 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 promising planning tool	

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