

Agronomists' Induction: Session 7

Judith Stafford



East Midlands



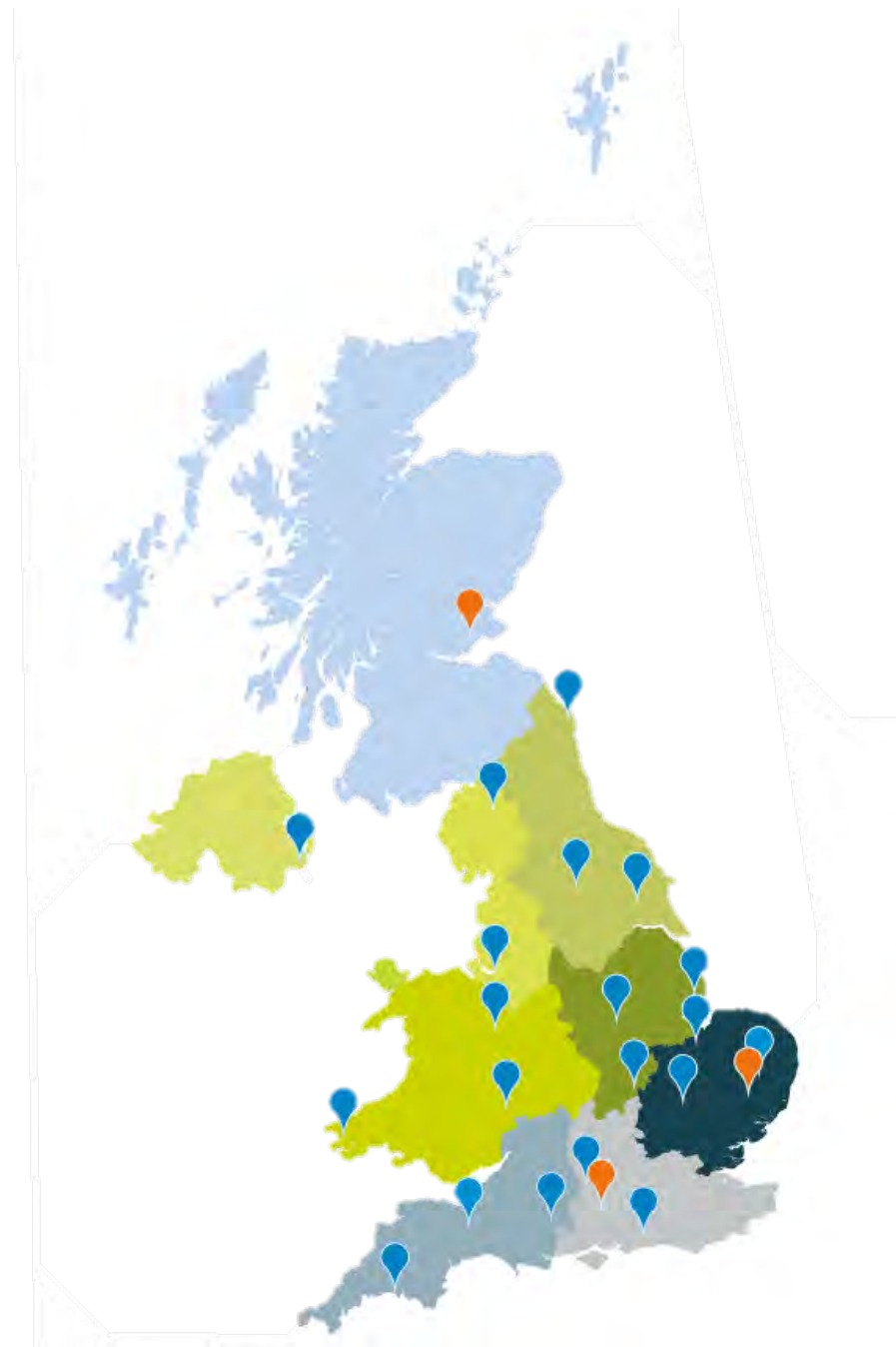
Wainfleet
Gary & Debbie Willoughby



Vale of Belvoir
James & Michael Parker



Northampton
Rick Davies



Agronomists' Induction: Session 7

Soil health

Amanda Bennett, Resource Management Scientist (Soils), AHDB

Livestock in the arable rotation

Lizzie Sagoo, Principle soil scientist, ADAS

Soil health

Dr Amanda Bennett, AHDB

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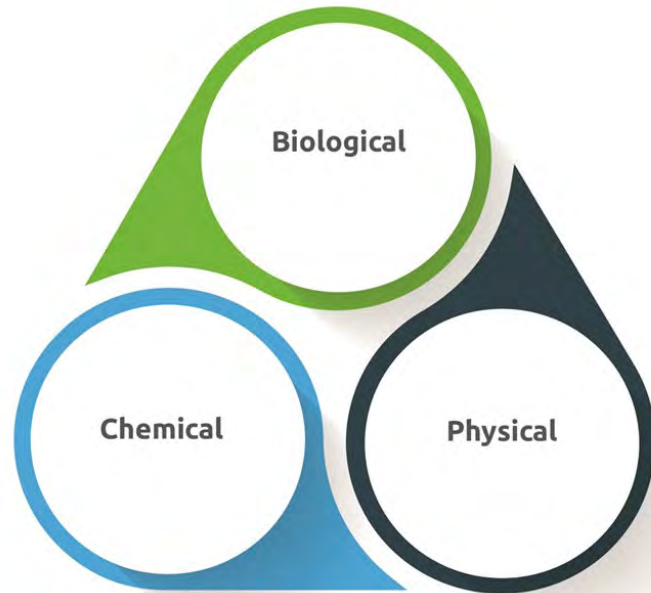
Soil functions

Soils deliver ecosystem services that enable life on Earth



Principles of soil management: Soil health

- “In a healthy soil, the interactions between **chemistry** (pH, nutrients and contaminants), **physics** (soil structure and water balance) and **biology** (including earthworms, microbes and plant roots) are optimised for the conditions in that place”



All soils are different



Physical

- Texture
- Structure
- Drainage

Chemical

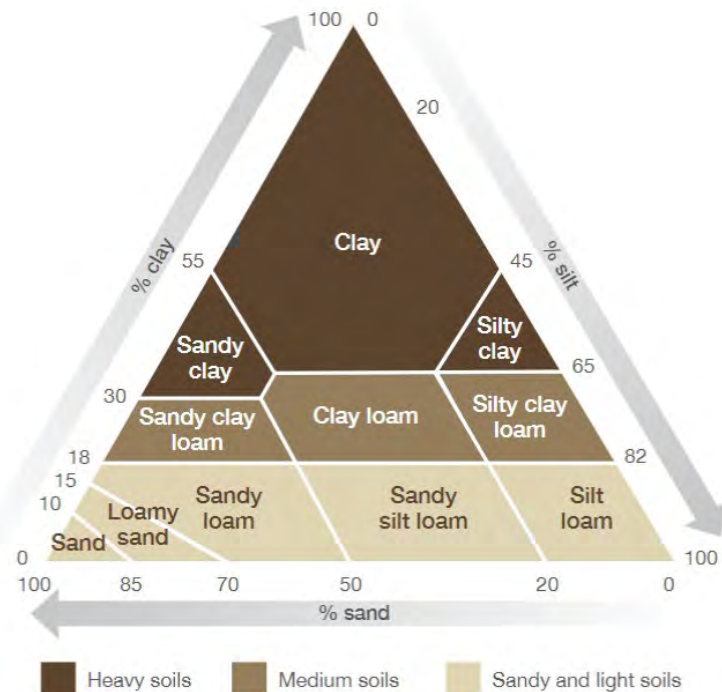
- pH
- N, P, K, Mg
- Minor nutrients

Biological

- Earthworms
- Soil food web
- Microbiology

Physical

- ✓ Know soil textures to understand limits to workability and trafficability
- ✓ Improve soil structure to provide an effective continuous pore space
- ✓ Optimise water balance, through drainage if necessary





FACTSHEET

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Soil structure and infiltration

Figure 1. Mini Disk Infiltrometer measuring effect of compost on soil infiltration

This factsheet outlines a simple method for measuring infiltration in the field. It also explains how adding organic matter to soil can improve soil structure and water infiltration.

Action points

- Improve soil structure to increase the ability of soil to absorb and retain water
- The use of organic materials such as compost and green manure can improve infiltration and the ability of soil to absorb increasingly intense winter rainfall
- Use the drainage test as a cheap and simple way to measure the infiltration of water into soil. When combined with the spade test, the cause of reduced infiltration (eg compaction at depth) can be quickly identified
- Improved infiltration of rainfall helps to reduce soil erosion and the loss of nutrients from land to water

Challenges

Although average annual rainfall for England and Wales hasn't changed significantly since records began in 1776, all regions of the UK have experienced an increase in heavy rainfall events in winter. These events are not restricted to winter: the spring of 2012 saw exceptionally wet weather which affected all of England, Wales and eastern Scotland.

An increase in the intensity of single-day rainfall events could lead to an increase in soil erosion and the associated loss of nutrients such as phosphate to drains and rivers. Managing soil health, in particular maintaining good soil structure, is an essential part of the strategy to improving resilience to changing rainfall intensity. Improving the ability of soil to absorb water during intense rainfall events (infiltration) reduces the risk of erosion. Improved infiltration also retains more water within the soil rooting zone for use by crops and reduces the risk of subsurface flow and leaching.

There are several ways to assess the rate of infiltration of water into soil (the hydraulic conductivity), with the more sophisticated methods giving more detailed information. For example, a Mini Disk Infiltrometer (Figure 1) not only

BETTER RETURNS

AHDB

Improving soils for Better Returns

MANUAL 3

BEET & LAMB

GREATSOILS

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Healthy grassland soils

Four quick steps to assess soil structure

Step one: Surface assessment

Look at the quality of the sward to identify potentially damaged areas that require further assessment. Where the sward is moderate or poor, this may indicate that further investigation of the soil quality is required.

 Good • Sward intact • No poaching • Few wheelings	 Moderate • Surface poached • Wheelings in places • More weed species	 Poor • Surface cupping • Soil exposed • Severe poaching • Poor sward quality
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Step two: Soil extraction

- Dig out one spade sized block of soil (approx. 30cm). Cut down on three sides and then leave the block out, leaving one side undisturbed
- Lay the soil block on a plastic sheet or tray

Tip: When starting out, it is useful to dig in an area where you know there may be a problem (eg a gateway) and get familiar with signs of soil structure damage.

Remember: Sample when the topsoil is moist – if the soil is too dry or too wet, it is difficult to distinguish signs of poor soil structure.

Step three: Soil assessment

Identify open the soil block like a book to break it up:

- If the structure is uniform – assess the block as a whole
- If there are two or more horizontal layers of changing structure, identify this layer with the poorest structure (the straggly layer)
- Carry out the rest of the assessment on this straggly layer

 Good	 Moderate	 Poor
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Step four: Soil scoring

Break up the soil with your hands into smaller structural units or aggregates (see clumps).

- Assign a score by matching what you see to the descriptions and photos below
- A score of 1 to 3 is Good, a score of 3 to 4 is Moderate and 4 to 5 is Poor and requires management action
- Record the depth of the straggly layer to assess management options

 Good	 Moderate	 Poor
----------	--------------	----------

How to conduct a quick assessment of your soils



Chemical

- ✓ Maintain an optimum pH
- ✓ Provide plant nutrients in the right amounts in the right place at the right time

GREATSOILS

Soil pH – how to measure and manage it based on an understanding of soil texture

Audrey Litterick, Earthcare Technical

Figure 1. Lime spreading

Action points for farmers and growers

- Know the texture and type of soils on your holding
- Test your soil pH regularly (at least once every four years and ideally once every two years if you are a high value crop grower on a light soil) and interpret the results correctly for your own soil types
- Choose an appropriate sampling strategy for your own farm and be prepared to spend money on more samples where you find evidence that soil pH could be impacting on crop yield or where you suspect big differences in soil pH within fields
- Be aware that some organic materials applied to improve soil health (e.g. composts, digestates and some types of paper crumblies) have a liming (or neutralising) value. It is easy to test these materials for their liming value so that you can determine the likely effect of using them at different application rates on soil pH
- Be aware of the differences between different types of liming agents and their relative advantages and disadvantages. As well as bearing in mind price, choose those appropriate for your own soils

Background

Maintaining optimum soil pH values in all parts of the field is essential in order to maintain soil quality and health, crop quality and yield. This guidance document explains why soil pH is important and outlines the impact of soil type and texture on pH. It describes how and when to test soils for pH, how to calculate the amount of lime or other neutralising materials required, which liming product(s) to use and how and when to apply them.

Soil pH is a measure of the relative acidity or alkalinity of a soil. While the scale goes from 0 to 14 (with a neutral pH represented by 7.0) most agricultural soils have pH values of between 5.5 and 7.5. The pH scale is logarithmic; that is a pH of 5 is ten times more acidic than a pH of 6. The natural pH of a soil is determined by its chemical composition, but most agricultural soils with natural pH values of less than 7 will gradually acidify over time and regular applications of lime will be needed to maintain soil pH at target (Figure 1).

Soil pH has a profound effect on nutrient availability to crops, with most essential plant nutrients being most available to most crop plant species within the pH range of 6.0 to 6.8. Crop quality and yield can be severely affected where soil pH is not maintained close to target for the soil and crops in question and total crop failure is possible in vegetable crops where trace element deficiency has resulted from inappropriate soil pH. Soil pH also affects uptake of potentially toxic elements (PTEs), with PTEs such as cadmium made more available for crop uptake at lower pH values. Soil pH also affects the numbers, diversity and functions of beneficial and pathogenic micro-organisms as well as the larger organisms including both soil-dwelling pest species and beneficial macrofauna species. For example, the soil-borne pathogen *Rhizoctonia solani*, which causes clubroot in vegetable brassicas and oilseed rape, prefers more acidic soils, and liming to raise the soil pH is a management option for clubroot control. Earthworms are most abundant and active in soils with pH values between 6.5 and 7 and most species cannot function well in soils with pH values lower than 6.0.

Failure to correct soil acidity can cause substantial yield losses and a decline in soil quality and health. Over-use of lime (or certain organic materials which have neutralising values) can create problems with trace element availability. A survey by the Professional Agricultural Analysis Group in 2014-15 found that soil pH was less than 6.0 in 17% of arable soils tested and less than 5.5 in 19% of grassland soils tested.

CASE STUDY

GREATSOILS

Soil Biology and Soil Health Partnership Research Case Study

Testing the long-term effect of pH on soil health

Figure 1. Aerial image of the Woodlands long-term experiment at Craibstone. Crop rotation: Three-year grass/clover ley (Grass Year 1-3), winter wheat, potatoes, spring barley, swedes, spring oats undersown (u/s) with grass-clover

Background

Food and fibre crops need suitable soils that are maintained to provide optimal soil structure, water retention and nutrient availability. The physical, chemical and biological properties of soil interact to deliver these functions. Measuring soil health, therefore, requires an integrated approach, combining the assessment of these three factors. The chemical and physical constraints of soil on crop and grassland productivity are well understood, but the role of soil biology is less clear. A key aim of the Soil Biology and Soil Health Partnership is to improve our understanding of soil biology and to explore the ways in which farmers can measure and manage soil health. The Partnership has developed a soil health scorecard, which aims to provide information on key indicators of soil chemical, physical and biological condition, to help guide soil and crop management decisions. This is now being tested at long-term experimental sites (LTS), where the key drivers of soil biology – food source, physical and chemical environment – are being explored.

Long-term experiments at SRUC Craibstone

Soil pH is a key component of soil health because it affects soil chemical (e.g. availability of nutrients), biological (e.g. microbial activity) and physical properties (e.g. aggregation of clay minerals). The long-term pH trial in Woodlands Field at SRUC Craibstone near Aberdeen was set up in 1961.

Nutrient Management Guide (RB209)

Updated January 2018

Nutrient Management Guide (RB209)

Updated January 2021

Section 2 Organic materials

Biological

- ✓ Feed the soil (organisms) regularly with organic matter
- ✓ Move soil only when you have to
- ✓ Diversify crops in space and time



GREATSOILS
Compost is good news for soil health
Case Study 1 – Audrey Lister, Earthcare Technical

Figure 1. PAS 100 compost

Action points

- Aim to increase your Soil Organic Matter (SOM) levels, as this can have multiple benefits for soil health. Adding compost to your soil is an effective way of increasing SOM. In trials, compost increased SOM in half the time of farmyard manure.
- Check guidelines before using compost. Most UK farm assurance schemes now permit the use of quality PAS 100 composts*, as do most produce buyers, but some have rules governing their use.
- Determine if adding compost to your soil is cost effective by comparing the costs of buying, hauling and spreading compost with the financial value of the nutrients compost supplies and the yield benefit.
- Bear in mind that soil quality and yield benefits can take several years of continued compost use to develop.

*Quality compost suppliers can be found by visiting the holdings page on the UK Compost Certification Scheme website: qualitycompost.org.uk/index.htm

Background

Soil Organic Matter (SOM) is the organic component of soil, consisting of these main parts:

- Fresh plant residues and small living soil organisms
- Decomposing (active) organic matter and
- Stable organic matter (humus)

Organic matter is important for soil fertility and crop productivity: building and maintaining it is a vital component of sustainable soil management. The amount of organic matter in soils depends on soil texture, climate, the input and composition of organic materials, decomposition, and the type of farming system employed.

Soil used for arable and vegetable production typically contain 1-2% organic matter (generally higher in Scottish soils). In general, for any one cropping system, the natural level of SOM in a clay soil will be higher than in a sandy soil, and grassland soils usually contain more relative to a continuous arable rotation. Therefore, whilst it is generally good to increase your SOM content, vegetable growers on a sandy soil should not expect to achieve and maintain the same SOM content as pasture-fed livestock-producing neighbours on a heavier soil.

Many soils are suffering from a lack of organic matter. Farmers and growers often want to maintain or enhance SOM content as this can have a range of benefits for soil health. However, recent work has shown that, where improved soil quality is concerned, not all forms of organic matter are equal. Given that applying bulky organic matter has a financial cost, it is important to understand the merits of different organic materials.

FACTSHEET
GREATSOILS
Measuring and managing soil organic matter

Figure 1. Well structured clay loam soil in an arable rotation with organic matter distributed throughout the topsoil (credit: Simon Cowell)

What is soil organic matter?

Soil organic matter is the term used for all living, or once-living, materials within, or added to, the soil. This includes roots developing during the growing season, incorporated crop stubble or added manures and slurries. All organic matter contains carbon (C), but it also contains nitrogen (N), phosphorus (P), sulphur (S), potassium (K), magnesium (Mg), calcium (Ca) and a whole range of micronutrients (e.g. copper, (Co) and zinc (Zn)).

Soil organic matter is found in all sorts of forms with a range of ages. If we look very carefully at the C atoms, we find some that were fixed from carbon dioxide by photosynthesis last week and some that date back over 10,000 years. The intermingling of organic matter with minerals from the underlying parent material (geology) is a key process in soil formation.

What does soil organic matter do?

Organic matter adds to soil fertility and overall soil health by enhancing the physical, chemical and biological properties of soil (Figure 2):

- Fresh plant residues fuel biological life in soil
- The amount of active decomposing organic matter in soil has a large impact on biological properties, nutrient cycling and soil structure
- Stable organic matter changes the colour of soil and adds significantly to the active surface area, thereby changing the physical and chemical properties and processes in soil. This is very important in sandy and light silty soils.

Organic matter is more than just carbon.
Researchers more often use 'soil organic carbon' rather than 'soil organic matter', but these are different ways of measuring the same basic soil property.

AHDB
Livestock and the arable rotation

FACTSHEET
GREATSOILS
How to count earthworms

Importance

Earthworms improve plant productivity, are principally responsible for engineering the soil environment and are an important food source for native birds such as the song thrush. There are up to 10 common earthworm species in agricultural soils and these can be grouped into three ecological types: epigeic, endogeic and anecic earthworms – each group having a unique and important function. Earthworms are an indicator of soil health, being impacted by pH, waterlogging, compaction, tillage, rotation and organic matter management.

What do earthworms tell us?

- A good presence of earthworms across a field means the benefits are likely to be widespread
- High numbers of earthworms indicate the potential for significant benefits to plant productivity
- The presence of each ecological group indicates the potential for specific earthworm benefits, such as carbon cycling, nutrient mobilisation and/or water infiltration

How to identify earthworms

Epigeic (litter-dwelling earthworms)

- Dark red-headed worms
- Small (<10cm) in size, typically about the length of a matchstick
- Often fast-moving (most likely to escape from the worm pot)

Sensitive to: Tillage (disturbance) and organic matter management (such as manure applications) (beneficial)

Roles: Carbon cycling and prey for native birds

Endogeic (topsoil earthworms)

- Pale-coloured and green worms (not red)
- Small to medium size
- Often cut up when handled, and green worms may emit a yellow fit

Sensitive to: Organic matter management (beneficial)

Roles: Soil aggregation and nutrient mobilisation for plants

Anecic (deep burrowing earthworms)

- Dark red or black-headed worms
- Large size (>10cm), typically similar size to a pencil
- More deep vertical burrows, often 2m
- Often found below surface earthworm casts or midden residue piles
- Feed at night, foraging the soil surface around their burrows for litter
- Commonly found in grassland but often absent from ploughed fields and where there is no surface litter

Sensitive to: Tillage (disturbance) and organic matter management (such as manure applications and straw return) (beneficial)

Roles: Deep burrows that improve aeration, water infiltration and root development

Principles of soil health

- > [Soil is an essential natural resource](#)
- > [Soil classification \(type\)](#)
- > [Soil structure](#)
- > [Soil organic matter](#)
- > [Water and soils](#)
- > [Principles to improve soil health](#)
- > [Useful links](#)

Although soil type cannot be easily changed, knowing which soil type is present helps determine how to manage the soil to optimise its structure, water relations, and nutrient supply.

Soil is an essential natural resource

Healthy, fertile soil is a dynamic living system with physical, chemical and biological properties that promote plant and animal health and maintain environmental quality.

Soil classification (type)

Soils are formed over thousands of years and reflect geology, past climate, vegetation, landscape, human activity, and management.

[Find out more about the inherent properties of different soil types](#)



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Sector Topic

soil biology

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Soil organisms stabilise soil structure

Soil organisms help bind soil into stable aggregates.



The function of soil biology

Soil biology drives soil functions – find out more.



Soil microorganisms – fungi and bacteria

Soil microorganisms play a central role in driving soil processes.



Soil management for horticulture

This soil management guide is a practical manual for growers and agronomists with the primary focus on



Soil macrofauna – earthworms

Earthworms incorporate organic material into the soil and provide



Measuring and Managing Soil Organic Matter

Soil organic matter is the term used



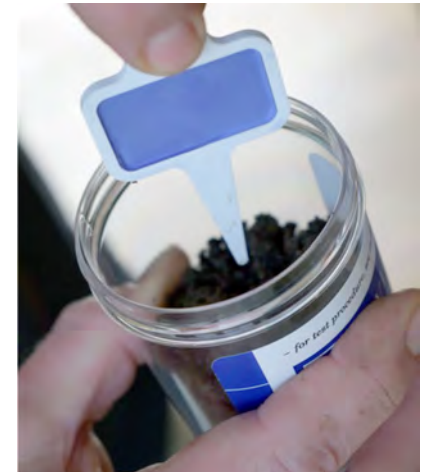
Research Case Study: Testing the effect of organic material additions on soil health



The soil food web and nutrient cycling

Soils contain a very high diversity of organisms. These soil organisms

Measuring and monitoring indicators of soil health



Overview

- Approaches to improve soil health:
 - ✓ Increasing organic matter inputs
 - ✓ Increasing crop rotation (length and diversity)
 - ✓ Reducing tillage intensity, where possible
- A soil health review can be used to:
 - highlight areas for investigation
 - measure and monitor improvements over time
 - start conversations about management approaches



Soil Biology and Soil Health Partnership



Soil health scorecards at Harper Adams University

Long-term experiment: Comparison over time on same replicated plots

October 2017 – 2 year Grass/clover ley

Attribute	Control	FYM (23 yrs)	Green compost (13 yrs)
SOM (%LOI)	3.0	4.1	4.0
pH	6.4	7.0	7.0
Ext. P (mg/l)	56	73	60
Ext. K (mg/l)	80	311	187
Ext. Mg (mg/l)	44	87	63
VESS score	2	2	1
Earthworms (No./pit)	11	13	11
PMN (mg/kg)	23	90	43
CO ₂ -C (mg/kg)	198	228	222

October 2020 – cereal stubbles

Attribute	Control	FYM (25 yrs)	Green compost (15 yrs)
SOM (%LOI)	2.7	3.2	3.4
pH	6.3	6.7	6.7
Ext. P (mg/l)	73	82	72
Ext. K (mg/l)	82	212	144
Ext. Mg (mg/l)	33	69	50
VESS score	3	3	3
Earthworms (No./pit)	1	1	1
PMN (mg/kg)	24	37	37
CO ₂ -C (mg/kg)	87	111	109

	Investigate
	Review
	Continue rotational monitoring

Unearth a wealth of resources on soil management at:

www.ahdb.org.uk/greatsoils

Visit the AHDB knowledge library for further information and access to research reports

www.ahdb.org.uk/knowledge-library

Find out about the Soil Biology and Soil Health Partnership at

www.ahdb.org.uk/soil-biology-and-soil-health-partnership



The background features a stylized landscape with rolling hills. The hills are represented by a series of concentric, wavy lines that transition from a dark blue on the left to a light green on the right. The text is overlaid on this background.

Livestock in the arable rotation

Integrating beef production into arable systems

Lizzie Sagoo, ADAS Soil Scientist

Grass/herbal leys – benefits for the arable producer

- Diversification
- Improved soil quality
- Weed management
- Profit



Integrating livestock into arable systems – benefits for the livestock producer

- Potential to start or expand production
- Reduced cost of production
- Need to link to arable farmers



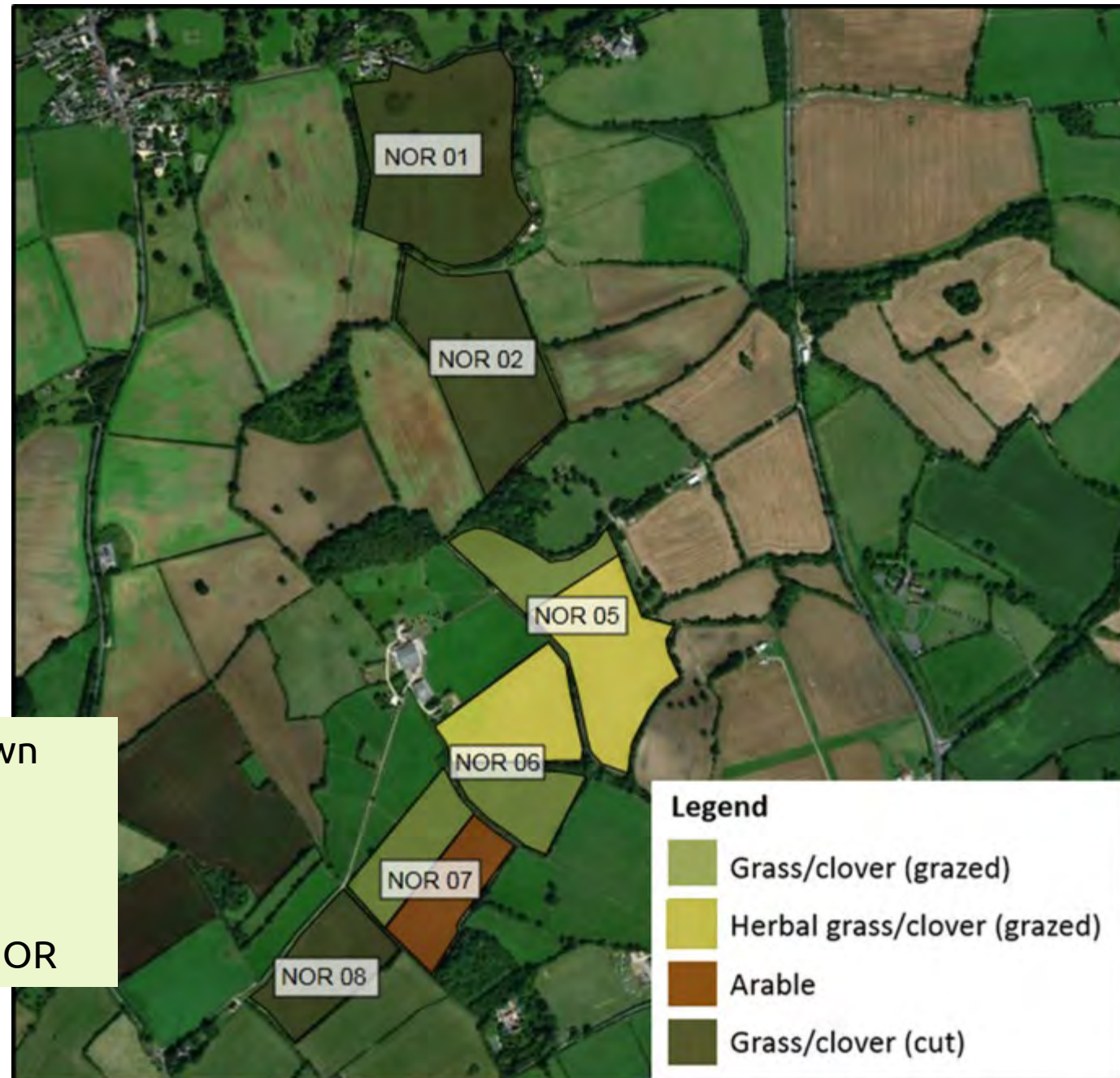
Integrating beef production into arable systems

- AHDB Beef & Lamb project (2016-2022)
- **Aim:** Investigate the practical, economic, environmental & agronomic implications of integrating beef enterprises into arable systems
- Norwood Farm, Somerset



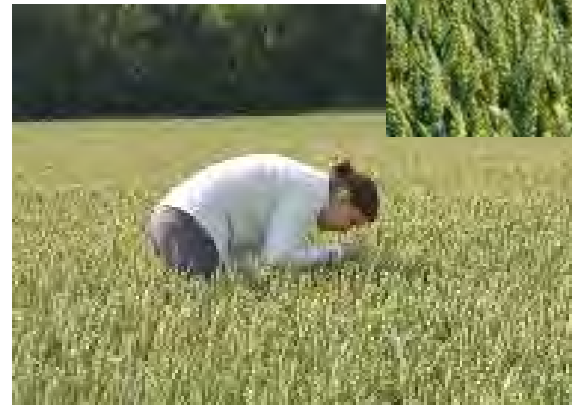
Norwood Farm Somerset

Autumn 2017 – grass sown
2018 – 1st yr grazing
2019 – 2nd yr grazing
2020 – 3rd yr grazing
2021 – Arable, cereals (NOR 07)



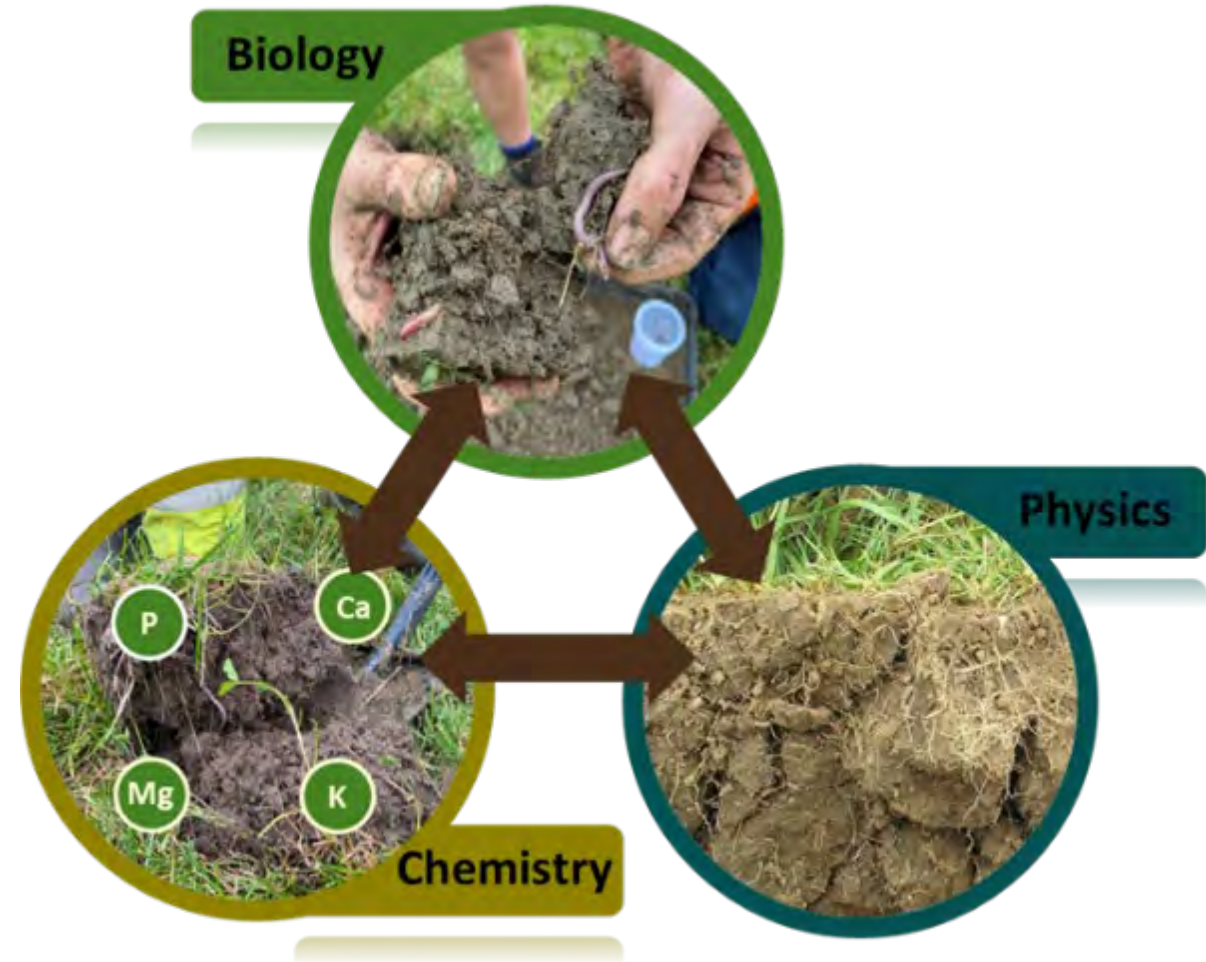
Norwood Farm - measurements

- Effect of grass/herbal ley on
 - Soil quality
 - Blackgrass
 - Yields of the following arable crop
- Forage quality & livestock performance
- Economics



Impact on soil quality

- Assess soil health
 - 6 fields at Norwood Farm
 - Baseline measurements in autumn 2017
 - Repeat measurements in autumn 2020
- Quantify the impact of grass and herbal leys on soil quality
 - Change between 2017 and 2020 measurements



Soil organic matter

- Measured by loss on ignition
- Average increase 0.3 percentage points between 2017 and 2020 ($P < 0.05$)
- Equivalent to an increase of 6 t/ha organic matter in the top 15 cm layer of soil

Leys – taking land
out of cultivation

Grazing animals –
manure inputs



Soil biological health - earthworms

- Earthworm numbers increased by a mean of 60% in grass fields between 2017 and 2020

Field		Worms (number/m ²)	
		2017	2020
NOR07	Arable	209	154
NOR07	Grass/clover	139	169
NOR06	Grass/clover	95	332
NOR06	Herbal	139	228
NOR05	Grass/clover	222	215
NOR05	Herbal	197	323



What is the benefit to the following arable crop?

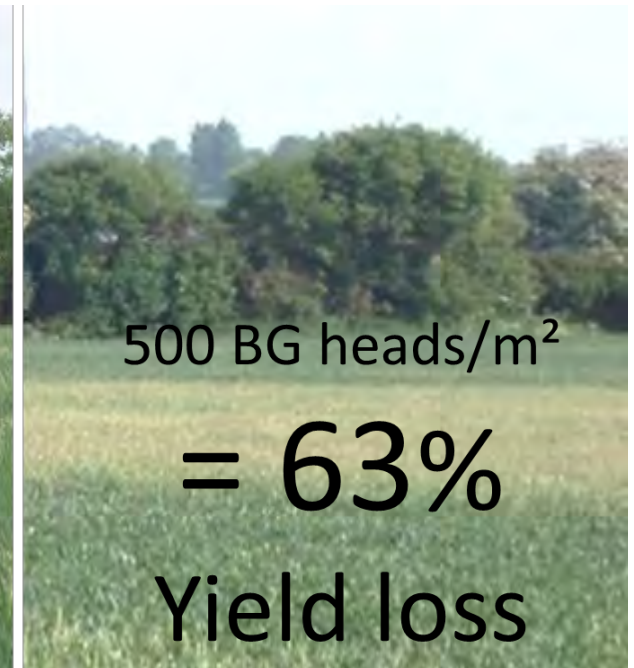
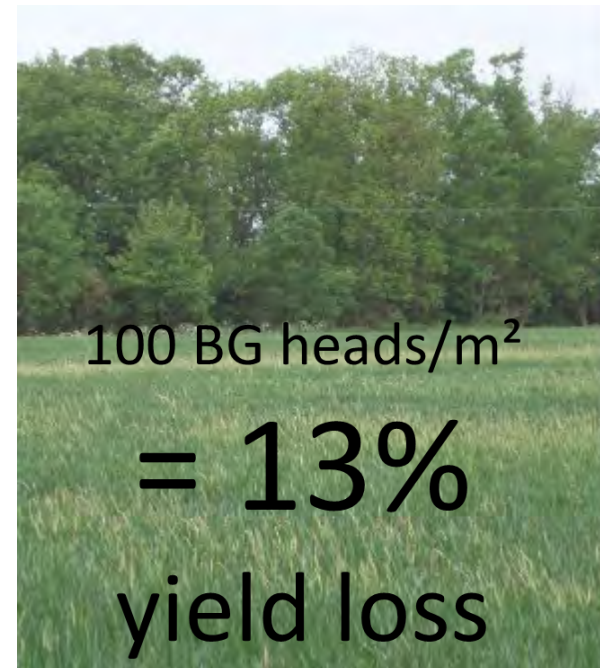
- NOR 07 field was split grass/clover and arable in autumn 2017
- Impact on blackgrass and 2021 barley crop

2017	Winter wheat	
2018	Grass/clover	Winter oilseed rape
2019	Grass/clover	Winter triticale
2020	Grass/clover	Wild bird mix
2021	Spring barley	



Using leys to manage weeds in the rotation

- Why do we need to manage weeds?
 - Herbicide resistance
 - Loss of actives
 - Yield loss
- Breaking the weed seed cycle
 - Seed return
 - Seed back



What is the benefit to the following arable crop?

- Blackgrass

2017	Winter wheat	
	57.5 heads/m ²	52.5 heads/m ²
2018	Grass/clover	Winter oilseed rape
2019	Grass/clover	Winter triticale
2020	Grass/clover	Wild bird mix
2021	Spring barley	
	0.16 heads/m ²	1.30 heads/m ²



- Impact on spring barley yields
 - Yields were 0.7 t/ha higher following grass/clover

Do the economics stack up?

Full cost benefit analysis of cattle in the rotation at Norwood

List of costs considered in the setting up of the ley and rearing the cattle

Set-up costs	Cattle production costs
Establishment of the ley	Variable costs
Tillage (e.g. discing, drilling, rolling)	Additional forage or supplementary concentrates
Inputs (e.g. seeds, sprays, fertiliser)	Fertilisers or sprays
Infrastructure costs	Vet and medicines charges
Fencing posts	Overheads
Fencing wire	Labour
Electric fencing equipment	Machinery/vehicles
Water troughs and pipes	Electricity
Handling system	Water
Labour	




Set-up costs at Norwood Farm

Ley establishment	Grass/clover ley £/ha	Grass/herbal ley £/ha	
Subsoiling, power harrowing + drilling and rolling	113	113	All associated costs included – e.g. fuel, labour and depreciation
Seeds	178	205	Price at time
Total	291	318	



Infrastructure	Grass/clover ley £/ha	Grass/herbal ley £/ha	
Fencing, gates water troughs, pipes, cattle crush	603	603	Materials only
Labour	417	417	All infrastructure labour
Total	1,020	1,020	



Total set-up cost	165	174	£/year of ley (inc. depreciation of materials)
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Cattle rearing/production costs at Norwood






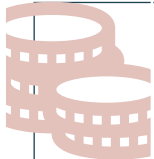
Variable costs	Grass/clover ley £/ha	Grass/herbal ley £/ha	
Supplementary feed, fertiliser and sprays	171	145	Only the grass/clover group received some additional silage
Vet and med	16.6	16.6	3 insecticide treatments
Total	187.6	161.6	



Overheads	Grass/clover ley £/ha	Grass/herbal ley £/ha	
Labour - cattle	150	150	Cattle management
Fertiliser spreading	15	15	Cost of the machinery and labour
Electricity, fuel and water	46	46	Mains water
Total	211	211	

Total rearing costs	93	87	£/head
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Estimated margin for Norwood Farm

	Cattle output - Valuation change
	Set-up costs - Ley and infrastructure costs
	Rearing costs - Cattle production
	Margin - Before rent and finance

Grass/clover ley	Grass/herbal ley
<i>Output per head</i> £184* <i>Output per ha</i> £791/ha	<i>Output per head</i> £191* <i>Output per ha</i> £821/ha
£165/ha	£174/ha
£399/ha	£373/ha
£227/ha	£274/ha

* Weight gained x £1.80 per kg

Margin comparisons

Net margin before rent and finance

Grazing leys

- Grass/clover ley
 - £227/ha
- Grass/herbal ley
 - £274/ha

Crops

Winter wheat	£567/ha
Winter barley	£222/ha
Spring oats	£198/ha
Spring barley	£180/ha
Winter oilseed rape	£101/ha
Winter beans	£27/ha
Spring linseed	£-293/ha

Source: AHDB Farmbench, South West farms on clay loam and silty clay loam soils
– 3 year average 2018 -2020
– Before rent and finance

Take home messages

- Grass and herbal leys & grazing livestock in the rotation
 - Soil quality benefits
 - Help control blackgrass
 - Diversified rotation
 - Impact on farm profitability
 - AHDB 'Mix and match' cost benefit calculator

ahdb.org.uk/beef-in-the-arable-rotation-mix-and-match-calculator



Thank you

Lizzie.Sagoo@adas.co.uk

 @Lizzie Sagoo



Day 2 Workshop – 12:25

- Red Group – Seminar 2
- Green Group – Emperor Suite
- Blue Group – Seminar 1