GREATSOILS AHDB CP107b

Information for farm advisors

13th March 2018

GREATSOILS

Summary

* What is soil health and why is it important?
* AHDB GREAT soils project - aims and objectives
* Measuring soil health - our findings and publications
* Managing soil health – strategies to improve soil health
* Outputs from the GREAT soils project
* Future work linked to GREAT soils
* Conclusions

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).

Why is soil health important?

- Without it, soils will fail to deliver optimal crop yields
- As soil health declines, we will see increasing practical and environmental problems:
  - Decline in soil structure and reduction in percolation rates in wet weather.
    - Increasing susceptibility of soils to wind/water erosion;
    - Reduced resilience of soil to traffic and other stresses (especially when soils are wet);
    - Increased requirement for fuel and tractor power when cultivating;
  - Increased susceptibility of crops to pest and disease attack;
  - Reduction in potential yield, with the worst yields happening in poorer weather.

Soil health crisis?

- Clear evidence that soil health is declining in some cultivated UK soils.
- Problems worst in East coast arable and vegetable soils, especially in England to date, but in many Scottish soils too.

Why is soil health declining in some areas?

- Lack of organic matter returns to many soils (and reliance on synthetic fertilisers, which do not “feed” soil micro and macro-fauna).
- Linked to lack of livestock in many arable and vegetable cropping systems.
- Frequent mono-cropping (other than grass) is bad for soils (esp. Some species, e.g. maize)
- Requirement (e.g. by supermarkets) to harvest some crops (esp. roots) in winter when soil conditions are unsuitable.
- Wetter Summers?
- Heavier rainfall events and greater volumes of rainfall at some times of year.

Looking at the health of our soils

AHDB HORTICULTURE

GREATSOILS

Soil Association

THE ORGANIC RESEARCH CENTRE
ELM FARM

Earthcare TECHNICAL

A project which aims to enthuse and encourage farmers and their advisors to measure and manage soil health.

GREATSOILS

Project Funder and Project Partners

Funder:

AHDB horticulture

Leader:

Soil Association

Ben Raskin, Liz Bowles, Simone Osborn

Partners:

The Organic Research Centre

Anja Vieweger and Bruce Pearce

Earthcare Technical

Audrey Litterick and Martin Wood

Duration: 1 April 2015 – 31 March 2018

Aims of the project

The GREATSOILS project has:

- Evaluated soil assessment methods for growers
- Improved growers' confidence in 'reading the signs'
- Offered opportunity to practise assessment methods with colleagues and advisors
- Developed methods and approaches for practical soil analysis and evaluation to enable confident choice of management options.
- Engaged with, and disseminated information on soil assessment techniques to a wide range of levy payers, growers, advisors and other stakeholders.

Aims of the project

Benefits for growers:

- Improved health assessment of their soils;
- Ability to follow a more accurate and integrated strategy for soil management, specifically adapted to their own conditions;
- Better-informed decisions when aiming to optimise inputs, increase soil fertility and increase soil organic matter.

➢ Where growers are able to optimise and maintain soil organic matter levels, the benefits can be **financially and environmentally** significant. Improved soil health management can **increase yields** and potentially **reduce costs** as the land will become **more productive**.

Aims of the project

- **What is available out there?** **We critically reviewed and evaluated existing methods** and approaches for assessing, benchmarking and improving soil health.
- **What is actually useful in UK soils?** **We determined the usefulness, efficiency and practical applicability** of the methods and approaches during initial consultation and then in the project as a whole.

What has happened?

- **Literature review ✓**
- **Information leaflet on soil health assessment methods ✓**
- **Comparison of most relevant approaches.**
  - **Six UK sites/farms undertook field trials.** Comparisons of soil management and soil assessment tools were made in two project years (2016/2017 and 2017/2018).
  - **Four farms or groups of farms undertook Field Labs linked under the Innovative Farmers programme.** All compared strategies to improve health and used various means to assess the impact.

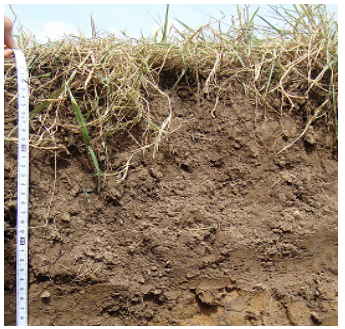
What has happened?

- **Grower workshops on soil health (throughout the UK)**
- **Twelve case studies and guidance notes on topics relevant to soil health, e.g.**
  - Compost for soil health
  - Engineering the landscape to secure asparagus production
- **Webinars on soil health, e.g.**
  - Short-term green manure strategies for intensive growers
  - Managing soil health using organic manures
- **Project team presence at key events (e.g. CPNB, key veg conferences) to publicise project outputs and get growers involved.**
- **Press articles (over 20 in key sector publications to date)**

Review of soil assessment methods

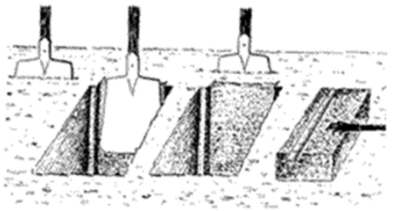
Indicators of soil health

- Physical (texture, structure, compaction, erosion etc.);
- Chemical (nitrogen e.g. Nmin, ammonia (NH4), nitrate (NO_3), other macro nutrients (P, K, Mg etc.), micro nutrients (Fe, Cu, Mn, B etc.), pH CEC, eC, salinity etc.);
- Biological (SOM, number and diversity of micro-organisms, AMF diversity and root colonisation, Earthworms [number and diversity], soil respiration rate, total DNA etc.).



Review of soil assessment methods

Physical - visual soil assessment



1. Spade diagnosis

Very easy and quick method. Dig a cube soil sample of a spade's width and the topsoil's depth (around 25-30cm)

It assesses:

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

Assesses a broad spectrum of soil health indicators in the top layer. Best done 2 weeks before and 2 weeks after harvest, or before and after main growing season.

Review of soil assessment methods

Physical - 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).

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

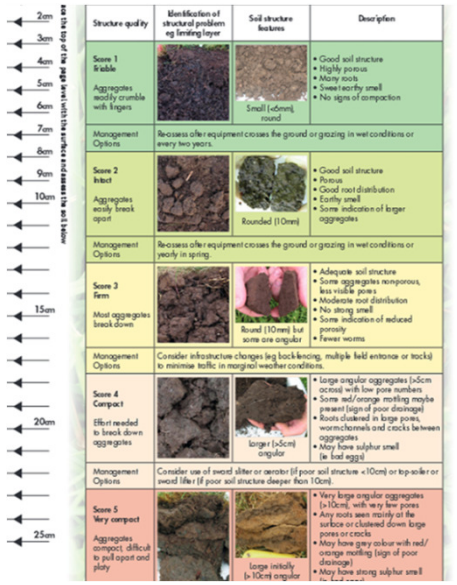
Method is more labour-intensive and challenging in very dry conditions or in highly compacted soils. May require the support of an experienced advisor, at least when first done.

Review of soil assessment methods

Physical - visual soil assessment

3. VSA tools - Eblex-DairyCo healthy grassland soils tool

Various VSA tools and guides available - fairly similar and easy to use.



Based on scoring of different soil health indicators; soil is sampled with a spade and then compared to photos or scales in the evaluation sheets. Scores of each indicator are summed up, indicating the 'range' or category of state of the soil.

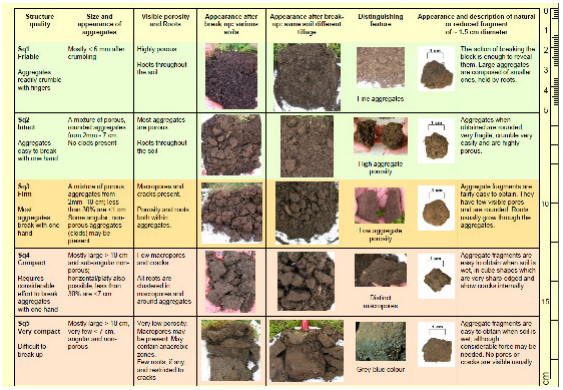
Methods allow a good, rough overview of physical and biological soil quality. If done regularly (e.g. twice a year), with a bit of practice, they can be a useful/efficient monitoring tool for soils in all soil-based agricultural systems.

Review of soil assessment methods

Physical - visual soil assessment

4. VESS tools - Visual assessment of soil structure from SRUC

Similar to EBLEX tool in that sample is taken with a spade and results compared and rated against colour photos and scales.



Assesses soil structure quality, aggregate size and appearance, visible porosity and root development.

An established and useful method for a quick and easy soil structure assessment, particularly for practical long-term monitoring and evaluation in the field. Does not take any biological soil health indicators into account.

Review of soil assessment methods

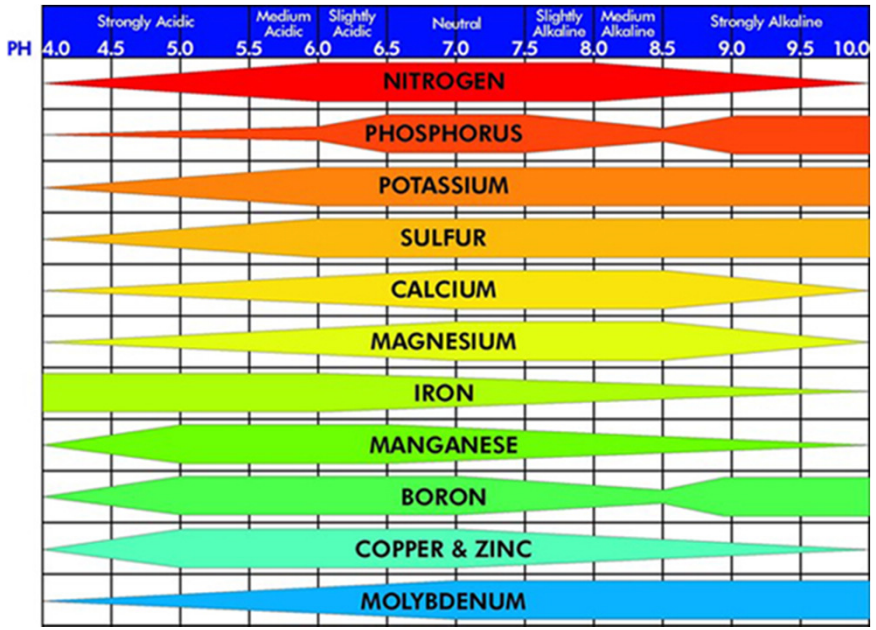
Chemical - laboratory soil tests

1. Standard soil analysis

Offered by various labs and services, and usually measures:

- soil pH as an important aspect of soil fertility, influencing nutrient interactions and release, root development and microbial activity.
- ext'able phosphorus (P)
- ext'able potassium (K)
- ext'able magnesium (Mg)

Well-proven, tested techniques which are known to work.



Review of soil assessment methods

Chemical - laboratory soil tests

2. Soil Organic Matter (SOM) by "loss-on-ignition" a blunt tool!
Tested through analysis at labs which offer standard soil analysis services. Useful indicator of total soil N and C reserves. Gives indication of how soils will behave under stress (such as dry or wet conditions, and during cultivation).

- **Labile SOM:** provides energy and nutrients for soil micro-organisms that release nutrients for plant use.
- **Stable SOM:** less decomposable OM, the main function of which is its CEC, often bound in organic-mineral aggregates.
- **Inert SOM:** least reactive OM fraction, composed of products of humification that are very resistant to mineralisation. It, along with the other forms of OM, affects soil physical properties.

Review of soil assessment methods

Chemical - 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 (a biological test)

Results are presented as 'Soil Health Index'. If regularly evaluated, this may be useful for assessing the general health of the soil over time? Not yet clear how results could inform soil management decisions to directly improve soil health and crop performance. Has not been fine-tuned to make it relevant to Scotland and Scottish soils.

Simpler method – the Solvita soil health test kit (a biological test)

Review of soil assessment methods

Chemical - laboratory soil tests

4. Laverstoke Soil Food Web Test

Test measures microbial biomass and diversity in soils:

- total bacteria and total fungi and active bacteria and active fungi
- protozoa (single-celled micro-organisms)
- nematodes
- mycorrhizal root colonisation
- leaf organisms

Lab accesses a database with results from >100,000 samples from all over the world. It compares clients' results to soils where the plant species are growing in native ecosystems. Lab claims that info. can be used to determine need for organic amendments to correct "soil microbial imbalances" and to improve soil biology and fertility.

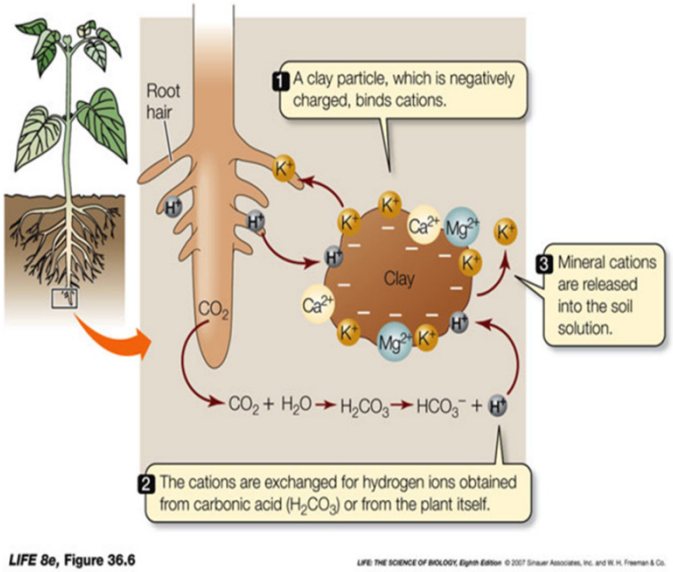
Proof of relevance to real horticultural production systems?

Review of soil assessment methods

Chemical - laboratory soil tests

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

Assesses the colloidal clay fraction, CEC and optimum ratios of basic of cations for balanced plant nutrition.



LIFE 8e, Figure 36.6

Optimum ratios of :

Ca to Mg (4:1 to 7.5:1)

Mg to K (15:1 to 38:1)

are at the heart of the interpretation and recommendations often include purchase of significant quantities of soil amendments e.g. gypsum on heavier soils.

Lack of evidence to prove its worth.....

Review of soil assessment methods

Earthworm counts (biological)

- Earthworm numbers are a good indicator of soil health. More worms = better soil health.
- Best to use an established method, such as OPAL, so that you can repeat the method exactly and compare your results to those of others.

The underpants test – a novel biological test

- Bury a new, clean, white pair of cotton underpants vertically in soil, with the waistband 1 cm below the soil surface. Leave them in there for a few weeks or months, then dig them up and have a look.
- Poor decomposition = poor soil health
- Good decomposition = good soil health

The underpants test – a novel biological test

- Maggie Sutherland's commercial organic veg business, Inverness
- Pants unrecognisable after 6 weeks burial!

Strategies to maintain and enhance soil health

- Organic amendments
- Green manures and cover crops (inter-cropping or partial or full year leys)
- No-till/min till
- Agreed rotational strategies (multiple land managers)
- Other?

Grower trials – who is doing what, where?

Trial number	1	2	3	4	5	6
Region	**Scotland**	**West-Midlands**	**East-Midlands**	**East-Midlands**	**South/South-East**	**South/South-East**
System	Carrot rotations (large-scale, conventional)	Protected baby leaf salads (lettuce/ oriental veg), large scale conventional)	Salad/lettuce crops, large scale conventional)	Salad/lettuce crops, (large scale organic)	Top fruit orchard (conventional)	Diverse field and protected veg, smaller scale, stockless (organic)
Host	David Aglen, Balbirnie Estates (R Balfour) growing for Kettle Produce). Fife, Scotland	Steve Nickells, Valefresco. West Midlands	Phillip Hubbert, Jepco, East-Midlands.	Joe Rolfe, Taylorgrown Ltd. (growing for Produce World). East-Midlands.	Paul and James Smith, Loddington Farm, Southeast England	Iain Tolhurst, Tolhurst Organics, Southeast England
Methods to evaluate	Impact of green compost on soil health. Focussed on **soil respiration, earthworm counts, soil structure assessments.**	Pros/cons of short-term cover crops. Focussed on **respiration rates,** and **soil health suite.**	Assessment of SOM Focussed on **respiration rates,** and **soil health suite.**	Assessment of SOM Focussed on **respiration rates** and **soil health suite.**	Assessment of SOM Focussed on **labile SOM fraction, food web tests** and **earthworm counts.**	Assessment of SOM Focussed on **labile SOM** and **food web tests.**

Field labs – who is doing what, where?

Field lab	1	2	3	4 In development
Region	**Northeast Scotland**	**East-Midlands**	**Southeast England**	**UK-wide**
System	Vegetable rotations (large-scale, conventional)	Arable/veg rotation (large-scale conventional)	Top fruit (large scale conventional)	Veg and salad rotations but also involving livestock as part of some rotations.
Host	Mid Coul Farms, Moray Coast	Jepco, Worth Farms and Loveden Estates	Seven organic and conventional top fruit farms in southeast England.	Three main grower groups (two in England, one in Scotland).
Methods to evaluate	Impact of whole digestate on soil health. Focussed on: **soil respiration, earthworm counts, soil structure assessments, soil nutrient status** and **soil organic matter content.**	Impact of cover crops on soil health and cash crop yield/ quality in land managed over a shared rotation. Focussed on: **various soil health measurements** and looking at **cost/benefit of different green manure/cover crop mixtures, crop quality and yield.**	Impact of soil amendments (biochar, compost, composted and uncomposted woodchip, biostimulants, digestate, mycorrhizae) on soil health. Focussed on: **soil structure, weed control, soil pH, water retention/drainage, tree establishment, fruit quality, yield** and **storage potential**.	Impact of several factors (green manures/cover crops, organic amendments, livestock, reduced tillage and rotation planning) on soil health. Focussed on: **measuring impact of on a range of soil health parameters.**

Balbirnie Estates Field trial

- **Aim:** To determine the impact of compost with and without chopped straw on soil health, crop growth and yield of spring barley grown as part of a field veg rotation)

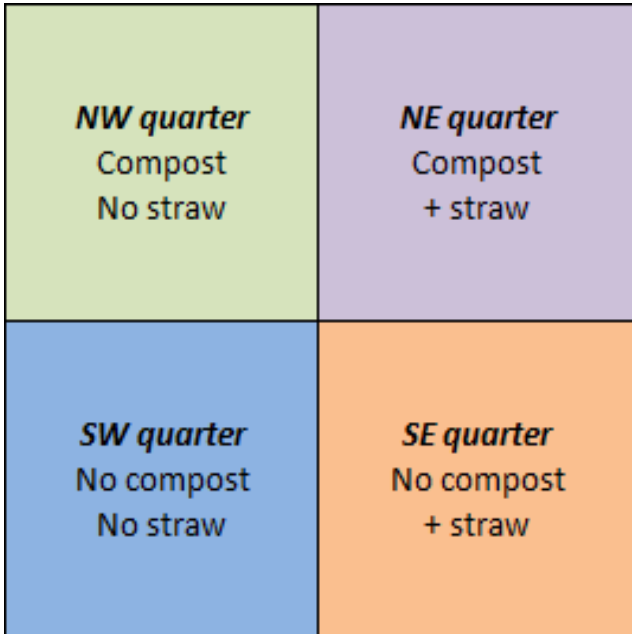
Balbirnie Estates Field trial

Balbirnie Estates Field trial

Treatments:

1. No compost, no straw
2. No compost + straw
3. Compost, no straw
4. Compost + straw

Compost (20 t/ha of green compost)
Straw (50 t/ha)
Paper crumble to all plots (5 t/ha)



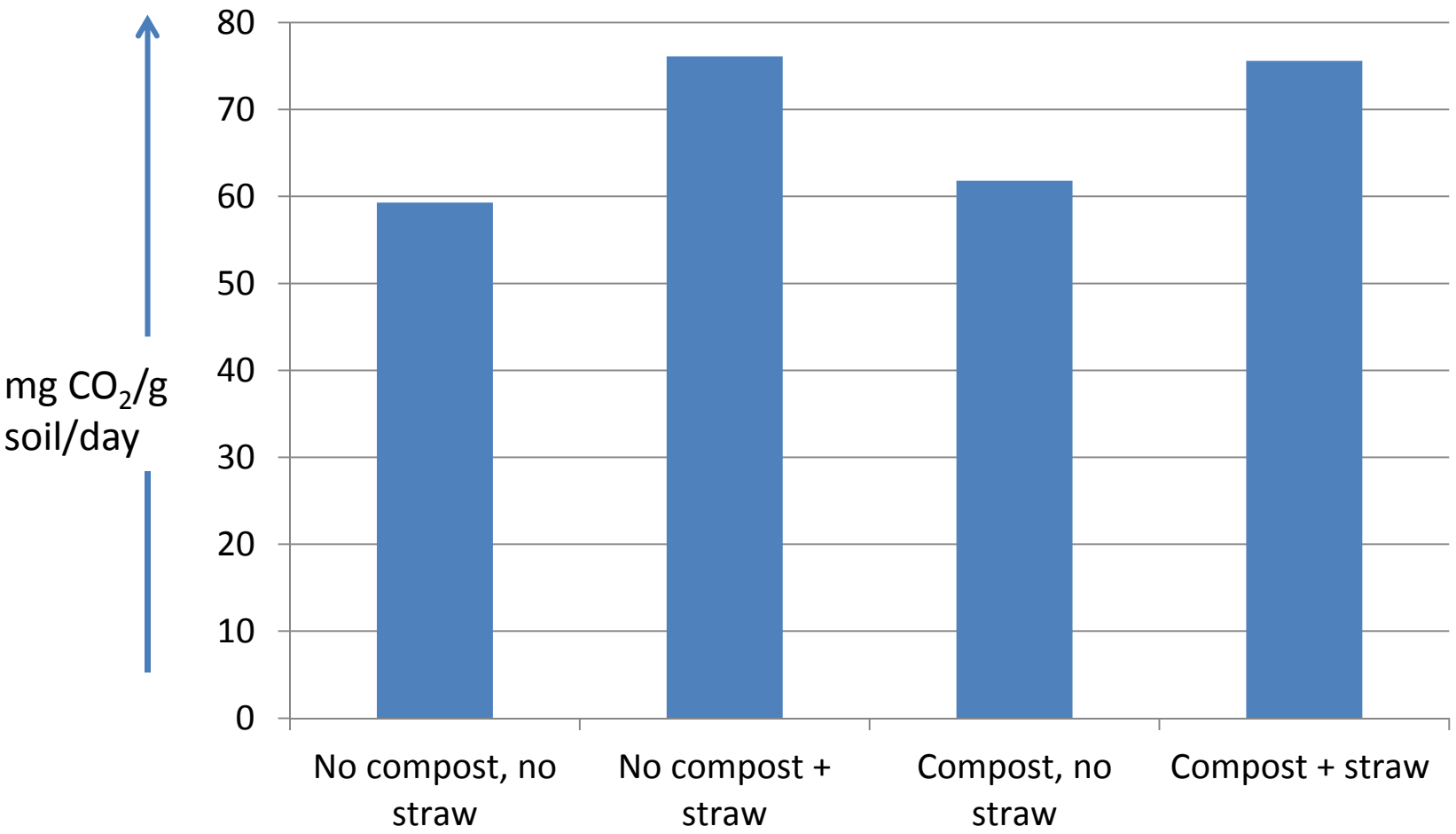
Field trial design

Balbirnie Estates Field trial

Assessments:

1. Routine analysis and SOM (pre carrots [2015] and post-barley [2017])
2. Visual crop assessment notes
3. Soil structure assessments
4. Soil compaction probe
5. Worm counts
6. Soil respiration (Solvita test with plate reader)

Soil respiration measurements



Balbirnie Estates Field trial – key conclusions

- Regular inspections of soil structure and use of compaction probe give quick, useful indications of the physical aspects of soil health.
- Need for new, perhaps simpler system to assess the health of soils which are subject to frequent, intensive cultivations.
- Use of compost and straw can add a large amount of organic matter (2 – 24 t/ha of C depending on treatment) plus a lot of P, K, Mg and trace elements. Keep track of nutrient additions.

Balbirnie Estates Field trial – key conclusions

- Soil respiration increased greatly after addition of straw at 50 t/ha), but then dropped to baseline within 6 months. What does that mean?....

- Earthworm counts are a useful indicator of soil biology, but to count them properly is time consuming – is it worth it???

- Soil respiration measurements are a relatively new method for estimating the biological life in soil. Further data must be gathered on different soil types, growing systems and using different methods in order to learn how to interpret the data gained and take actions based upon it.

Moray coast veg growers Field Lab

Aim: To determine whether the application of whole digestate made from farm-produced energy crops has an impact on the health of soils in Moray coast vegetable rotations.

Moray Coast veg growers “Field Lab”

The trial:

- Grower applied digestate at 20 m^2/ha in Autumn 2016 and in Spring, Summer and Autumn 2017 to two fields
- Control strips (no digestate applied) were left in each field for comparison.
- Treated and untreated areas of soils in the fields were assessed and sampled prior to the first digestate application and after each further digestate application. Final assessments made in Autumn 2017.

Assessment methods

- **Routine analysis (Soil pH, extractable P, K, Mg)**
- **Soil structural evaluations**
- **Earthworm counts**
- **Soil respiration**
- **Quadrat weed counts in treated areas**
- **Germination tests (weeds germinating in samples of known volume of digestate spread onto sand or growing media)**
- **Crop growth and quality assessments**

Moray Coast Field Lab

Findings

- Ensure soil is at target pH of 6.5 and that soil P and K status are at target (of “High”) and Mg status is at target (of “Moderate” in the autumn prior to sowing a high value crop.

- Ensure that Crop N supply from digestate is correctly accounted for.

- A single digestate application of 15 m^3/ha ***could*** provide approximately 19% of the N required, 10% of the P required and 58% of the K required whilst the soil is below target for P and K.

- Additional digestate applications AND bagged fertilisers will be required annually in order to supply sufficient nutrients for maximum yield of a single crop of rye.

Findings

- Regular inspections of soil structure, through frequent test digs and allocation of structure scores (e.g. VESS) give quick, useful indications of the physical aspects of soil health.

- There is a need for a new, perhaps simpler system to assess the health of soils which are subject to frequent, intensive cultivations.

- Where soil structure has been degraded by regular, intensive cultivations, it becomes more important than ever to try to cultivate and harvest when soil conditions are suitable (i.e. relatively dry), since weakly structured soils can be badly damaged if worked in wet conditions.

- Had similar question marks in our minds about the value of earthworm counts and soil respiration measurements . They are useful indicators of soil biology, but how can we clearly relate the results to decisions on management options?

Findings

- No evidence from this short trial that digestate applied at 15 m^3/ha on several occasions had any deleterious effects on:
  - soil structure
  - microbial respiration
  - soil earthworm populations
  - weed growth in the sward
  - growth or health of hybrid rye

- Neither did the digestate have any beneficial effects on these parameters.

- It would be a good idea to repeat the tests every 2 years annually for a period of at least 10 years in order to further study the impact of digestate on soil properties, since it is well known that soil properties can take a very long time to change in a significant way.

What have we learnt?

- Regular basic chemical analysis essential. pH and extractable P, K, Mg – basic soil health information which affects crop yield and quality.
- Spend the time sampling properly – the results are only as useful as the quality of the sample itself.
- Choose your method (and ideally your soils laboratory too) and stick to them. You want variation in results to be real, and not due to differences in methods or labs used.

What have we learnt?

- Soil physical assessments very useful, whether documented or not.
  - Look at what's possible in surrounding uncultivated land
  - Use a compaction probe? Aim to achieve minimal compaction in field soils. If you are regularly struggling to get the probe in, at times during the year, or at particular points in the rotation, start asking why and consider management changes.
  - Conduct regular test digs. Look for evidence of good soil colours, healthy soil smells, good rooting, visible pore spaces and good structure VERSUS mottling, anaerobic smells, compaction, limited rooting, deformed or horizontal roots, platyness and drainage problems.
  - Learn how to quickly assess whether soils are functioning as well as they could, given the crop, system and weather
  - Question why soils are in the condition that they are.....

What have we learnt?

- Biological assessments – the jury is still out..
- Earthworm counts are very time consuming.
  - Interpret results with care (e.g. soil moisture affects results).
  - To be most effective, at least four pits per field should be dug in fields of interest every spring and autumn throughout the rotation, ideally six to eight pits.
  - Records should be kept to build up pictures of what is “normal” for particular fields in a particular rotation. Can then assess the impact of management changes and compare to earlier results.
- Soil respiration measurements
  - Useful blunt instrument to measure soil health, but we cannot yet interpret the results in terms of being able to recommend management options.
  - Useful to test pre, during and post-crop in order to build a picture of what is normal for particular fields.
- Soil foodweb – this really is the future – not easy to interpret

GREATSOILS

Project outputs

- Literature review
- Initial guidance note on soil health assessment methods
- Reports from Field Labs and Field trials
- Grower workshops to disseminate project findings
- Advisor/agronomist training events
- Case studies
- Guidance documents
- Project annual and final reports

GREATSOILS

To find out more, visit:

https://www.soilassociation.org/greatsoils/

www.ahdb.org.uk/greatsoils.

AHDB HORTICULTURE

Soil Association

THE ORGANIC RESEARCH CENTRE ELM FARM

Earthcare TECHNICAL