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Project leader:	Ben Raskin, Soil Association
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The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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GROWER SUMMARY

Headline

The project has brought together growers from a broad range of sectors to trial and share soil health assessment methods. Observations from field trials, wide mainstream and social media coverage, and peer to peer learning indicate that soils assessment and management information dissemination is being taken on board by growers, which may lead to improved soils and financial gain in the long term.

Background

The importance of improving the health of soils is increasingly recognised by goverments and policy makers as fundamental to the agronomic and financial sustainability of horticultural enterprises. It is widely acknowledged by scientists and an increasing number of farmers and growers that there is a problem with the state of UK soils. Most suffer from degradation (e.g. compaction, declining soil organic matter content, nutrient leaching, erosion), partly as a result of current farming practices. Many growers understand the importance of soil health but do not keep up to date with the research and latest best practice.

Project CP107b seeks to work with growers to improve the health of soils by assessing and field testing current methods of soil testing. The project aims to inspire and empower growers to improve their soil through training events, building connections, and by translating these methods, tools and approaches into clear practical information.

Summary

The first year of field trials is now complete; full details of work done can be found in the 1st annual project report. The project has also continued to deliver a full programme of knowledge exchange events during its second year.

In the field trials, which look at the efficacy of different soil health assessment methods and tools on six regionally and system diverse horticultural sites, early findings demonstrate that the set of soil assessment tools need to be refined for the specific needs of each growing system.

For example:

- The Visual Soil Assessment (VSA) tool is proving less relevant for the intensive field horticultural systems, though this might be addressed by changing the timing of the testing.
- For earthworm counts 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. It is 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/soil. Soil management also needs to be taken into account in the interpretation of results, as heavy tillage machinery can decrease populations very quickly.

The Year 2 programme of knowledge exchange has delivered 19 free grower events made up of workshops, online webinars, field trial demonstration days, and field lab meetings, attracting in total over 275 attendees. Details are provided in the appendix section of the full report. In some cases people have attended more than one event so overall attendance numbers are around 350. Recordings of the online webinars have been viewed nearly 1000 times. These activities are demonstrating that there is real interest from growers in understanding and measuring soil health. The events have particularly shown the value of peer-to-peer learning, as growers demonstrate and discuss their growing systems and the challenges that they face.

Sample attendee feedback includes:

"We need to consider how we are managing our soils if we want to be able to farm for the next few hundreds of years in the line"

"Think about soils in terms of biological activity rather than chemical and physical properties"

"Very interesting and easy understanding of how important your soil is."

"I found it very informative and useful" "Good balance of theory and practical."

Work Package 1 - Review

A literature review was completed in Year 1. It is available on the AHDB Horticulture website.

Work Package 2 - Developing an integrated approach to soil health assessment and improvement.

The project team is working with six host farms on two-year field trials to compare the usefulness of a number of different soil assessment methods and tools.

The focus of the tests chosen for the field trials is to monitor soil organic matter. Grower consultation events held in 2015 showed that this is what the vast majority of growers were most interested in exploring. The focus for each site is as follows:

- Balbirnie Estates (Scotland) (growing for Kettle Produce) - Studying the impact of conventional carrot production in beds on soil health parameters including routine soil nutrient testing (pH, P, K, Mg), SOM, VESS and soil respiration.

- Valefresco (West-Midlands) Monitoring the effect of cover crops on soil health, fertility and structure in a large scale conventional protected and field veg production system. Comparing respiration rates (NRM soil health test), earthworm counts and VSA.
- Jepco (Lincs) Using short-term green manures to assess and monitor soil health in a large scale conventional field veg production system. Comparing respiration rates (NRM soil health test), earthworm counts, VSA and their result interpretation.
- Taylorgrown (Lincs) Assessing the effect of green manure strips through a carrot field on beds on soil health and crop health. Comparing respiration rates (NRM soil health test), earthworm counts, VSA and their result interpretation.
- Loddington Farm (Kent) Using two different flowering green manures to increase soil health in an apple orchard, and attracting beneficial insects as pollinators and predators. Comparing respiration rates (NRM soil health test), earthworm counts and VSA.
- Tolhurst Organic C.I.C. (Oxon) Organic matter assessment and monitoring (for a long-term increase), in a stock-free, small scale organic veg system without animal inputs: Comparing respiration rates (NRM soil health test), earthworm counts and VSA.

A demonstration field day was held in each of the six locations during the year. The events were public and open to all growers, advisors and other interested parties and intended to provide broader access to the learnings of the project. The events were well attended with participants ranging between 12 and 20 (Figure 1).

Figure 1. Field trial open days

The methods used to assess soils in the first year of the field trials were:

- **Earthworm counts** the OPAL earthworm survey's guide to earthworm assessment. Monitoring numbers and species of earthworms over time and throughout growing seasons can deliver good information about soil organic matter. The OPAL guide is

publically available and free to download here: https://www.opalexplorenature.org/soilsurvey

- **Visual Soil Assessment (VSA)** using the Healthy Grassland Assessment Tool developed by EBLEX-DairyCo (now AHDB Beef & Lamb and AHDB Dairy). This tool consists of a 2-page glossy soil scoring sheet, with colour pictures to compare the own sampled soil with, as well as a small pocketbook for some further detail and information. It provides practical instruction to sample a soil block with a spade and how to assess and compare it with the provided pictures and their scores.
- **NRM Soil Health Test** This is a laboratory test which provides an overall soil health index/score based on chemical soil health indicators (P, K, Mg, pH, total soil organic matter), a physical indicator (texture) and a biological indicator (respiration rate), with certain soil management recommendations derived from the results.

Earthworms were counted on each of the six trial sites during spring and autumn 2016. At Tolhurst's for example, 9 worms were counted in total in May, all juvenile and rather small. However, at the sampling date in autumn, 191 worms were found; again taken from 3 locations in each bed of the green manure trial. The full results are shown in the full report. On this site, we were able to perform a species identification of the adult worms that were found in the field. The species identified are common and expected to be present in such systems. It is notable however, that the total number of worms found in early sown green manure was larger in each bed compared to the later sown green manure beds. Overall, when summing up the numbers per treatment, the difference between the two treatments was still very clear.

Also the VSA/VESS test was performed in each of the six trial sites. Here however, it was clear that this tool, specifically developed for soil assessment in grasslands, has it's challenges when applying it in intensive horticultural systems. In many field veg production systems beds are formed and the soil is managed regularly and often with a significant impact on soil structure, e.g. at Taylorgrown or JEPCO. For such systems, this tool is only (if at all in the current stage) useful if applied in early spring for example, when the soil has had a certain amount of time to settle down and structure assessment is possible. In more extensive horticultural systems, such as the top fruit orchards at Loddington however, our trials have shown that this easy and quick soil assessment tool can deliver highly relevant information on changes in soil structure and the direct impact of different management strategies.

Since this is only the first year of the trials, there is not yet enough data to draw meaningful conclusions (the data from year one is provided in the full report). The team has however

determined from the data collected, that the chosen set of tools needs to be refined for the specific needs of each growing system.

The team is also discussing the possibility of adding some tests which could better serve the needs of a system – for example an infiltration rate test or soil compaction assessment.

For year 2 of the trials, each site will make slight adaptations to their set of methods, such as adding simple infiltration rate measurements using a drain pipe and stop watch, or changing timing of particular soil assessments, as the VSA method (developed for grasslands) is not useful in most seasons for intensievely worked soil, such as horticultural crops on beds etc.

Work Package 3 - Development of KE strategy and materials.

The KE strategy developed in Year 1 is being delivered. A synopsis on the delivery of events and media coverage appears below under Work Package 4 and in more detail in the Knowledge Transfer and Technology section below and Appendices 1-4.

The first Case Studies (CS) and Guidance Notes (GN) for the project have been delivered and are awaiting publication. They cover a variety of topics including:

- CS1 Compost for soil health
- CS2 Soil testing for carrot production
- CS3 Engineering the landscape to secure asparagus production
- GN1 Avoiding the pitfalls of Soil pH testing to maximize your soil health

Work Package 4 - UK wide KE programme

Attendees to Year 2 events break down as follows:

167 attendees at 10 Soil Health and Farm Viability workshops around the country

110 attendees at 4 online webinars, these have been viewed 995 times since then

64 attendees at 4 field trial demonstrations

26 attendees at 3 field lab meetings

Interactive one day workshops: Throughout this year the project delivered ten of a programme of 24 interactive workshops for growers. (Figure 2) The subject of the workshops has been Soil Health and Farm Viability. Workshops have included a variety of topics including introduction to soil health, the use of compost to increase fertility and soil structure, managing runoff and erosion in row crops, maintaining soil fertility and structure in a high rainfall area, using green manures for soil health, and avoiding soil compaction They have been delivered at farm hosts across the country taking in different sectors including field veg, soft fruit, ornamentals, and protected growing.

Figure 2: GREATsoils workshop in Cornwall

Online webinars: The team delivered a series of four online webinars on soil health.

- Soil Health and the Bottom Line
- Soil health and what to measure
- Managing soil health using organic manures
- Short term green manure strategies for intensive growers

Attendance was higher than hoped for with most participants staying for the duration of the event. The benefit of the webinars is that growers can access the information and ask questions without giving up a day of their time. In addition the recordings of these sessions are now available as a resource on the AHDB Horticulture website and are being accessed regularly.

Field Labs: The first GREATsoils field labs commenced towards the end of the year and will run through Year 3 of the project. The field labs are year-long grower led practical farm trials. The results of these trials will add to the knowledge base of the project as they demonstrate real world examples of growers trialling methods to improve soil health.

These are five new field labs specifically for the GREATsoils programme being run in collaboration with the Innovative Farmers programme https://www.innovativefarmers.org/. The methodology and achievements from each are being documented on the Innovative Farmers portal as the project develops. This data can be accessed for free.

The first three field labs are:

1. **Improving Soil Health And Organic Matter Using Cover Crops In A Shared Rotation**
2. **Amendments For Soil Health In Top Fruit**
3. **The Impact Of Whole Digestate On Soil Health In Field-Grown Vegetable Crops On The Moray Coast**

Video: The first video from the project has been designed to replicate the successful peer-to-peer learning of the workshops by featuring a particular grower sharing his story. The video promotes the benefits of cover crops which have been an important area of interest for the field trials and the workshops. It has so far been viewed 174 times. It can be viewed here: https://www.youtube.com/watch?v=cMdP2Igv5mU.

Media campaign and other outreach: Interest in the project from trade media has been strong, indicating that awareness of the importance of soil health in horticulture is growing. In this year of the project GREATsoils CP107b has been featured in 14 major articles across a range of industry publications. The team has also published 5 original blog posts by growers involved in the trials.

The project team have met growers and advisors at 15 conferences and sector events as part of the Soils Roadshow during Year 2. Team members have taken part in events as speakers, run stalls, and given demonstrations. At the Elsoms Seed day and the British Herbs field events the project team teamed up with GREATsoils projects CP107c and CP 107d projects to provide a cross programme focus.

The project has been building up a network of growers via sign-ups at events, website, newsletters, and twitter. By the end of Year 2 the network had 460 members and 933 followers on Twitter. To keep the network informed the team has published an email GREATsoils bulletin. This has included information on this project and also events from the other AHDB soils projects.

Financial Benefits

Evidence of financial savings from improved soils is still anecdotal. Growers have reported financial benefits from using green manures in relation to cultivation costs and nitrogen use. The results of the field trials may add some practical evidence to support this; however more testing and benchmarking would need to be carried out in order to build a more robust case for this.

Action Points

More detailed recommendations will form part of the final year report for the project however interim results from the field trials as well as feedback from the peer to peer learning have shown that:

- If not already doing so growers should start testing their soil for health. Those that are already doing some testing can always improve or expand their testing. The summary from year 1 will help growers make a decision about which methods to use. Additional findings

have emerged for instance ensuring optimal timing of earthworm counts and VSA within specific production systems – full details are given in the full report.

- Building organic matter - This is well-recognised as one of the best indicators of soil health, but changes take place slowly and implementing is tricky within intensive vegetable/salad production systems.
- Grow a green manure as part of the horticultural rotation. Trials work indicates that even a very short term green manure can make a difference to soil structure and health. Choice of cover crop and timing of sowing may also have a significant impact.
- Join or set up a group of local, like-minded growers to work together. This will help benchmark findings as growers develop their soil health testing methods, but also provides a framework and discipline for testing and sharing findings with fellow growers.

SCIENCE SECTION

Introduction

In work package 2, six demonstration field trials were set up during early 2016 to compare a number of potentially useful soil assessment methods and tools for horticultural systems. The six sites were identified during the grower consultation events in the first project year (2015/2016 – details are provided in the first project annual report), and were chosen by the regional grower groups to represent relevant growing systems for the different UK regions. As reported in March 2016, the highest priority in all of the regional groups was the reliable and useful assessment and monitoring of soil organic matter and soil biology. The six demonstration trials are running for two growing seasons, between spring 2016 and autumn 2017; in this management report we present the outcomes of the first growing season.

Materials and methods

The six host farms for the demonstration trials were chosen by the members of the regional grower groups during the consultation events in autumn 2015. The sites cover a range of horticultural sectors and systems: including field veg (leafy salads, carrots or brassicas), soil based protected cropping (spinach and rocket) and top fruit orchards (apples); and they range across major British growing regions from Scotland, East and West Midlands down to Kent.

As the regional groups have identified that their primary focus of interest lies on soil organic matter and soil biology, they were asked to choose a number of system-specific soil assessment methods and tools from which they expect the most useful results with regards to this focus. The different methods were to be practically tested and compared in the same field of the host farm over two years. The selection was made by the host growers with help of the project team, and informed by the literature review performed in work package 1. The choice was deliberately left primarily with the growers, to ensure practicability and usefulness of the results for the different horticultural systems. Only one of the growers had previous experience with some of the identified methods. The final list of selected methods to be compared in the fields was however surprisingly similar across the various systems, showing that overall the general approaches of those methods are seen as promising and worth trying out.

Each of the six growers selected a field and a crop/s in their rotation in which they wanted to conduct the comparison of soil assessment methods over the two years. To maximise outcomes for the growers and potentially increase the ability for comparison of methods, each host has identified a small experiment as framework for this method comparison. Reflecting their strong interest in increasing soil organic matter and their ability to measure and monitor

it, all host growers have adopted a basic farmer experiment design, and several have included green manures in their system and rotation. In most systems, the aim of the green manure application was to increase and improve soil organic matter and soil biology; in some cases, a flowering green manure mixture was chosen to also attract and support beneficial insects, pollinators and natural predators (e.g. in the apple orchard or carrot fields).
A demonstration field day was held on each of the six locations. The events were public and open for all growers, advisors and other interested individuals in the region. They aimed to introduce the project and the specific trial, as well as the compared methods with a background from the literature review and first results of soil assessment.

The six sites and their chosen trial set-up are introduced and described individually in the following section, stating the soil assessment methods used in each trial.

Field demonstration sites

Site 1

System: Conventional field veg, Scotland

Host and location: David Aglen, Balbirnie Estates, Scotland (growing for Kettle Produce)

Details of experiment: Investigate the impact of crop residues and compost application on soil health (same parameters to be used as in baseline testing) after a **carrot** crop and prior to the following crop (Figure 3).

Methods to compare: Earthworm counts, VSA/VESS and NRM soil health test.

Assessment dates: March 2016 and November 2016 (before and after investigated cropping period).

Field day in 2016: 7 July 2016

Figure 3: Soil assessment at Balbirnie Estates

Site 2

System: Conventional protected cropping in soil, West-Midlands

Host and location: Nick Mauro and Steve Nickells, Valefresco, Hampton Lucy, Stratford Upon Avon, CV35 8BQ

Details of experiment: Monitor two intensive rotations: (1) protected cropping with **spinach and rocket**, and (2) intensive **field lettuce** rotation. Investigate the effect of the short-term green manures, phacelia and buckwheat in protected cropping; and assess and monitor benefits of overwintering rye and vetch mixture in field lettuce rotation (Figures 4 - 7).

Methods to compare: Earthworm counts and VSA in the field, NRM soil health test in protected cropping

Assessment dates: 28 April 2016 and 11 October 2016 (before and after investigated cropping period).

Field day in 2016: 2 December 2016

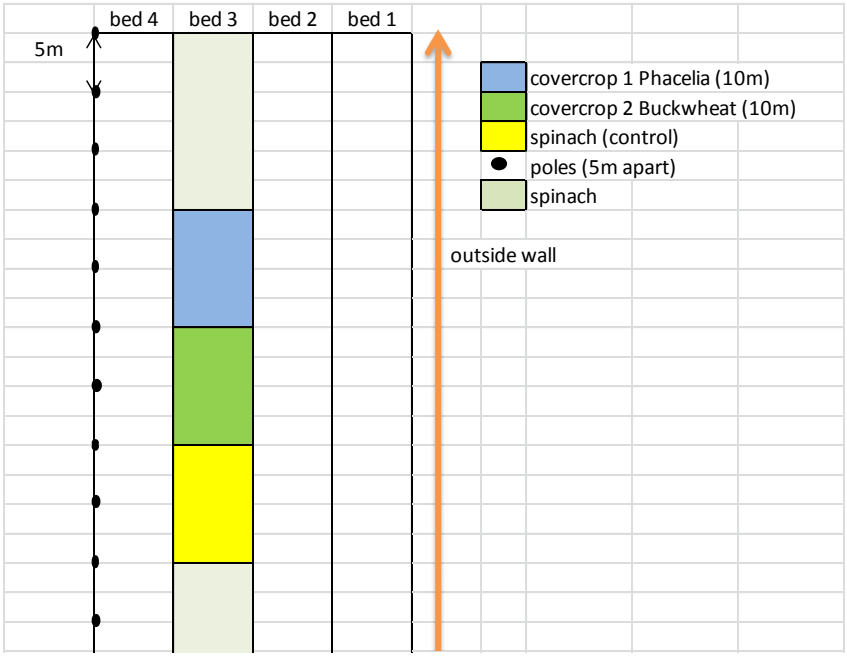

Figure 4: Experimental design at Valefresco (1 - protected crops)

Figure 5. Photos of trial site and field day

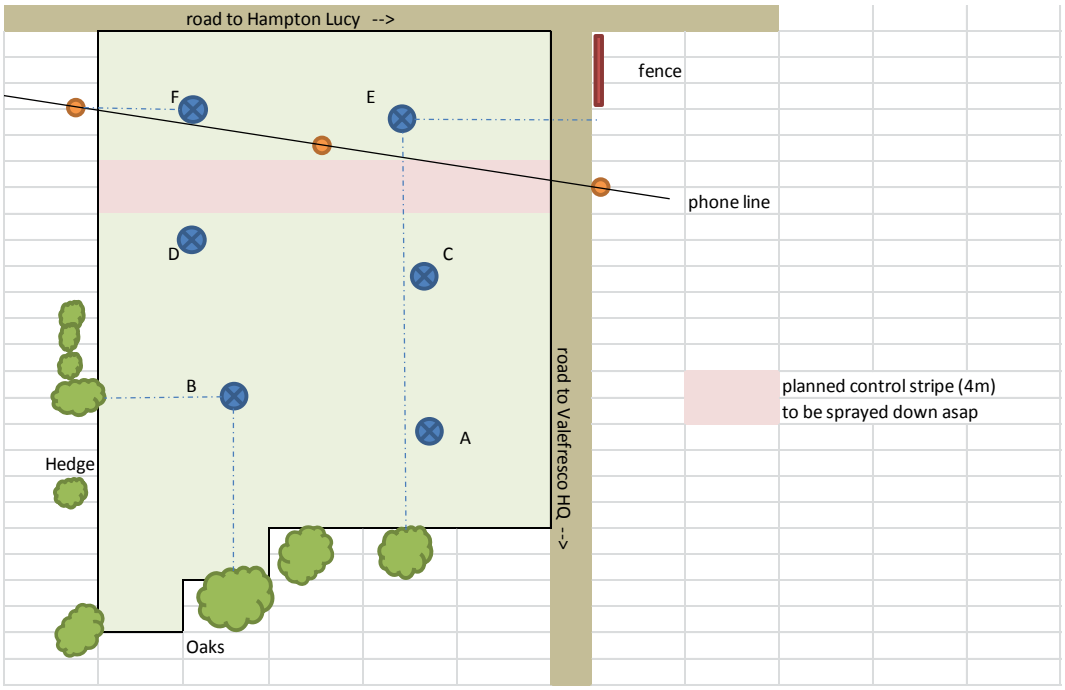

Figure 6. Experimental design at Valefresco (2 - field lettuce)

Figure 7. Photos of field trial site in green manure (rye/vetch mix)

Site 3

System: Conventional field veg, East-Midlands

Host and location: Phillip Hubbert and Ben Dodsen, JEPCO, Spalding, Lincs, PE12 9PB

Details of experiment: Investigate the effect of short term green manure strips on beds in an intensive **salad** rotation on soil biology, organic matter and crop health/quality (Figures 8 & 9).

Methods to compare: Earthworm counts, VSA, NRM soil health test

Assessment dates: 21 July 2016 and 26 October 2016 (before and after investigated cropping period).

Field day in 2016: 6 July 2016

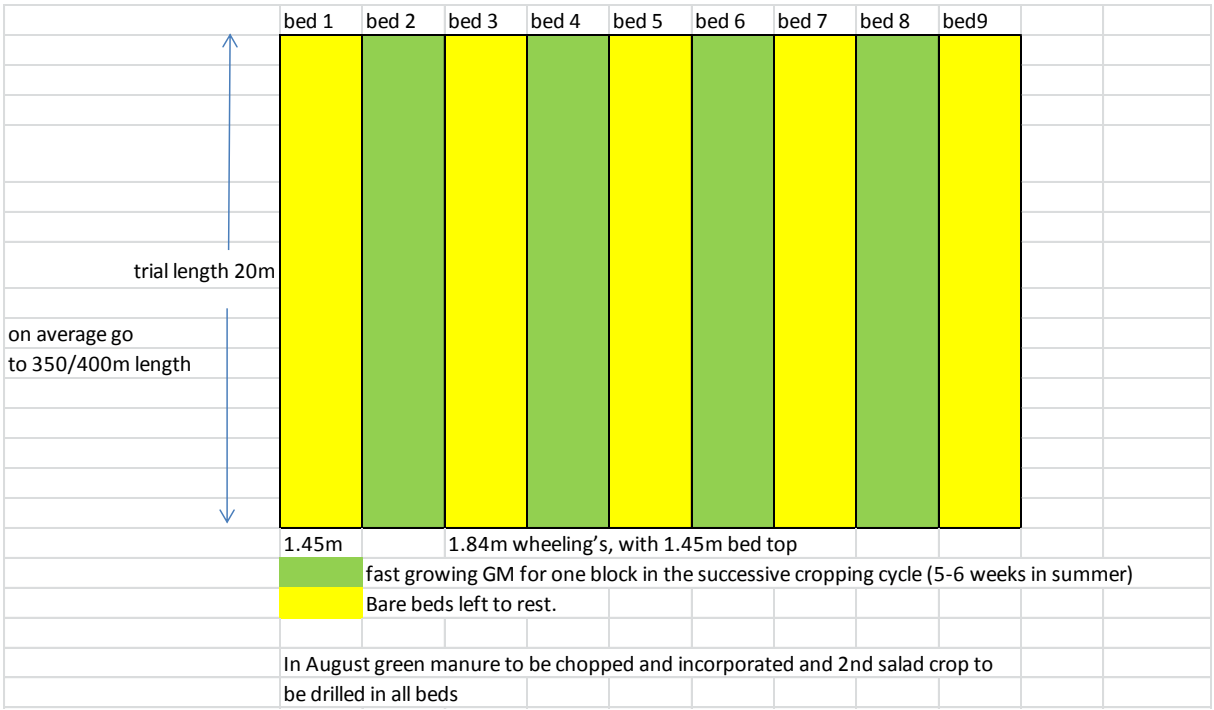

Figure 8. Experimental design at JEPCO (field lettuce)

Figure 9. Photos of trial site and field day

Site 4

System: Organic field veg, East-Midlands

Host and location: Joe Rolfe, Taylorgrown, Houghton, Norfolk, PE31 6ZD

Details of experiment: Investigate the effect of flowering green manure strips in a **carrot** field on beds on soil organic matter, biology and pests (Figures 10 & 11).

Methods to compare: Earthworm counts, VSA, NRM soil health test, plus pest damage evaluation on carrots just before harvest

Assessment dates: 31 March 2016 and 15 December 2016 (before and after investigated cropping period)

Field day in 2016: 6 July 2016

Figure 10. Experimental design at Taylorgrown (field carrots)

Figure 11. Photos of trial site and field day

Site 5

System: Conventional top fruit, South-East

Host and location: Paul and James Smith, Loddington, West Pike Fish Farm, Laddingford, Maidstone, Kent ME18 6BH

Details of experiment: Investigate the effect of two green manure mixtures in a **new apple plantation** on beneficial insects and soil structure, organic matter and biology. Three alleys grass mixture (herbicide) as control; three alleys flowering green manure A (pollinator mixture); and three alleys flowering green manure B (soil improver mixture), Figures 12 & 13.

Methods to compare: Earthworm counts, VSA, NRM soil health test

Assessment dates: 22 April 2016 and 25 October 2016 (before and after investigated cropping period)

Field day in 2016: 30 August 2016

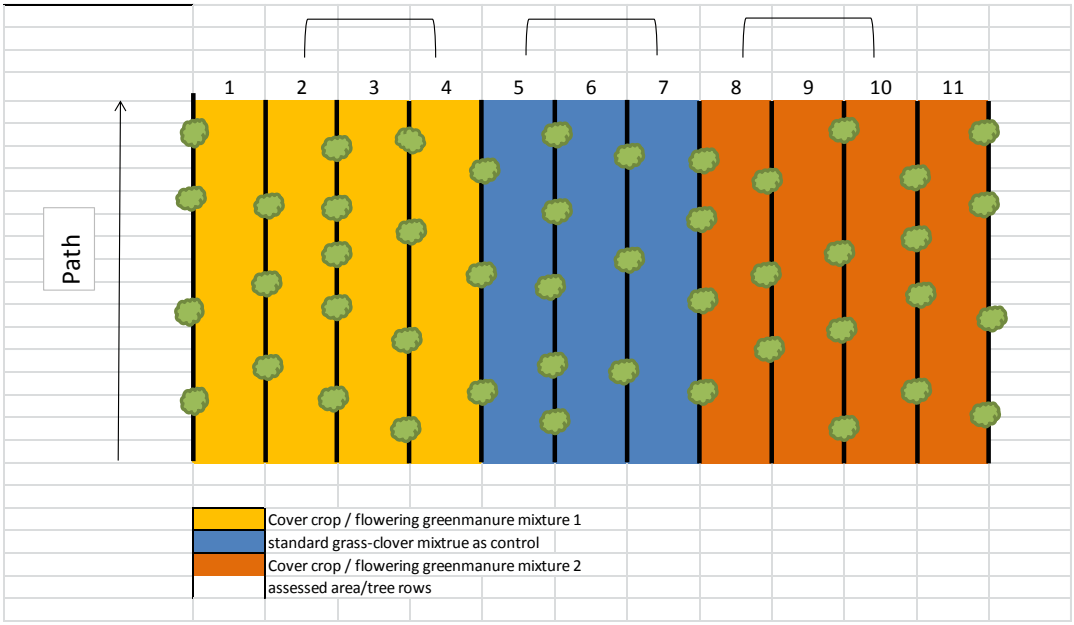

Figure 12. Experimental design at Loddington (new apple orchard)

Figure 13. Photos of trial site and field day

Site 6

System: Organic field veg, South-East

Host and location: Iain Tolhurst, Tolhurst Organic C.I.C., Hardwick Estate, Whitchurch-on-Thames, RG8 7RA

Details of experiment: Investigate the effect of an early (28/07) and late (05/09) sown green manure mixture after early **potatoes** (harvested in June) and before **brassica**s (to be planted in spring 2017), on soil organic matter, structure and biology in a stock-free horticulture system without animal inputs (Figures 14 & 15).

Methods to compare: Earthworm counts, VSA, NRM soil health test

Assessment dates: 16 May 2016 (earthworms only), 19 July 2016 (NRM soil health test and VSA) and 6 October 2016 (all)

Field day in 2016: 21 November 2016

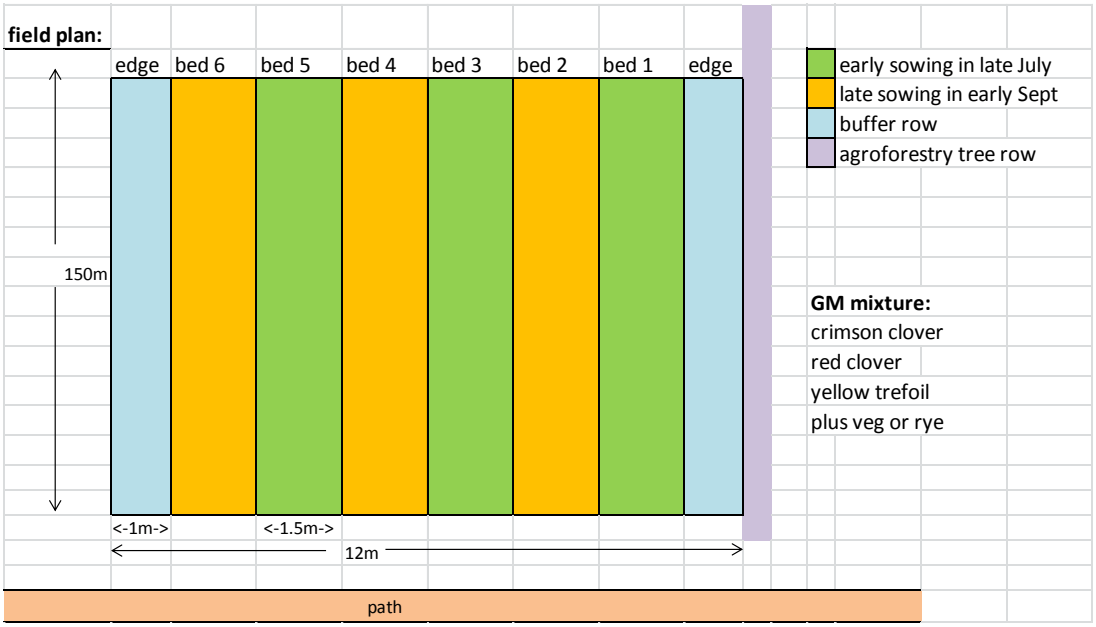

Figure 14. Experimental design at Tolhurst Organics (green manure after potatoes)

Figure 15. Photos of trial site and field day

Soil assessment methods chosen to compare in the field experiments

The grower consultation events in 2015 showed that the vast majority of involved growers were most interested in soil organic matter and soil biology assessment methods. They were aware of the crucial importance of soil organic matter on soil fertility and the general sustainability and profitability of their growing system and business. In order to improve and increase soil organic matter, the growers wanted to identify useful, practical and efficient tools and assessment methods to reliably monitor soil organic matter and soil life, and gain reliable results as basis for soil management decisions and strategies. Please see annual report of year 1 for further details.

In the following, we describe the identified soil assessment methods which the growers chose to compare in the field experiments. The methods were chosen for their practical application ('easy' to use by the growers themselves), seemingly good cost-benefit balance, and promising results. The aim of the selection was on one hand a) to assess if maybe one single tool might deliver sufficient and comprehensive results to inform soil management in a specific system; and on the other hand, b) if for certain horticultural systems, a specific tool combination (tool box) might deliver the most useful results. All chosen methods recommend an assessment once or twice a year, optimally at the same time and during similar conditions; for example in spring and autumn, before and after the growing season or before and after a certain crop in the rotation to assess its specific effect on the soil.

The three methods are briefly introduced below. The reader should refer to the literature review (work package 1, or links to each method) for further details.

Earthworm counts

Earthworms are some of the more common and easily assessable soil organisms and are widely accepted as an indicator for soil fertility, soil health and soil organic matter. In many soils and environments, monitoring earthworms over time and throughout growing seasons can deliver good information about soil organic matter (e.g. derived from the available food source), soil structure or fertility. Many growers were very interested in earthworm counts, but none had any previous experience with this approach. A number of methods is available for earthworm counts; for these trials we have chosen the OPAL earthworm survey's guide to earthworm assessment. It is publically available and free to download here: https://www.opalexplorenature.org/soilsurvey

The guide offers a short introduction, and explains its technique for sampling in a short and practical manner. It also comes with a glossy and colour pictures for species identification, in case the aim is to take the assessment one step further and identify which species are present on the farm, which ecotypes might be dominant or most effected by soil management. The

species evaluation requires some previous experience, and in most cases a microscope to identify differences between the worms. For the field experiments, however, the focus was on earthworm counts alone, and the method was followed until this step (total number of adults – those worms that have a saddle, and total numbers of juveniles, Figure 16). With one exception, where the species identification was performed for one of the farms, because the extra staff costs for bringing the sampled and counted worms back with us and identify them under the microscope, could be carried by another project currently running on that farm.

The method is freely available; however, it is the one that requires most time and labour input among the three chosen soil assessment tools.

Figure 16. Counting earthworms at Tolhurst Organics, October 2016

Visual Soil Assessment (VSA)

Due to the current lack of sector-specific methods for horticulture, the VSA tool (Figure 17) 10used for these field experiments is the Healthy Grassland Assessment Tool developed by EBLEX-DairyCo (now AHDB Beef & Lamb and AHDB Dairy). This tool consists of a 2-page glossy soil scoring sheet, with colour pictures to compare the own sampled soil with, as well as a small pocketbook for some further detail and information. It provides practical instruction to sample a soil block with a spade and how to assess and compare it with the provided pictures and their scores. Also this tool is publically available and free to download at:

http://beefandlamb.ahdb.org.uk/research/climate-change/climate-change-generic/grassland-soil-assessment-tool/

This tool was used in all field veg and top fruit experiments, although its usefulness in intensive horticulture systems, especially when growing on beds is under discussion. 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 had a short rest. Further in-depth assessment by the growers will follow in year two of the experiments (during 2017 growing season).

Figure 17. VSA at Loddington orchard (under green manure left and control alley right), October 2016.

NRM Soil Health Test

This is a relatively newly developed laboratory test, providing an overall soil health index/score based on chemical soil health indicators (P, K, Mg, pH, total soil organic matter), a physical indicator (texture) and a biological indicator (respiration rate), with certain soil management recommendations derived from the results.

Background on choosing this test: Total soil organic matter is very difficult to increase in the short term, e.g. during 3-5 project years, where 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 growers are most interested in, as they can potentially see effects of changes in soil management strategies relatively quickly and it has a direct impact on nutrient availability. The labile fraction covers all soil biology (fungi, bacteria, etc.) and there are several lab tests currently available which relate to this fraction (e.g. food-web-tests, enzymatic activity, microbial biomass C, basal respiration rates, etc.). These tests are often relatively expensive (up to £150-200 per sample for food web tests), and interpretation of the results as well as correct sampling requires great skills and caution. Microbial communities in the soil often vary significantly during different seasons, weather, 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' 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, and for a relatively affordable price per sample (around £40), this test was chosen in our experiments. Not many growers have had experience with this

test yet, but they were very keen on trying it out, assessing its value to them and its potential to reliably inform soil management.

A reasonable number of soil sub-samples are taken with a soil corer (Figure 18), following the method's instructions (similar to other nutrient analyses for example), and sent off to the laboratory. Time and labour costs are comparably small for this test, but depending on number of samples (or replicates), analysis costs can become relatively high.

Figure 18. Soil sampling for NRM Soil Health Test in protected crops at Valefresco, April 2016, and example analysis result.

Field Days 2016

During 2016, we organised one field demonstration day on each trial site. The exact dates of the events are shown in the site descriptions above, and numbers of participants ranged between 12 and 30 (Figure 19). This first series of events aimed to raise awareness of the project and the trials that are running. During each event, a workshop on soil health assessment and the different tools discussed in the project was followed by a field walk led by the host growers, introducing the group to the trial site and explaining the motivations and expectations of being part of the project. Also during 2017, a field day is planned on each site. There we will present the trial results to the regional groups, including host grower feedback; and together with the participants, formulate potential adaptations/ recommendations to develop a tool set most useful for each specific horticultural system.

Figure 19. Field demonstration days 2016

Results

This chapter of the management report presents the outcomes of the first year of the field comparison of soil assessment methods. At each of the six trial sites soil samples were taken twice in 2016 and the outcomes are shown below for each soil assessment method used. Samples were taken at random locations in each treatment of the trials. As these results are only based on the first year of the trial, sound conclusions cannot be drawn yet; neither on experiment results nor on method comparisons. However, we will present first impressions and feedback from the growers in the discussions chapter below. Further, in detailed discussions with each host grower, slight changes are made for the next growing season with regards to which tool is compared in which growing system. Some additional methods are introduced in 2017 to better meet the needs of specific horticultural systems, and to enable

the identification of a reliable set of tools (tool box) tailored for the different circumstances of growing systems. See conclusions chapter below.

Note that, due to the nature of these additionally introduced grower experiments (participatory farmer experiments, not fully randomised scientific field trials!), and due to the low amount of data from only one year, full statistical analysis was often not possible at this stage. It is important to keep in mind that the main aim of these field comparison trials is the testing and direct comparison of the methods, especially to gain feedback from growers on their usefulness and relevance in practice. More information and complete results of all sites will be presented in the final report in spring 2018. Once the outcomes of the second year of trials can be added, more data is available and an overall analysis can be performed; founded conclusions on most useful and system-specific soil assessment methods can be drawn and recommendations developed. The following chapter presents data and results found during the first year.

Outcomes of earthworm counts

In some of the six growing systems, probably due to the intensive nature of soil management or unsuitable timing in the rotation, we did not find many earthworms during the first year of sampling. Where the total number was lower than 20, the results are not shown in a graph. Soil samples of 20x20x30cm were taken with a spade at three to five locations within one treatment or bed, depending on the trial design. As described above, numbers, length and adult/juveniles were recorded; on some trial sites, also the additional step of species identification of adults was possible. Where applicable, the results were then summed up per bed and per treatment.

Site 1 – Balbirnie Estates, Scotland – carrots

For this site in Scotland, results are presented in the table below. Earthworms were sampled on each of the three fields in April and in September 2016 (except for one field, *New Inn*, which was only sampled in spring) and samples were taken in 4 locations in the cultivated area. At the sampling date in September, no earthworms were found at *East Field* or *East Moss*. Total numbers and average numbers per sample are shown below.

Table 1. Earthworm counts at Balbirnie Estate, 2016

Field	Total number Apr-16	average per pit	Total number Sep-16
East Field	23	5.8	0
East Moss	26	6.5	0
New Inn	56	13.8	--

Site 2 – Valefresco, Hampton Lucy – protected cropping

There were no earthworms found in the protected cropping trial, which is probably due to the very intensive soil management and rotation. At first sampling in the field trial on 11.10.2016 there was only one worm found, curled up for winter at location B (see field plan above). Second sampling for earthworm counts will take place in early spring, before the green manure is sprayed down for bed preparation.

Site 3 – JEPCO, Spalding – field salad

At first sampling date 21 July at JEPCO, no earthworms were found. The figure below shows the total numbers found at the second sampling date, 26 October. The results are summed up across all three 20m beds of control (total number found = 24), against all three 20m beds of green manure (total number found = 22); and split up into juveniles and adults. Samples were taken at 3 random locations in each bed.

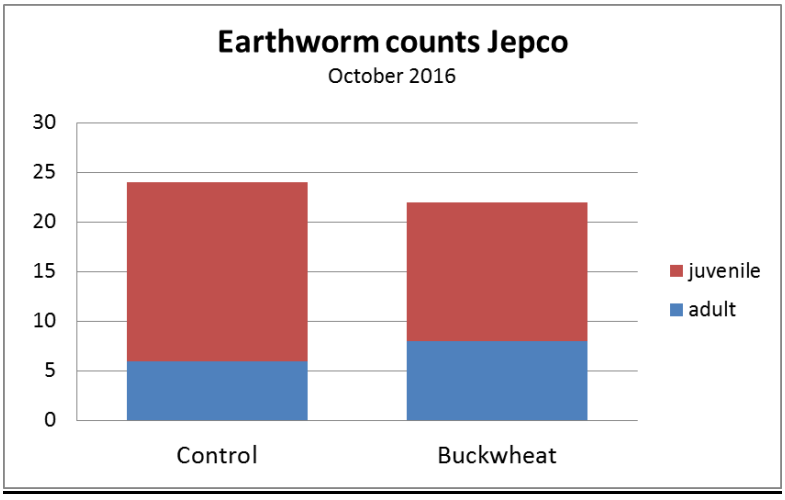

Figure 20. Earthworm counts at JEPCO

Site 4 – Taylorgrown, Houghton – organic carrots

Earthworm counts were conducted at this site on 31 March and 15 December 2016. There were only 11 worms found in March, all juveniles, but beds were already formed at that time and it was not expected to find a large number of worms then. But also in December, when the field was in ley (glover/ryegrass), only 6 worms were found in the entire field, 5 juveniles and 1 adult.

Site 5 – Loddington, Maidstone – top fruit, apples

Earthworms were counted on 22 April and 25 October 2016. In spring, we found 3 juvenile and 2 adult worms in the (to be) soil improver green manure alley, 3 juvenile worms in the (to be) control alley, and 4 juveniles in the (to be) pollinator green manure alley. In autumn the numbers did not improve much, which could be due to the recently set up new orchard and the heavy soil management that was needed to remove the old trees the autumn before. In October we found 9 worms in total, 1 juvenile under the soil improver green manure mixture, and 8 under the control alley.

Site 6 – Tolhurst Organics – potatoes/brassica

Earthworms were counted on this site on 16 May and 6 October 2016. In May, 9 worms were found in total, all juvenile and rather small. Samples were taken at 3 random locations in each bed. However, at the sampling date in autumn, 191 worms were found; again taken from 3 locations in each bed. The results are shown in the figures below, first split up for each bed, and then summarised for the early (GM) and late sown green manure (control). For this site, we were able to perform a species identification of the adult worms found in the field. The 4 species identified are common and expected to be present in such systems. It is notable that the total number of worms found in early sown green manure was larger in each bed compared to the later sown green manure beds. Overall, when summing up the numbers per treatment, the difference between the two treatments was still very clear.

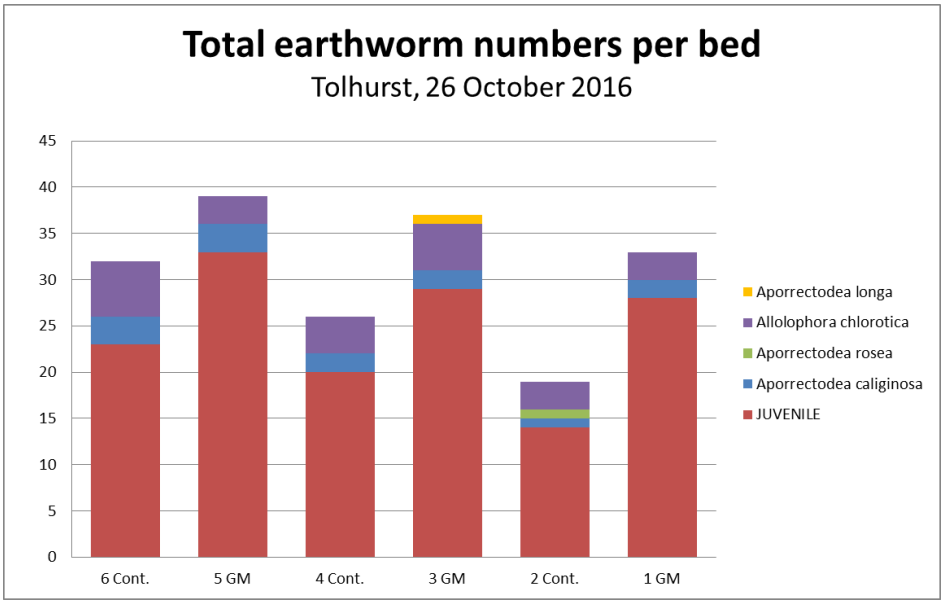

Figure 21. Earthworm counts and adult species per bed at Tolhurst Organics. (GM = early sown green manure, Cont. = late sown green manure).

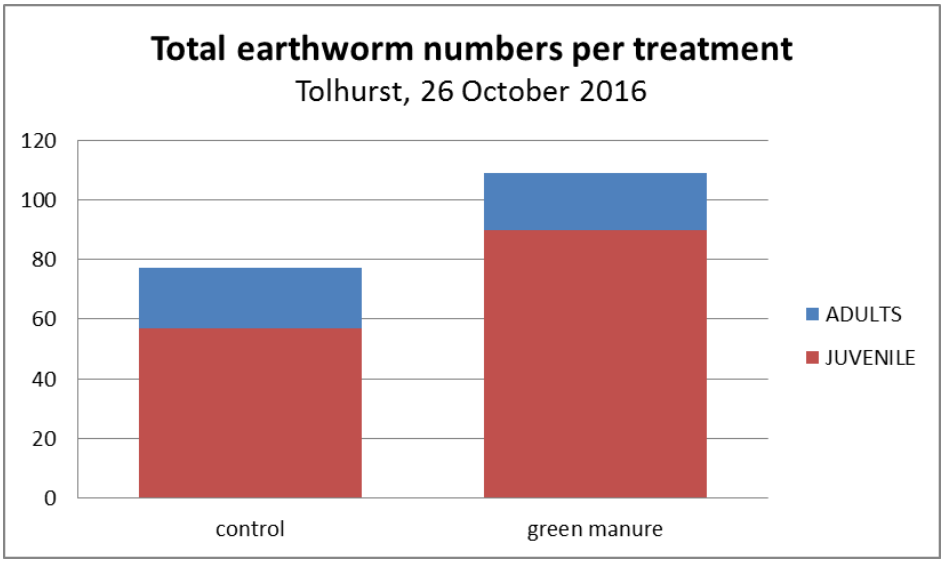

Figure 22. Earthworm counts per treatment at Tolhurst Organics. (Green manure = early sown green manure, control = late sown green manure).

Outcomes of Visual Soil Assessment

At some locations, it was not appropriate to perform a VSA test along with the worm counts, and NRM soil sampling because the soil had been “bed-formed” and all visible soil structure was absent (as is normal with beds formed for root crops and some other field veg). This was the case at sites 1, 3 and 4, where only one set of outcomes is shown in the results of 2016 below. This aspect will be discussed in detail with the growers, especially with regards to usefulness and usability of the currently available VSA tools specifically for growers.

Note that the Healthy Grassland Tool used for the VSA scores soils from 1-5, with 1 being 'friable' and 5 being compacted, so the lower the score the better.

Site 1 – Balbirnie Estates, Scotland – carrots

The visual assessment of soil structure was made at this location on 6 April 2016. Five assessments were made in five locations of each of the three fields, chosen at random throughout. The results are shown in the table below.

Table 2. VSA scores at Balbirnie Home Farm in April 2016

Field	Zone	Score	Average
East field	1	3	2.8
East field	2	3	
East field	3	3	
East field	4	2	
East field	5	3	
East moss	1	3	2.4
East moss	2	2	
East moss	3	2	
East moss	4	2	
East moss	5	3	
New Inn	1	2	2.4
New Inn	2	3	
New Inn	3	2	
New Inn	4	2	
New Inn	5	3	

Site 2 – Valefresco, Hampton Lucy – protected cropping

In the field trial of this site, first VSA assessments were conducted on 11 October 2016 when the entire field was green manure (rye and vetch). The scores of the 6 sampling points (compare trial map above) are shown in the table below.

Table 3. VSA scores at Valefresco in October 2016

Zone	Score	Average
A	4	3.5
B	4	
C	3	
D	3.5	
E	3	
F	3.5	

Site 3 – JEPCO, Spalding – field lettuce

At this site, the VSA method was used at 3 locations in each bed on 26 October 2016 (compare trial map above). The scores are shown in the table, and summarised below.

On this scale of 1-5, the results of this site show that the green manure beds tended to score slightly better than the control beds. Although both scores are relatively good, the higher score in the Buckwheat beds might be due to additional organic matter added to the soil .

Table 4. VSA scores at JEPCO in October 2016

Treatment	Bed	Score	Treatment	average score
Control	A	2	Control	1.9
Control	A	2	Buckwheat	1.1
Control	A	1		
Buckwheat	B	1		
Buckwheat	B	1		
Buckwheat	B	1		
Control	C	2		
Control	C	2		
Control	C	2		
Buckwheat	D	1		
Buckwheat	D	1		
Buckwheat	D	1		
Control	E	2		
Control	E	2		
Control	E	2		
Buckwheat	F	1		
Buckwheat	F	1		
Buckwheat	F	2		
Control	G	2		
Control	G	2		
Control	G	2		
Buckwheat	H	1		
Buckwheat	H	1		
Buckwheat	H	1		

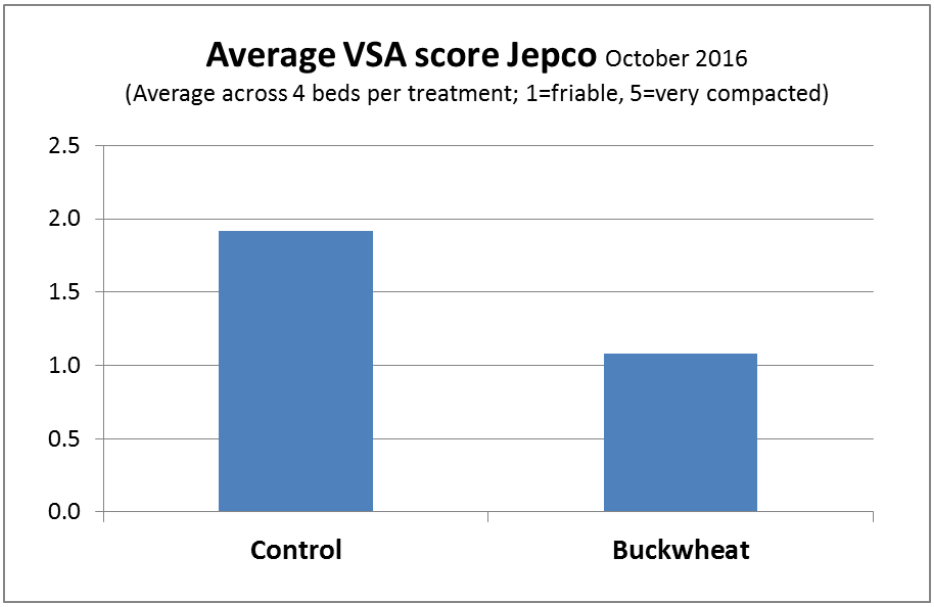

Figure 23. VSA scores at JEPCO in October 2016

Site 4 – Taylorgrown, Houghton – organic carrots

The VSA method was attempted early post bed-forming in March but was deemed inappropriate due to the lack of structure and assessable indicators for this visual evaluation tool. The VSA was carried out at the second soil sampling in December, after the field had been ploughed and drilled as a grass-clover ley during autumn. The sampling was done across the whole field.

TREATMENT	Sample	VSA Score March 2017	VSA Score December 2017
Whole Field	1	n/a	2
Whole Field	2	n/a	2
Whole Field	3	n/a	2
Whole Field	4	n/a	1
Whole Field	4	n/a	2
Whole Field	5	n/a	2
Whole Field	6	n/a	2
Whole Field	7	n/a	1
Whole Field	8	n/a	1
Whole Field	9	n/a	2
Whole Field	10	n/a	2
Whole Field	11	n/a	2
Whole Field	12	n/a	2

Site 5 – Loddington, Maidstone – top fruit, apples

The VSA method was used at Loddington 22 April and 25 October 2016. The table below shows the scores measured at the two sampling dates. Samples were taken at 3 random locations in each assessed alley.

The results from this site show a notable improvement of VSA scores under both green manure mixtures. During the main growing season from April to October, the green manure visibly improved soil structure and drainage. Also, the grower fed back the striking difference in look and structure of the soil under the alleys with green manure; and in this case, for these soils, the draining effect was a very welcome side-effect of the trial. The green manure will be left standing during the next year, only cut once, late in spring to benefit and support overwintering insects and natural predators (e.g. hover flies etc.).

Table 5. VSA scores at Loddington in April and October 2016

	Apr 2016	Oct 2016	average	Apr 2016	Oct 2016
Plot	**Score**	**Score**	Pollinator mix	3.8	2.2
1A	4.0	2.5	Control	4.2	3.7
1B	3.5	2.0	Soil improver mix	4.0	2.1
1C	4.0	2.0			
2A	4.5	4.0			
2B	4.5	3.0			
2C	3.5	4.0			
3A	4.5	2.0			
3B	4.0	2.3			
3C	3.5	2.0			

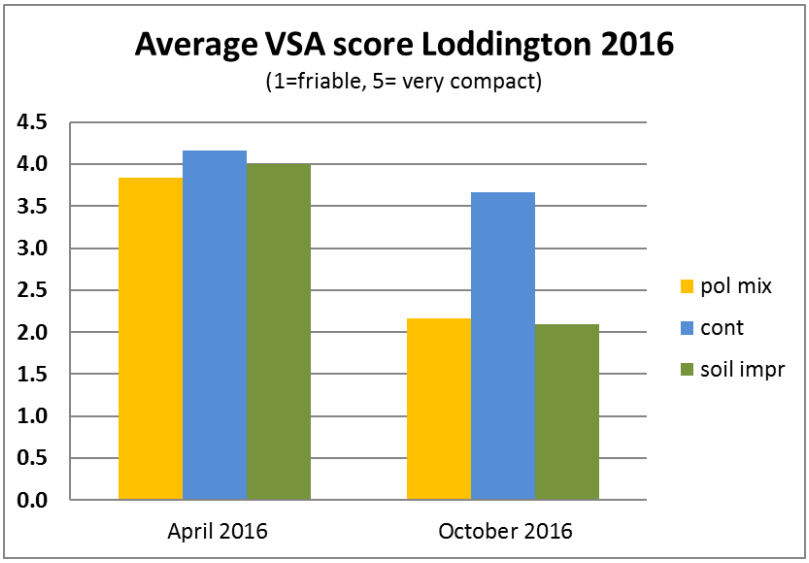

Figure 24. VSA scores at Loddington in April and October 2016

Site 6 – Tolhurst Organics – potatoes/brassica

Also at this site, the VSA was conducted twice in 2016, on 19 July and 6 October. The results are shown below. Samples were taken at 3 random locations in each of the 6 beds (please see trail design map above).

The results show that also here the early sown green manure could slightly improve VSA scores between July and October. The results imply that soil structure tended to benefit from early green manure application, whereas the structure of beds with late sown green manure decreased slightly; which may be due to an additional soil management step in these beds for weed management between the two sowing dates.

Table 6. VSA scores at Tolhurst Organics in July and October 2016

	Apr 2016	Oct 2016		Apr 2016	Oct 2016
Bed	**score**	**score**	**average**	**score**	**score**
1a	1	1	early sown	1.2	1.1
1b	2	1	late sown	1.3	1.6
1c	1	1			
2a	1	1			
2b	1.5	1			
2c	1	1			
3a	1	1			
3b	1	1			
3c	1	1			
4a	1	2			
4b	2	2			
4c	1	1			
5a	1	1			
5b	1.5	1			
5c	1.5	2			
6a	1	2			
6b	2	2			
6c	1	2			

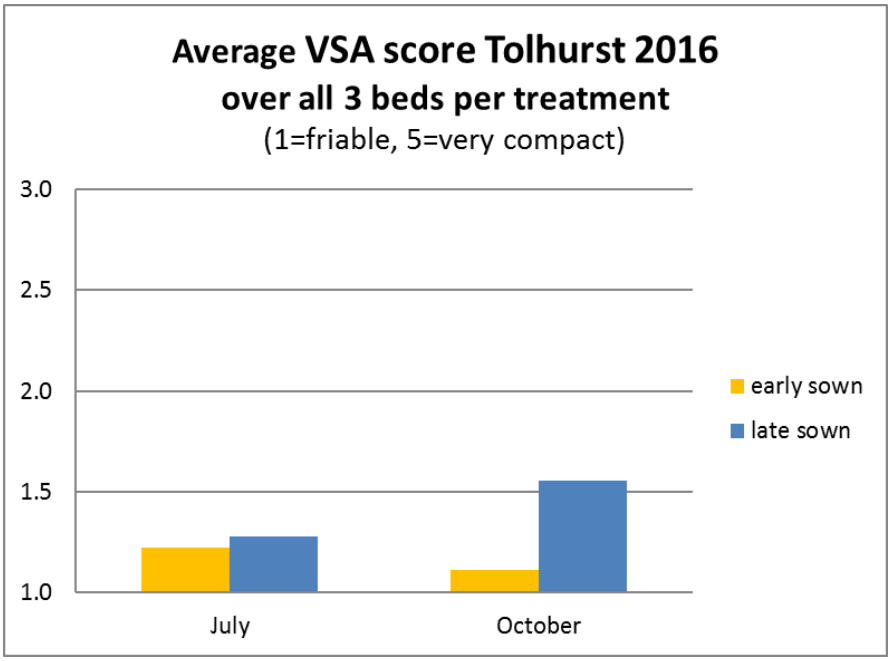

Figure 25. VSA scores at Tolhurst Organics in July and October 2016

Outcomes of NRM Soil Health Test

Site 1 – Balbirnie Estates, Scotland – carrots

Soil Health indicators are shown for the site at Balbirnie Estates below. On 6 April 2016, each of the three fields was sampled across its entire area by walking in a "W" pattern and taking 32 sub-samples using a spiral augur to 20 cm depth. Sub-samples were mixed in a clean bucket and 500 g samples were sent to NRM laboratories for analysis. The laboratories applied methods commonly used for Scottish soils (e.g. microbial respiration, as measured by the Haney Brinton CO2 burst test, as opposed to SOLVITA-based assessments for the rest of the trials).

Table 7. NRM Soil Health Test results from Balbirnie Estate 2016

Location: Balbirnie Estate	**Apr-16**		
Sample Ref.	East field	East moss	New Inn
Soil Chemical Analysis			
P (mg/l)	4.8	5.7	9.6
K (mg/l)	185.0	161.0	194.0
Mg (mg/l)	78.0	60.0	96.0
Organic Matter (LOI) (%)	4.3	4.1	4.1
Soil pH	5.6	5.5	6.5
Microbial Activity			
CO2 Burst (mg/kg)	20.0	148.0	19.0

Site 2 – Valefresco, Hampton Lucy – protected cropping

The table below shows the outcomes of all NRM Soil Health Tests conducted at Valefresco in 2016. It lists the results of the initial sample date in the protected cropping site before sowing 28 April, and the results of the later sampling date after the green manure was incorporated and the new spinach crop was sown, as well as the results of the first sampling in the field 11 October 2016. Please compare with trial design and maps above. Samples were taken with a soil corer at 10 random locations in each treatment/bed.

Table 8. NRM Soil Health Test results from Valefresco 2016

	Apr-16	**Oct-16**			
Location: Valefresco	**protected**				**field**
Sample Ref.	**initial sample**	**control**	**After phacelia**	**After buckwheat**	**field**
Soil Chemical Analysis					
P (mg/l)	47.6	50.2	62.2	62.0	60.4
K (mg/l)	134.0	103.0	99.1	137.0	230.0
Mg (mg/l)	104.0	96.7	108.0	103.0	124.0
Organic Matter (LOI) (%)	2.5	2.5	2.3	2.2	2.8
Soil pH	6.5	6.8	6.8	7.0	6.6
Microbal Activity					
CO2 Burst (mg/kg)	36.0	44.0	40.0	44.0	99.0
Pot. N Mineralisation (kg/ha/yr)	45-75	45-75	45-75	45-75	75-105
Textural Classification					
Sand (%)	74	76	77	76	70
Silt (%)	13	12	11	12	15
Clay (%)	13	12	12	12	15
Soil Textural Class	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
Major Soil Classification	Medium	Medium	Medium	Medium	Medium
Slope	0˚	0˚	0˚	0˚	0˚
Soil Health Index	3.0	3.0	2.8	2.9	4.1

Site 3 – JEPCO, Spalding – field salad

The table below shows the outcomes of all NRM Soil Health Tests conducted at JEPCO in 2016. Samples were taken with a soil corer at 10 random locations in each bed and then mixed for a sample in each treatment. Samples were taken in July and October, before and after the green manure.

Table 9. NRM Soil Health Test results from JEPCO 2016

Location: JEPCO	**Jul-16**		**Oct-16**	
Sample Ref.	**Control**	**Green manure**	**Control**	**Green manure**
Soil Chemical Analysis				
P (mg/l)	15.2	14.6	13.8	13.8
K (mg/l)	101.0	121.0	164.0	183.0
Mg (mg/l)	53.1	64.3	61.5	67.4
Organic Matter (LOI) (%)	2.8	2.8	2.7	2.6
Soil pH	8.0	8.1	8.2	8.1
Microbal Activity				
CO2 Burst (mg/kg)	33.0	32.0	57.0	60.0
Pot. N Mineralisation (kg/ha/yr)	45-75	45-75	45-75	45-75
Textural Classification				
Sand (%)	34.0	33.0	37.0	38.0
Silt (%)	50.0	51.0	50.0	49.0
Clay (%)	16.0	16.0	13.0	13.0
Soil Textural Class	Sandy Silt Loam	Sandy Silt Loam	Sandy Silt Loam	Sandy Silt Loam
Major Soil Classification	Medium	Medium	Medium	Medium
Slope	0˚	0˚		
Soil Health Index	2.3	2.4	3	3.1

Site 4 – Taylorgrown, Houghton – organic carrots

The soil health test was performed on 31 March 2016, when the beds were formed, but the carrots and green manure were not sown yet; and on 15 December 2016, when the field was ploughed and re-sown with over wintering cover crops. Samples were taken from 10 locations in each bed/field, and then mixed for one sample per treatment.

The initial idea on this site was to leave the flowering green manure beds standing over winter and serve as beetle bank for the next crop in 2017. However, the host needed to change this plan and was unfortunately not able to inform us in time to sample the beds again before ploughing. The results below show the outcomes of the two sampling dates, the baseline measurements in the formed beds in spring and the post sampling in December.

Table 10. NRM Soil Health Test results from Taylorgrown 2016

Location: Taylorgrown	**Mar-16**		**Dec-16**
Sample Ref.	carrot beds	green man beds	whole field
Soil Chemical Analysis			
P (mg/l)	47.8	56.6	50.0
K (mg/l)	172.0	182.0	114.0
Mg (mg/l)	42.1	40.5	41.3
Organic Matter (LOI) (%)	2.5	2.4	6.6
Soil pH	7.3	7.4	7.3
Microbial Activity			
CO2 Burst (mg/kg)	20.0	23.0	86.0
Pot. N Mineralisation (kg/ha/yr)	25-45	25-45	75-105
Textural Classification			
Sand (%)	81.0	81.0	83.0
Silt (%)	12.0	12.0	11.0
Clay (%)	7.0	7.0	6.0
Soil Textural Class	Loamy Sand	Loamy Sand	Loamy Sand
Major Soil Classification	Light	Light	Light
Slope	0˚	0˚	0˚
Soil Health Index	4.4	4.2	4.0

Site 5 – Loddington, Maidstone – top fruit, apples

Also at this trial site, we have conducted an NRM Soil Health Test on 22 April and 25 October 2016, just before the planting of the trees, and after general harvest time (although the young trees did not produce a harvest yet). The samples were taken and mixed from 10 random locations in each treatment/alley.

Table 11. NRM Soil Health Test results from Loddington 2016

Location: Loddington	**April 2016**			**October 2016**		
Sample Ref.	**Pollinator mix**	**Control**	**Soil impr. mix**	**Pollinator mix**	**Control**	**Soil impr. mix**
Soil Chemical Analysis						
P (mg/l)	44.0	60.0	45.8	79.4	78.8	60.0
K (mg/l)	197.0	224.0	227.0	296.0	279.0	223.0
Mg (mg/l)	94.8	92.1	94.9	103.0	98.3	109.0
Organic Matter (LOI) (%)	6.0	5.4	5.3	6.4	5.2	5.3
Soil pH	7.6	7.6	7.4	7.2	7.7	7.6
Microbal Activity						
CO2 Burst (mg/kg)	> 162	> 162	> 162	> 162	148.0	> 162
Pot. N Mineralisation (kg/ha/yr)	75-105	75-105	75-105	75-105	75-105	75-105
Textural Classification						
Sand (%)	44.0	34.0	37.0	33.0	29.0	28.0
Silt (%)	32.0	37.0	35.0	38.0	40.0	41.0
Clay (%)	24.0	29.0	28.0	29.0	31.0	31.0
Soil Textural Class	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam
Major Soil Classification	Medium	Medium	Medium	Medium	Medium	Medium
Slope	0˚	0˚	0˚	0˚	0˚	0˚
Soil Health Index	5.0	4.9	5.0	5.0	4.7	5.0

Site 6 – Tolhurst Organics – potatoes/brassica

On this site, we have sampled for the NRM Soil Health Test on 19 July and 6 October 2016. Samples were taken from 10 locations in each bed, and then mixed for one sample per treatment.

Location: Tolhurst	Jul-16		Oct-16	
Sample Ref.	**late sown**	**early sown**	**late sown**	**early sown**
Soil Chemical Analysis				
P (mg/l)	32.0	35.6	25.2	25.4
K (mg/l)	149.0	115.0	93.5	72.9
Mg (mg/l)	82.7	73.7	80.8	75.9
Organic Matter (LOI) (%)	6.1	6.2	5.7	5.8
Soil pH	6.6	7.2	6.8	7.0
Microbal Activity				
CO2 Burst (mg/kg)	162	134	162	155
Pot. N Mineralisation (kg/ha/yr)	75-105	75-105	75-105	75-105
Textural Classification				
Sand (%)	56	52	48	53
Silt (%)	32	35	33	30
Clay (%)	12	13	19	17
Soil Textural Class	Sandy Loam	Sandy Loam	Clay Loam	Sandy Loam
Major Soil Classification	Medium	Medium	Medium	Medium
Slope	0˚	0˚	0˚	0˚
Soil Health Index	5	4.9	5	4.9

Discussion

Although the field comparison of different soil assessment methods of work package 2 have shown some interesting first results during this first year of the trials, and we've had some interesting and relevant feedback from growers on specific methods already, there is not enough data yet to draw sound and final conclusions about the methods comparisons. During the second year of the trials, the chosen set of tools will be refined and adapted to the specific needs of each growing system, in order to develop recommendations for growers.

It was found for example, that the VSA tool is less relevant for intensive field horticultural systems, particularly those growing on beds. As the soil in these systems is worked very

regularly and heavily, soil structure assessment in the top 30cm is not possible/useful for most of the year. If the fields are sown with cover crops over winter, or are given a rest period where the soil has a chance to settle and recover, those times would be suitable for an assessment with the chosen VSA tool, e.g. before and after cover crops. However this does not necessarily apply to those methods that do not score soil compaction rate or structure. For example, taking a spade and looking at a soil (even in horticultural growing systems on beds), its colour, smell, plant rooting pattern/vigour etc. is a useful method at almost any point in time, as a practical and quick way of getting an impression of the health of the soil and the cash crop.

Also, earthworm counts can be more useful in some soils or systems than in others. 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 rotating tillage machinery. Therefore, earthworm counts and interpretation of their results should take soil management 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/soil. Finding 10 worms in a 20x20x30cm spade sample can be a lot in some soils, whereas in others it might be a very low result.

Different ideas for adapting the method selection for better serving specific horticultural systems was discussed with the host growers individually:

- Additional **infiltration rates** measuring (simple and quick method with drain pipe).
- Additional **soil compaction** assessment (simple and quick method with knife).
- Additional **soil biology** assessments (SoilBiolab – would require financial subscription from growers as they are quite expensive and interpretation is difficult).
- **Specific timing** of sampling in different systems (e.g. VSA only after winter in 'untouched' soils for systems growing on beds).

Each site will make slight adaptations to their set of methods for 2017 based on the list above, the outcomes will be discussed in the final project report.

Conclusions

At this stage, it is too early to draw conclusions about the practical soil assessment method comparison in work package 2, but based on initial findings and in-depth discussions with involved growers, some slight adaptations are being made to the tool selection on each trial site. The aim is to identify and fine-tune the set of tools which are most useful and reliable in specific horticultural growing systems. The list below shows the outlook and timeline for the final year of this work package:

- Two **soil sampling** dates on each site with growers to gain more of their in-depth feedback and opinions on each method
- One final **field day** on each site during summer 2017 (between June and September 2017) to discuss results and gain feedback from participants
- Three **grower workshops** for specific horticultural systems (e.g. field veg on beds, top-fruit, and protected crops) to identify most suitable combination of tools and scheduling of soil assessment. Most likely during October/November 2017
- One **project partner workshop** to jointly refine tool-set selection and develop recommendations for growers. Most likely during November/December 2017

Knowledge and Technology Transfer

Case Studies and Guidance Notes

We have delivered 3 Case Studies on aspects of soil health for growers in Year 2. These are awaiting publication. They cover a variety of topics as follows:

- CS1 Compost for soil health
- CS2 Soil testing for carrot production
- CS3 Engineering the landscape to secure asparagus production
- GN1 Avoiding the pitfalls of Soil pH testing to maximize your soil health

Events (Soil Roadshow)

In Year 2 the team has met growers and advisors at 15 events of which ten were ‘key events’ as identified in our project plan. See Appendix 1 for details. Team members have taken part in events as speakers, run stalls, and given demonstrations. At the Elsoms Seed day and the British Herbs field events the project team teamed up with GREATsoils projects CP107c and

CP 107d projects to provide a cross programme focus. Our target for the project was 18 key events, together with the eight attended in year we have reached this in Year 2 of the project.

Interactive workshops

The project has delivered ten interactive workshops which have been well attended and have attracted growers and farmers from across a range of the AHDB horticulture sectors. The workshops average at around 15 attendees per workshop which is in line with expectation. One workshop planned for the Moray Coast had to be cancelled due to low numbers.

The workshops have been billed as 'Soil Health and Farm Viability'. They have in each case been hosted by a farm (Figure 26). The agenda has included an introduction to assessing and managing soil health; a guest topic suggested by the host farm – for example green manures for soil health, or using compost for soil health; a farm walk or practical session looking at soil and discussing the host's growing system.

The response indicates that growers are increasingly aware of the importance of soil health and looking for ways to address it, albeit within the constraints of their business models. A highlight of the events has been the peer-to-peer learning that goes on between growers.

Figure 26. Attendees at a GREATsoils workshop in Lancashire

For attendance figures and on workshops see Appendix 2.

Youtube films

The first project video focuses on the importance of cover crops for building soil health and can be viewed here: https://www.youtube.com/watch?v=cMdP2Igv5mU. For viewing figures see Appendix 2.

Online webinars

In Year 2 we delivered a series of 4 interactive webinars on soil health. These webinars were complimentary to the interactive workshops above. See Appendix 2 for details including attendance.

Field Labs

This year we commenced three field labs. Public meetings were held for 2 of the field labs – more detail in Appendix 3. There will be 2 further field labs starting in Year 3 of the project and all of the field labs will have public meetings.

The first three field labs are:

4. **Improving Soil Health And Organic Matter Using Cover Crops In A Shared Rotation**

   The field lab aims to improve soil health and organic matter in a shared rotation of an arable/horticulture system, assessing effects of cover crops on cash crop yield and quality.

   http://www.innovativefarmers.org/field-lab/?id=d92b4947-a379-e611-80cb-005056ad0bd4

5. **Amendments For Soil Health In Top Fruit**

   This field lab aims to investigate how the addition of different soil amendments affects soil health in fruit production systems. Growers will try the various diversity of soil amendment materials including biochar, woodchip, mycorrhizae, according to their own individual recommendations, and then adapt them for the different fruit systems.

   http://www.innovativefarmers.org/field-lab/?id=c6bb2819-56d3-e611-80ce-005056ad0bd4

6. **The Impact Of Whole Digestate On Soil Health In Field-Grown Vegetable Crops On The Moray Coast**

   The field lab aims 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.

   http://www.innovativefarmers.org/field-lab/?id=0436327a-05b3-e611-80ce-005056ad0bd4

The field labs are new field labs expressly for the GREATsoils programme. They are being run in collaboration with the Innovative Farmers programme https://www.innovativefarmers.org/ and the methodology and achievements from each are being documented on the portal there as the project develops. This data can be accessed for free.

Media output

Twitter 933 followers

In Year 2 GREATsoils project CP107b has been covered in 14 major articles across a range of industry publications including:

- Fresh Produce Journal
- Horticulture Weekly
- IOFGA Organic Matters Magazine
- The Vegetable Farmer
- AHDB Grower
- Farming UK
- Organic Farming Magazine

In addition, we have published a series of 5 blogs by growers taking part in the project.

For full details see Appendix 4

GREATsoils network

The project has been building up a network of growers via sign-ups at events, website, newsletters, and twitter. At the end of the year there were 460 members.

This was not an indicator in the original proposal, however we believe tracking members who have signed up to be part of the network provides a good indication of grower engagement and potential for evaluating impact at the end of the project

Glossary

Not applicable.

Appendices

Appendix 1 – Events

Activity 3.1

Soils Roadshow – attendance at 18 key events

2016/17

21/04/2016	**FPJ event - speaking slot - LB**
17/05/2016	Agritech East - SIG Event: A Sense of Place – Geomatics Meets Soils Health event. Provided slide and postcards for promotion.
14/04/2016	Reading soil health event – Promoted project AV
07/07/2016	**NOCC - stand - AV**
25/08/2016	**British Herbs field event – stand and demo - MW**
14/09/2016	**Growing Innovation - Rijk Zwaan Organic Open Day 2016 – presentation BR, MW**
06/10/206	**BCGA variety and trade exhibition carrot day – stand**
12-13/10/2016	**Elsoms Seed open day 2016 - AHDB stand with ADAS - MW**
19-20/10/2016	**National Fruit Show – stand - BR**
09/11/2016	**Farm Business Innovation – stand - BR**
04-05/01/2017	**ORFC – promotion – BR, AV**
1-2/02/2017	**ORC Conf – workshop AV, BR**
08/02/2017	Presentation to ProCam East - MW
22/02/2017	PFLA soils meeting – promotion AV
21/03/2017	BSSS drinks reception – poster and promotion, BR, Anna Becvar Earthcare Techincal

2015/16

13 events attended in year one of the project of which **8** were “key” events as decided in our original plan (key events marked in).

- Grantham Centre, Sheffield University soil lecture - Promoted project BR
- 16th September **Rijk Zwaan Horticultural event** - Promotion and signup sheet BR
- **Soil Symposium** - 5 Nov 15 - stand, postcards and signup sheet, BR, AL, AV, LB
- **Onion conference** - 4 Nov 15 - attended with postcards MW
- **Reading University Soil Health Conference** - 18 Nov 15 - attended, and chaired conference session BR
- Innovative Farmers "Cracking Compost" event at GS grower Iain Tolhurst. Promoted GS and handed out postcards 8 Dec BR
- **Oxford Real Farming Conference-** 6/7 Jan 16 shared stand with Innovative Farmers, Review report, postcards and signup sheet BR, LB
- **ORC producer conference** session with 2 Paul Smith and Simon Gardner speaking (growers from the consultations) + stand with reports. 28/29 Jan AV, BR
- **Crop Protection in Northern Britain** – 23 Feb attending and speaking AL
- **Carrot Growers Conference** 22 March – sign ups BR

Appendix 2 – Workshops attendance and feedback

Grower workshops – Soil Health and Farm Viability

Date	Location	Guest topic	Attendees
21/09/16	Cornwall, host - Riviera Produce	Soil compaction	20
06/10/16	Lancashire, host - Molyneux Kale Company	Using green manures for soil health	17
13/10/16	Pembrokeshire, Wales, host - Springfields Fresh Produce	Maintaining soil fertility and structure in a high rainfall area	13
27/10/16	Cambridgeshire, host - G's	Green manures	13
09/11/16	Lincolnshire, host Pollybell Farms	Green manures	11
09/11/16	Fife, Scotland	Compost and green manures for soil health	11
22/11/16	Staffordshire, host New Farm Produce Ltd	Managing run off and erosion	9
01/02/17	Worcestershire - host Agrii		35
22/02/17	Hants - host Laverstoke Park Farm	Using green manures for soil health	12
28/02/17	Sussex, host Rathfinny Wine Estate	Compost for soil health	26

Webinars

	Attendees	Link	Views
Soil Health and the Bottom Line	28	https://youtu.be/O_MKtI57EIU	354
Soil health and what to measure	31	https://youtu.be/WZxC49CFZEE	195
Managing soil health using organic manures	35	https://youtu.be/9p420x382hg	214
Short term green manure strategies for intensive growers	15	https://youtu.be/PZ6cGBQjF8c	232

Appendix 3 – Field Labs

Field Lab 1: Improving soil health and organic matter using cover crops in a shared rotation

The field lab aims to improve soil health and organic matter in a shared rotation of an arable/horticulture system, assessing effects of cover crops on cash crop yield and quality.

This is an interesting group of three companies, Jepco, Worth Farms, Loveden Estates, where one rents land from other two members to grow salads/lettuce. They are interested in improving soil health by working together.

The aims are to:

- coordinate rotational soil health measures with different companies.
- improve soil organic matter and soil health in an arable/horticulture rotation
- quantify the short-term benefits of cover crops for following cash crops – lettuce, potatoes and sugar beet reduce growing costs by developing more efficient rotations in the long-term
- analyse the cost benefit of various green manures/cover crops species and mixtures.
- evaluate ease of seed bed preparation and soil cultivation generally after cover crops.

This project hopes to deliver initial evidence to other farmers that a joint strategic and long-term soil management approach of different parties using the same fields in a rotation is crucial for a long-term and sustainable improvement of soil health and soil fertility. We hope to initiate this idea and thinking process also in other growers and farmers to collaborate on this particular agricultural challenge.

Field Lab 2: Amendments for soil health in top fruit

This field lab aims to investigate how the addition of different soil amendments affects soil health in fruit production systems.

Many growers are already using green waste compost or composted woodchip to add fertility and organic matter to their soils. There are also a range of products being promoted to boost the health of soils. Working out not only which of these will have an impact and assessing which give the best value for money is tricky.

This group of growers has decided to undertake a field lab as part of the AHDB GREAT soils CP107b project to do some initial trials of currently available options.

Included in the trial are:

- Woodchip
- Biochar
- Green waste compost
- Bio-stimulant
- Mycorrhizae

Participants are interested in a variety of outcomes including:

- Soil structure
- Weed control
- Soil PH
- Water retention and drainage
- Tree establishment
- Fruit quality
- Fruit storability
- Yield

Growers will try the various diversity of soil amendment materials according to their own individual recommendations, and then adapt them for the different fruit systems. This is a farmer led trial experiment not a scientific experiment. the researcher will talk individually to each grower to advise on trial design.

A public meeting was held in November 2016 with 12 participants.

Field Lab 3: The impact of whole digestate on soil health in field-grown vegetable crops on the Moray Coast

The field lab aims 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.

The impact of whole digestate applications on soil health has not been studied in soils used for vegetable production systems to date. Despite the fact that there are now over 300 anaerobic digestation plants in the UK, some of which are operating in and around vegetable cropping land, only one study (The DC-Agri project http://www.wrap.org.uk/content/digestate-and-compost-agriculture-dc-agri-reports) has focussed on the use of digestate on arable soils and none have looked at soils used for vegetable production.

Many consultants and AD companies promote the benefits of digestate as a soil improver despite evidence that it typically contains very little organic matter. Recent DEFRA and WRAP-funded work has suggested that the application of whole digestate has sometimes resulted in reduced soil organic matter content. There is a clear need to better understand the impact of digestate on soil health parameters in UK cropping systems including vegetable production systems.

A public meeting was held in March 2017 with 8 participants.

Appendix 4 – Media output

Press in Year 2

FPJ print/online, 22 April 2016	**Soil Association Launches Soil Project - online version corrected to include partners**
FPJ print article p 26, May 2016	**British Soils 'Need More Care'**
Organic Farming Magazine Spring 2016 Issue 212	**Full page image with project info - What is a healthy Soil?**
IOFGA Organic Matters Magazine Spring 2016	**How Do You Assess the Health of Your Soil?**
FPJ online, 3 March 2016	Livestock Would Improve Soils for Growers - uses image from GREATsoils day
AHDB Grower, June 2016	**Breaking New Ground**
Horticulture Week, 22 July 2016	**Cross-sector funding secured for crop studies**
Farmers Weekly, August 2016	**Mention for project and workships in sidebar in article Why Future Uk Harvests Hang in the Balance**
Organic Farming Magazine, Summer/Autumn 2016 Issue 213	**Soil Health**
Horticulture Weekly, 16 September 2016	**Herbs field day covers soil issues**
The Vegetable Farmer, December 2016	**Cover crops show benefits for soil health**
South East Farmer, 1 December 2016	Field Trials
Farming UK, 21 December 2016	**GREATsoils programme showcases peer-to-peer learning**
East Anglian Daily Times, 24 December 2016	Success with soil events
Fresh Produce Journal 13/01/2017	Info box - GREATsoils project in 2017
Fresh Produce Journal, 13/01/2017	**Soil Organic matter in the Spotlight [Dirty Talk]**
Organic Farming Magazine Winter 2017 Issue 214	**How taking care of my soil bears fruit**
Western Daily Press, 22 March 2017	**Keep your Soil Covered for Financial Gain**

Blogs

Blog	Views to 31 March 2017
How I develop GREATsoils and cut costs - Phillip Hubbert, Jepco	210
Soil health is behind everything we do - Joe Rolfe, Taylorgrown	124
How taking care of my soil bears fruit - Paul Smith, Loddingtons	31
Does sowing green manures early improve soil quality? - Iain Tolhurst, Tolhurst Organics	51
Nurturing soil for intensive cropping - Steve Nickells, Valefresco	70

Video

Why managing soils is important – 174 views https://youtu.be/cMdP2Igv5mU

Twitter

933 followers – up from 168 at the end of the first year.

GREATsoils network

460 sign-ups via events and web form – up from 108 at the end of the first year.

