Crop establishment considerations

Strategic Farm Week 2020 Webinar

Rob Fox, Jane Rickson, Emily Pope and Richard Meredith

CEREALS & OILSEEDS

Housekeeping

@AHDB_Cereals
@Cereals_West
@SquabRob
@emilypope_KT
#strategicfarm

Strategic Farm Week 2020

ahdb.org.uk/sf2020

ahdb.org.uk/farm-excellence/strategic_cereal_farm_west

BASIS/NRoSO Points

Name; BASIS Account No; Postcode

Name; NRoSO Member No; Date of Birth; Postcode

Format

09:05	Introduction **Rob Fox, Strategic Cereal Farm West**
09:10	The global importance of soil health **Jane Rickson, Cranfield University**
09:20	The impact of crop establishment on soil health and crop rooting **Emily Pope, AHDB**
09:30	Soil management trials at Strategic Farm West **Jane Rickson, Cranfield University**
10:00	Harvest 2020 update and next steps for the trial at Strategic Cereal Farm West **Emily Pope, AHDB**
10:10	Discussion and questions

Your host…
Richard Meredith
@Cereals_West
Head of Arable Knowledge Exchange

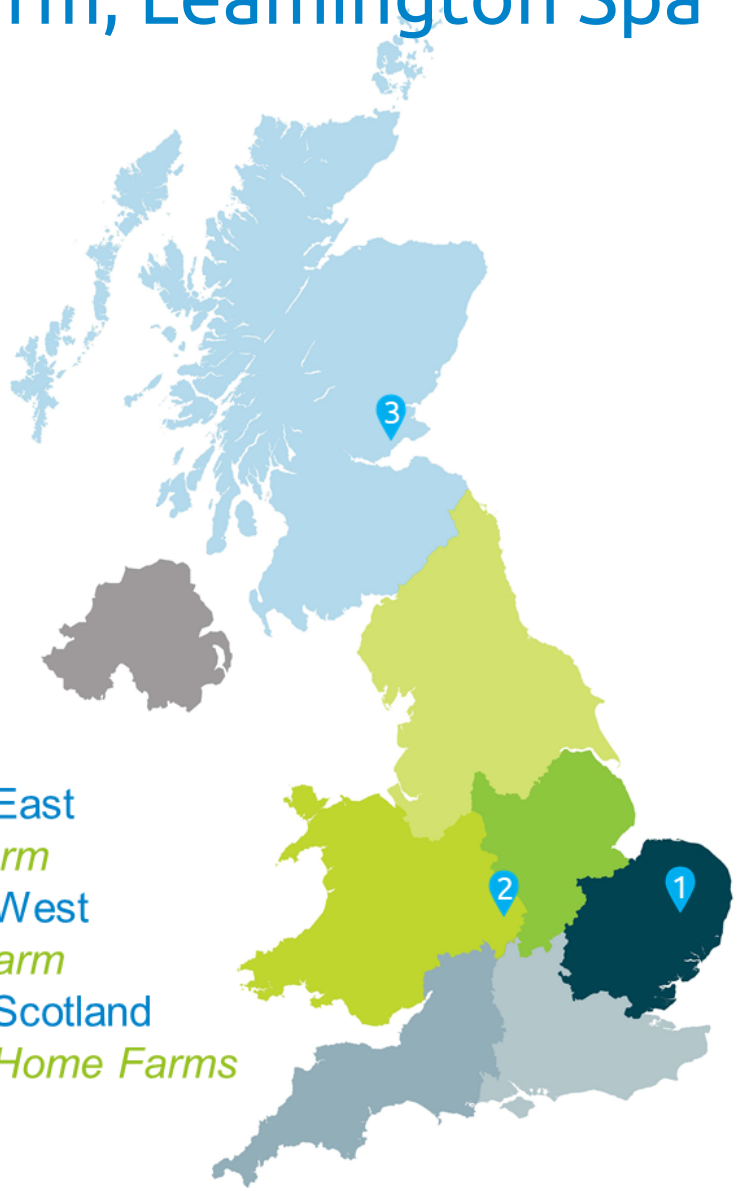
Introduction

Rob Fox, *Farm Manager at Squab Hall Farm and Strategic Cereal Farm West host* @SquabRob

CEREALS & OILSEEDS

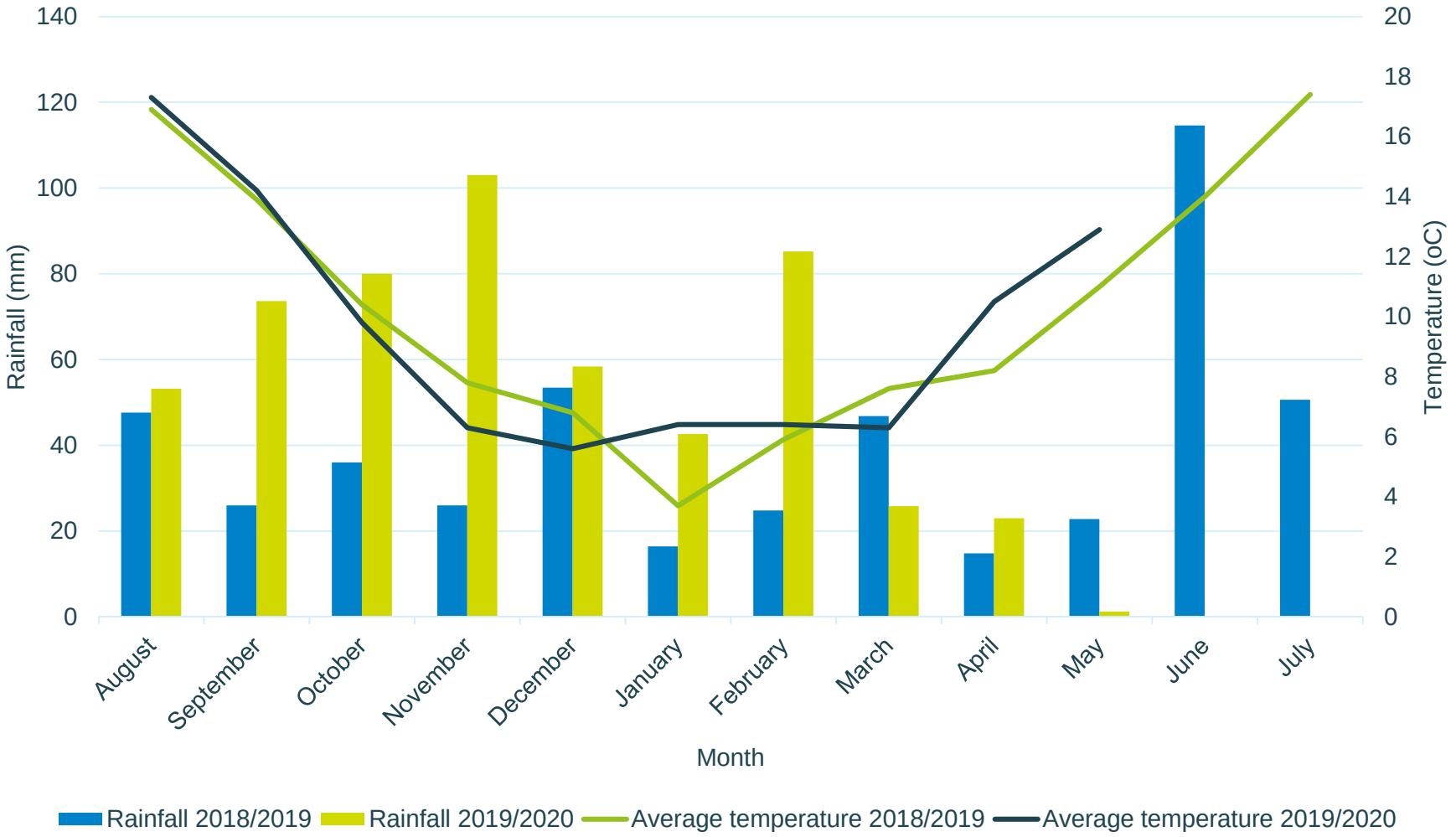
Rob Fox
Farm Manager, Squab Hall Farm, Leamington Spa

- AHDB Strategic Farmer 2018 – 2024
- 1000 acres arable
- 900 acres cropped
- Part of 1800 acre Arable Joint Venture



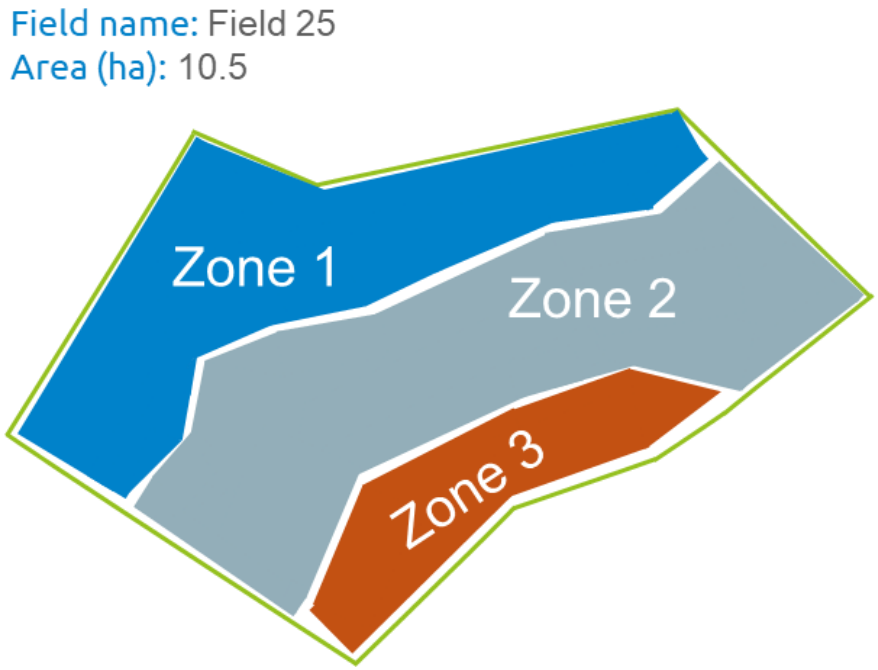
1 Strategic Cereal Farm East
Brian Barker, Lodge Farm
2 Strategic Cereal Farm West
Rob Fox, Squab Hall Farm
3 Strategic Cereal Farm Scotland
David Aglen, Balbirnie Home Farms

Weather data from Squab Hall Farm weather station



What is good soil health and how do we measure it?

- Baseline soil properties were assessed on 9 fields across the farm and evaluated using the soil health scorecard
- The fields were divided into soil management zones according to the underlying soil variability (as identified using the farm soil texture maps)



Overall evaluation across all fields on the farm (field averages)

Field number	2	6	16	13	15	25	42	7	49
Crop	WW	WW	WW	WW	WW	Sba	OSR	WW	WW
Texture	sandy loam	clay loam	clay				clay loam	sandy clay loam	
SOM (%LOI)	3.7	4.3	6.6	5.0	4.1	4.7	7.4	4.0	5.6
pH	6.1	6.6	7.4	7.1	7.3	7.9	7.5	6.6	6.6
Ext. P (mg/l)	42	53	23	20	21	17	32	47	19
Ext. K (mg/l)	233	288	233	331	202	384	455	244	160
Ext. Mg (mg/l)	169	490	707	1089	812	744	178	301	175
VESS score	2	3	3	3	3	3	3	3	2
Bulk density (g/cm^3)	1.31	1.30	1.20	1.27	1.36	1.24	1.20	1.35	1.20
Earthworms (number/pit)	9	11	6	10	3	3	6	7	8
PMN (mg/kg)	54	63	49	58	53	100	126	64	64
Respiration (mg CO_2-C/kg)	133	124	106	145	117	183	184	158	192

What is good soil health and how do we measure it?

- Both Visual Evaluation of Soil Structure (VESS) and bulk density showed evidence of some compaction across the farm, with poorer structure observed on the heavier textured soils
- Earthworm numbers were depleted in a number of fields

Summer Open Day 2019 handout is available at ahdb.org.uk

Field 15 Zone 3 Shallow cultivation Sq 4 'compact'

Crop establishment considerations: the importance of soil health

Professor Jane Rickson
Chair in Soil Erosion and Conservation

Soil and AgriFood Institute
School of Water, Energy and Environment
Cranfield University

AHDB Agronomy: West Conference – 4th June 2020

Crop establishment considerations: the importance of soil health

1. The global and local challenges ahead
2. The importance of soil and soil health
3. Soil management practices for healthy soils: implications of the Strategic Farm trials
4. Take home messages

1.The local and global challenges ahead: the need for soil health

How to achieve food security, given:

a) Increasing demands for safe, nutritious, accessible and affordable food

b) Finite amount of land

b) Competition with other land uses

biofuels, urban development, infrastructure

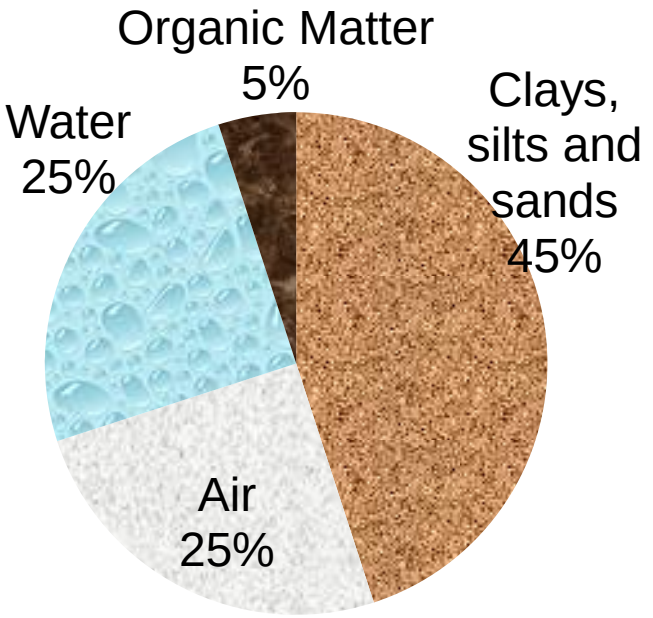
c) 'Yield plateau' – poor yield response to higher fertiliser use

d) Soil degradation (£1.2 billion per annum in England and Wales alone)

e) Climate change, extreme events and weather variability (and impacts on water management, crop production and land degradation)

…ALL ANSWERED BY "HEALTHY" SOILS???

2. The importance of soil and soil health



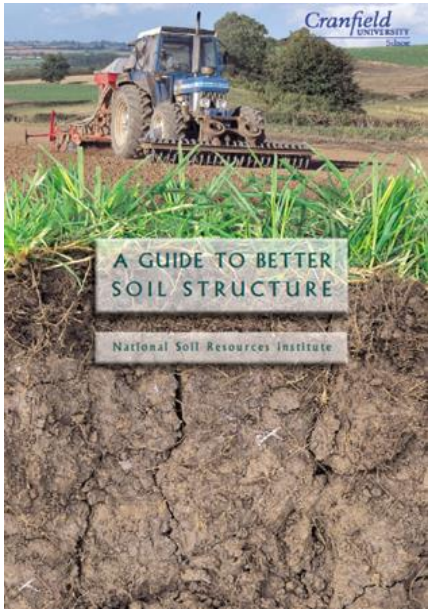
What is soil?

- Mineral content (texture: clays, silts and sands) ≈ 45%
  - Chemical composition (bonds between particles)
- Air ≈ 25%
- Water ≈ 25%
- Organic matter content ≈ 5%
  - Soil flora: roots and leaves
  - Soil fauna
    - macro-organisms e.g. earthworms
    - micro-organisms “microbes”
      - bacteria
      - fungi
      - viruses

The physical arrangement of soil particles, air space, water content and organic matter = soil structure

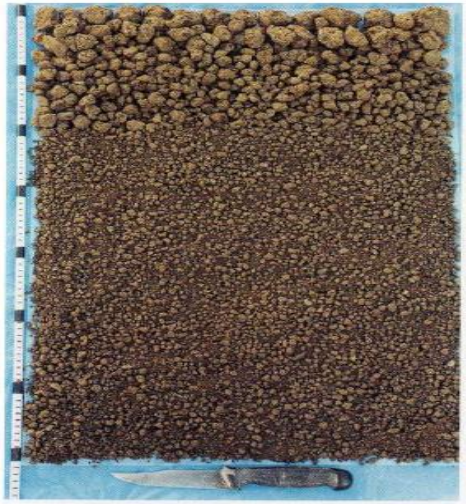
- Allows roots to grow
- Allows movement of air, water and soil organisms
- Affects soil strength / loading capacity (resist compaction)

2. The importance of soil and soil health

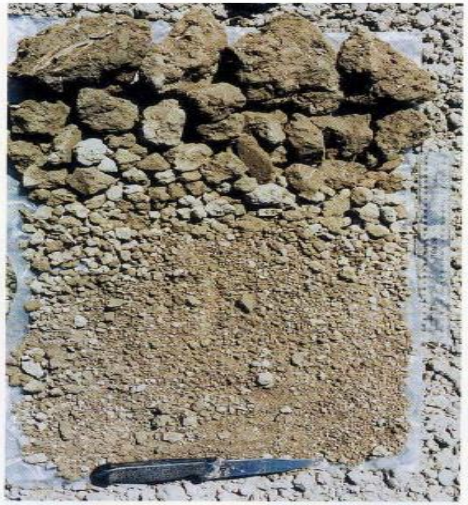


What is soil structure?

- Soil aggregate size distribution
- Pore size distribution
  - Macropores (easy drainage – a good or bad thing?; poor seed bed; lodging)
  - Mesopores (water storage / holding capacity (floods and droughts), water availability to crops)
  - Micropores (water unavailable to crops; less air and water movement)
- The 3 ‘Rs’: Well structured soils can **receive, retain and release** water



GOOD CONDITION VS = 2
Good distribution of friable finer aggregates with no significant clodding



MODERATE CONDITION VS = 1
Soil contains significant proportions of both coarse firm clods and friable, fine

POOR CONDITION VS = 0
Soil dominated by extremely coarse, very firm clods with very few finer aggregates

Visual soil assessment / evaluation (VESS/ VSA)

http://www.landcareresearch.co.nz/publications/books/visual-soil-assessment-field-guide

2. The importance of soil and soil health: The soils of England and Wales

Soils properties vary

- Texture
- Stoniness
- Organic content
- Depth to rock
- Mineralogy
- Permeability
- Natural drainage
- Consolidation
- Acidity

National Soil Map

- Product of 200+ years of field work
- 747 Soil Series (soil types)
- 306 Soil Associations (soil types occurring together)

www.landis.org.uk

2. The importance of soil and soil health: The soils of England and Wales

Soils p
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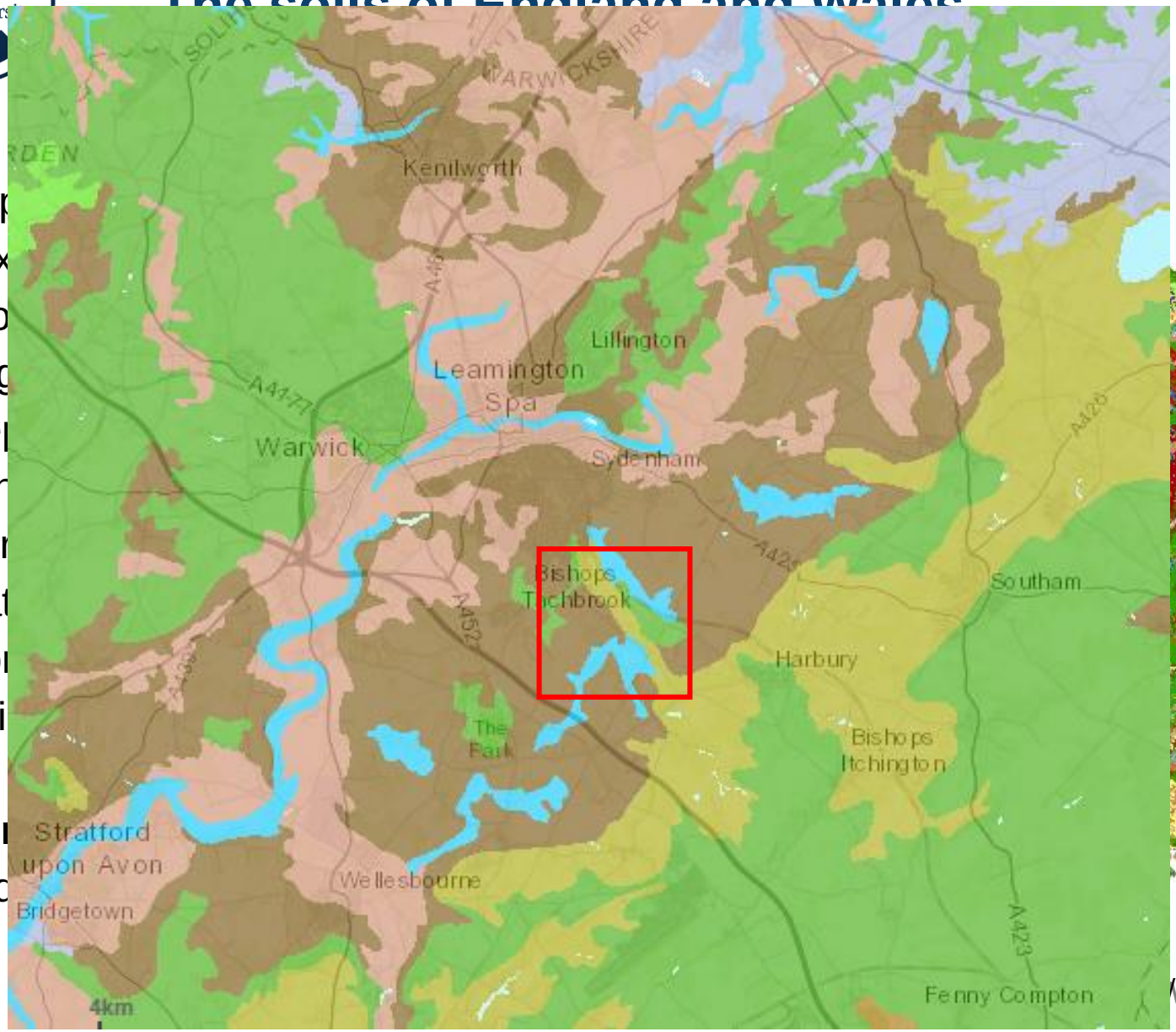

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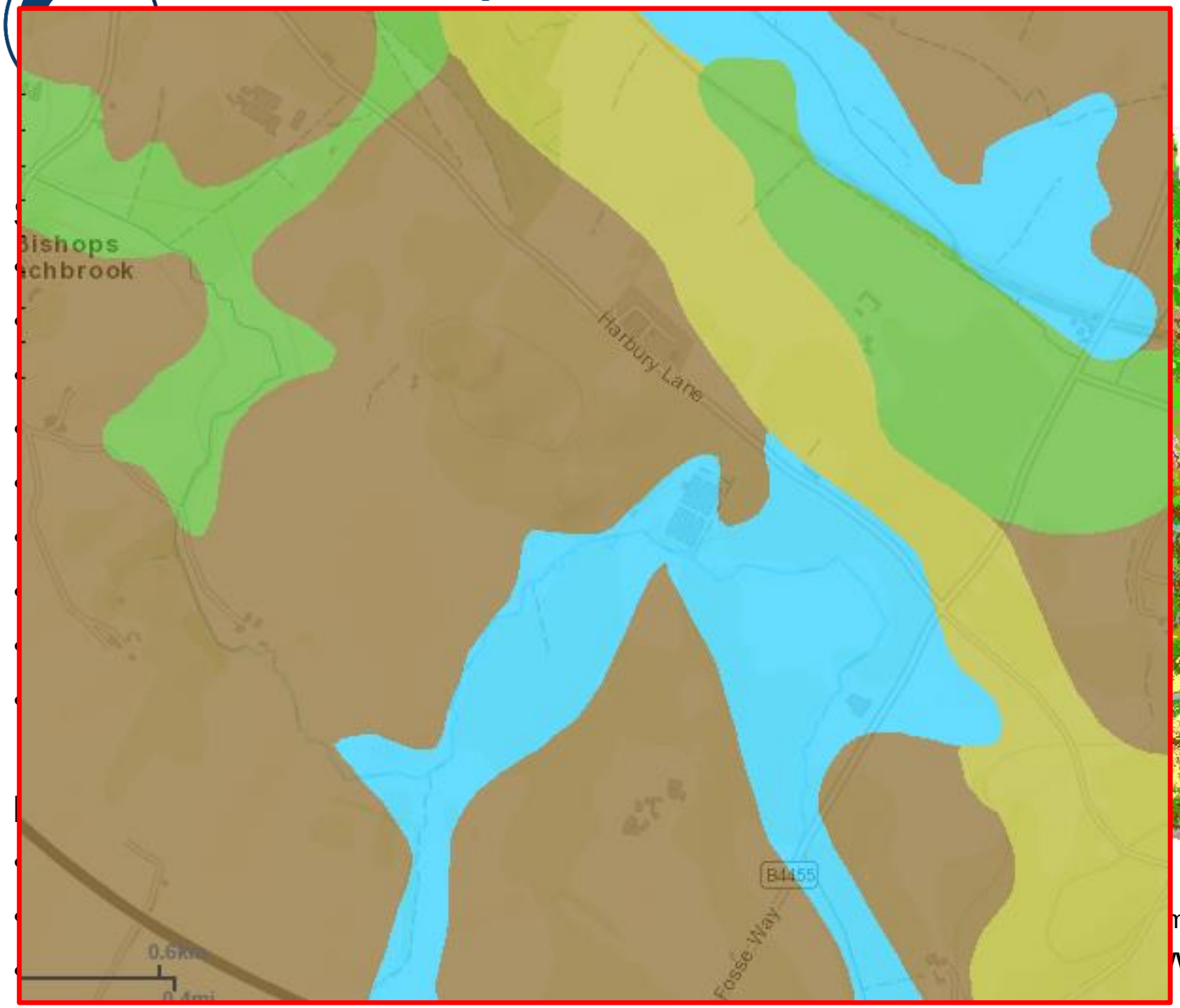

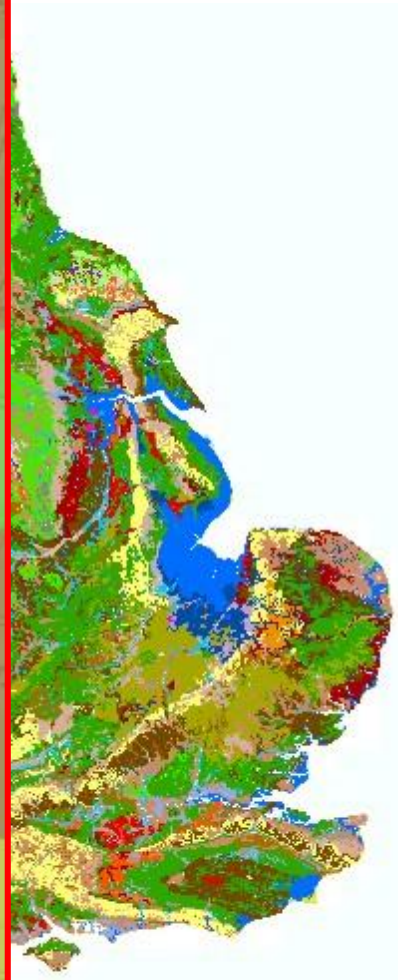

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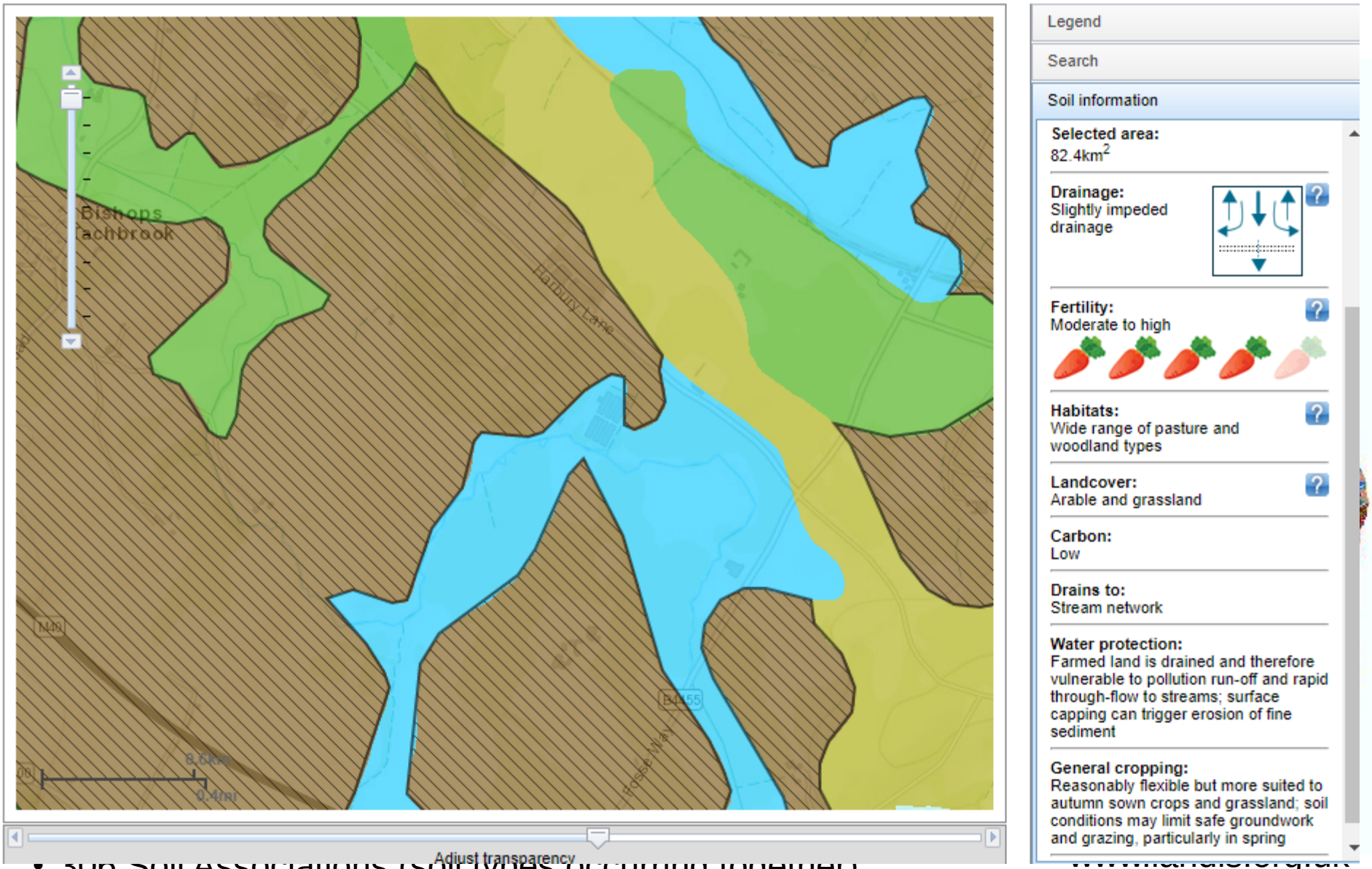


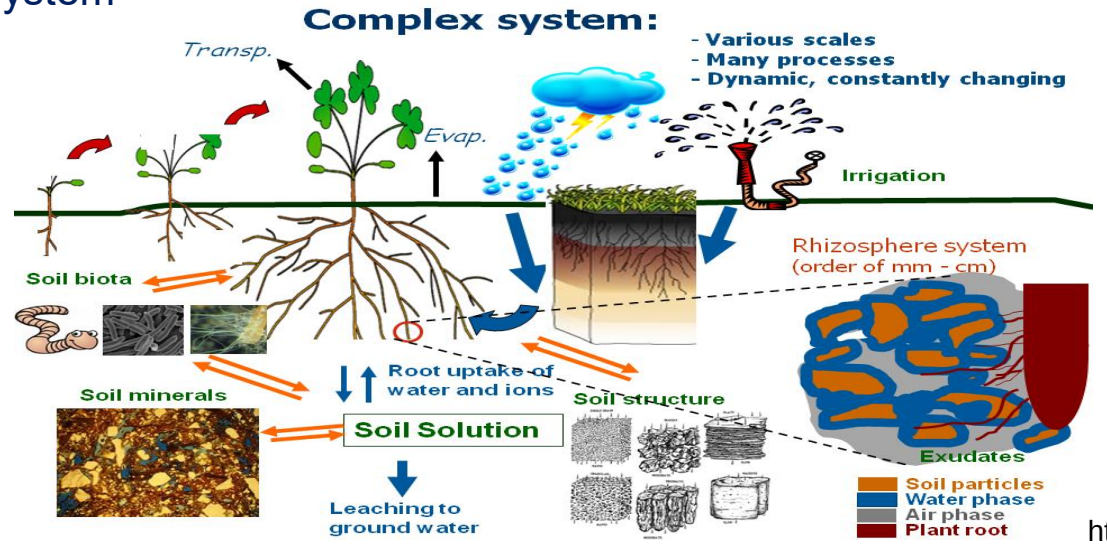
- 306 Soil Associations (soil types occurring together)

What is soil health?

Soil quality and health are related to soil properties:

- **Physical** (texture, depth, structure, porosity, density, water holding capacity, infiltration rate, stability: aggregates and mass)
- **Biological** (flora and fauna e.g. seed bank and micro-biota)
- **Chemical** (nutrients, carbon, pH)

…and interactions between them: soil as a complex 'system'



http://moradi.lawr.ucdavis.edu/Research.php

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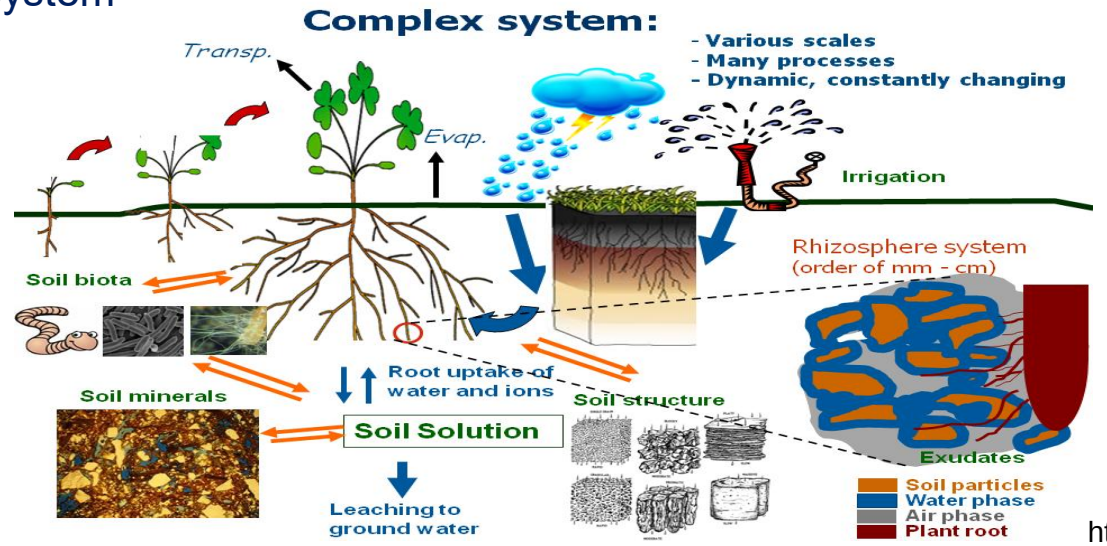

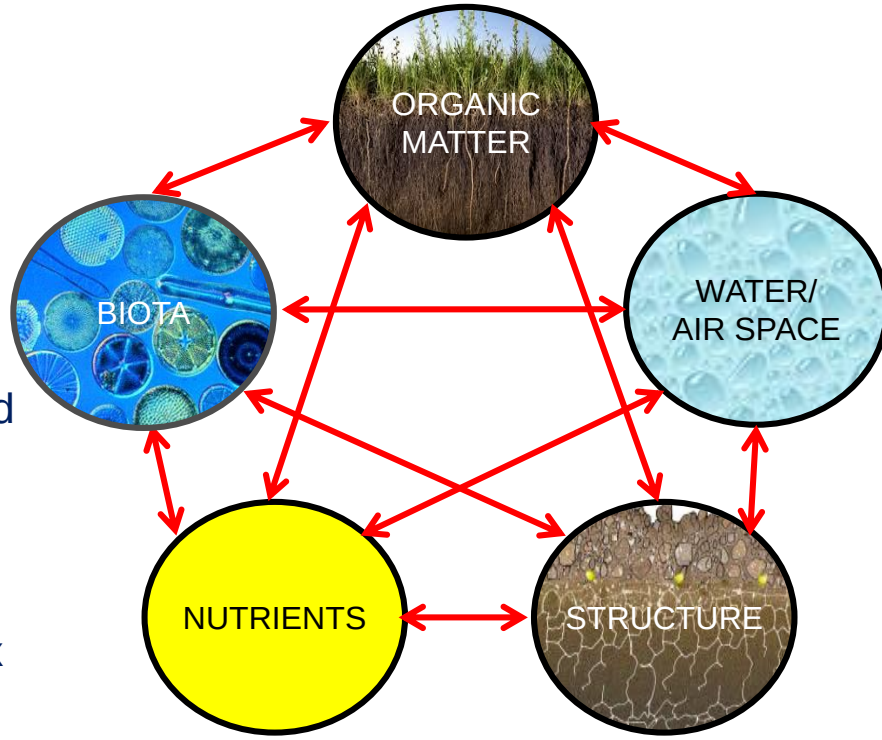

Soil health: the pivotal 5
(after K Ritz, pers. comm)

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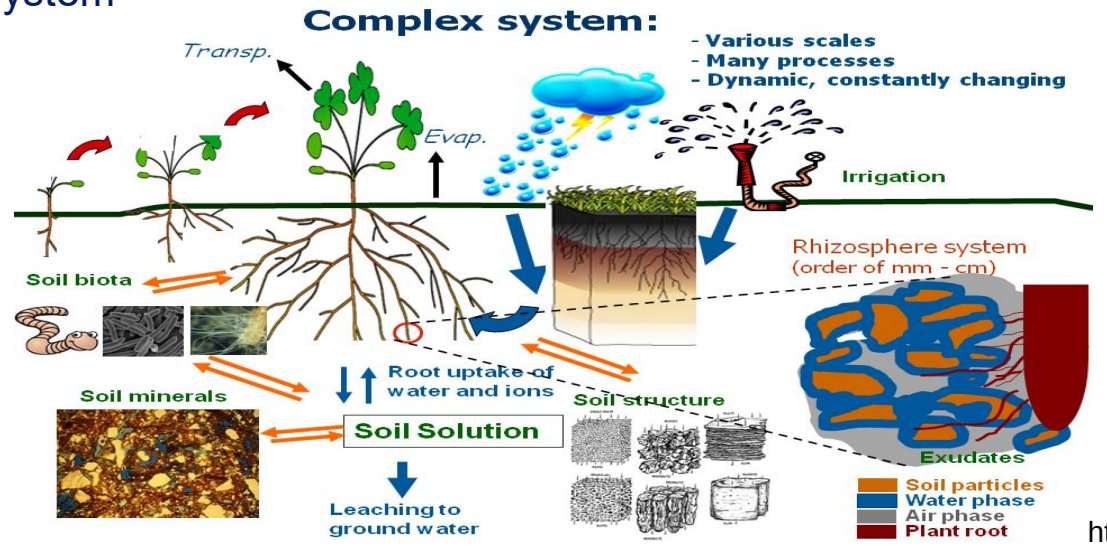

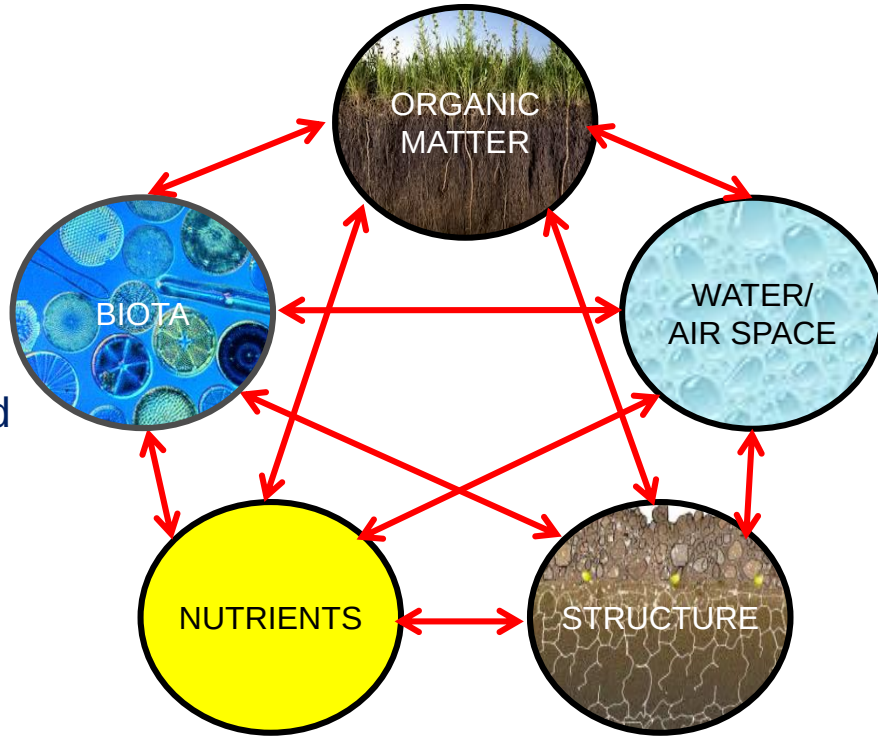

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3. Soil management practices for healthy soils

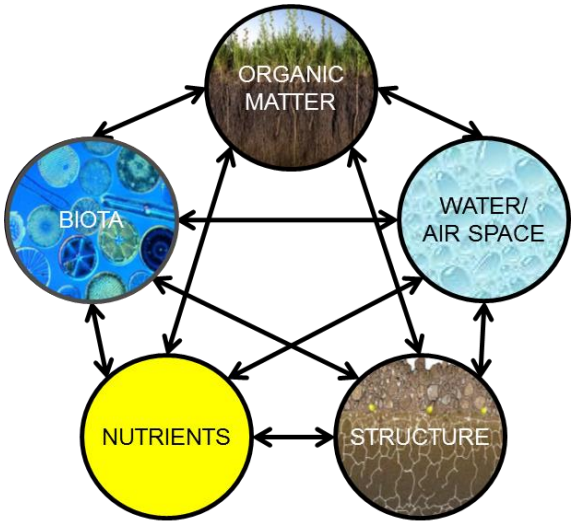
Aim: "To maintain a fertile seedbed and root zone, whilst retaining maximum resistance to soil degradation"

1. Enhance productivity (quantity, quality and reliability of marketable yield)
   - Improve uptake of water and nutrients by roots
   - Reduce pests / diseases / weeds

2. Control soil degradation
   - Erosion; diffuse pollution; compaction; losses of C, organic matter and habitats; salinisation; acidification

3. Concept of "sustainable intensification"
   - Producing more (quantity/ quality/ reliability of marketable yield) with less environmental impact / damage

1 + 2 = 3 ☺



Soil health: the pivotal 5
(after K Ritz, pers. comm)

Soil erosion, Bedfordshire

Cultivation trial at Strategic Cereal Farm West

Emily Pope *Senior Knowledge Transfer Manager*

@emilypope_KT

CEREALS & OILSEEDS

Background

Need to manage soils more sustainably and reduce erosion, loss of organic matter and compaction

Improving soil health is key part of the Strategic Cereal Farm west programme

Optimising cultivation strategies is one way of achieving improvements in soil health

Predicted decreases in summer rainfall in the UK pose a risk to anthesis and grain fill growth stages in cereal crops and a major limitation to crop yields

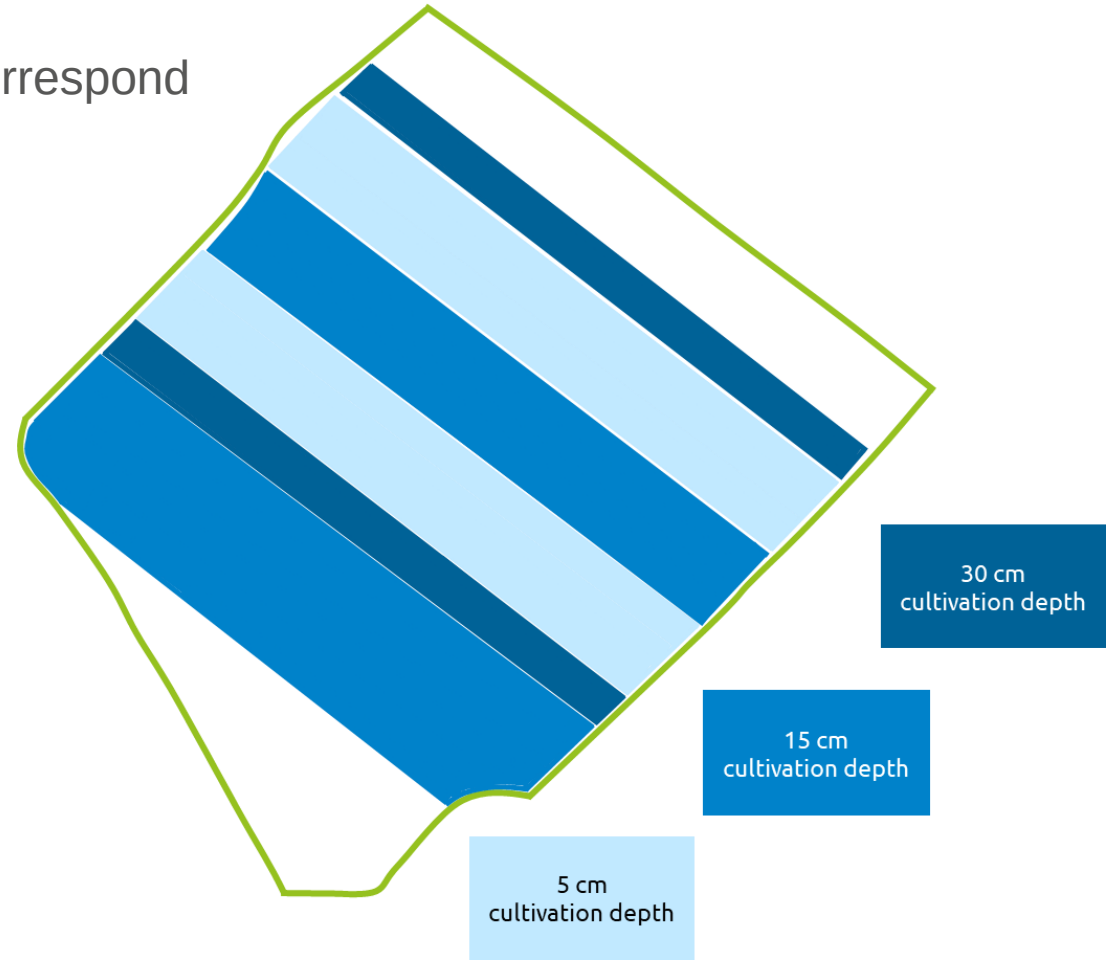
Roots cannot penetrate through strong soils

Many crops have insufficient roots systems to fully access water below 40 cm

Trial design – harvest 2019

- Drilled: October 2018
- Crop: winter wheat
- Six sampling zones to correspond with each treatment area

Area (ha): 16.88
Soil type: medium to heavy clay



Results – harvest 2019
Soil health scorecard

Treatment (cultivation depth)	5cm	15cm	30cm
Texture	Clay	Clay	Clay
% clay	38	39	39
SOM (%LOI)	4.1	4.1	4.1
pH	7.2	7.0	7.7
Ext. P (mg/l)	20	26	16
Ext. K (mg/l)	192	199	216
Ext. Mg (mg/l)	712	821	902
VESS score (limiting layer)	4	3	3
Bulk density (g/cm^3)	1.38	1.33	1.37
Earthworms (total number)	2	3	4
PMN (mg/kg)	50	45	65
Respiration (mg CO_2-C/kg)	121	121	110

ahdb.org.uk/soil-health-scorecard

No action needed Monitor Investigate

For more information visit ahdb.org.uk/greatsoils

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 (<8cm) in size, typically about the length of a matchstick
- Often fast-moving (most likely to escape from the worm pot!)

Sensitive to: Tillage (detrimental) 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 curl up when handled, and green worms may emit a yellow fluid
- The most common earthworm group found in arable fields

Sensitive to: Organic matter management (beneficial)

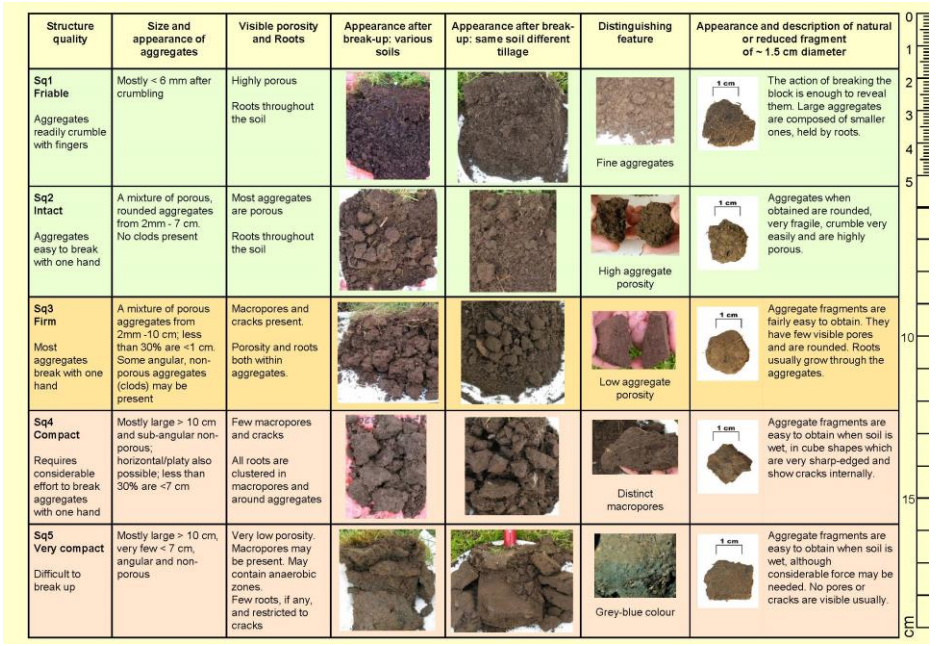
Roles: Soil aggregation and nutrient mobilisation for plants

***Anecic* (deep burrowing earthworms)**

- Dark red or black-headed worms
- Large size (>8cm), typically similar size to a pencil
- Make deep vertical tunnels, up to 2m
- Often found below surface earthworm casts or midden residue piles
- Feed at night, foraging the soil surface around their burrow for litter
- Commonly found in grassland but often absent from ploughed fields and where there is no surface litter

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

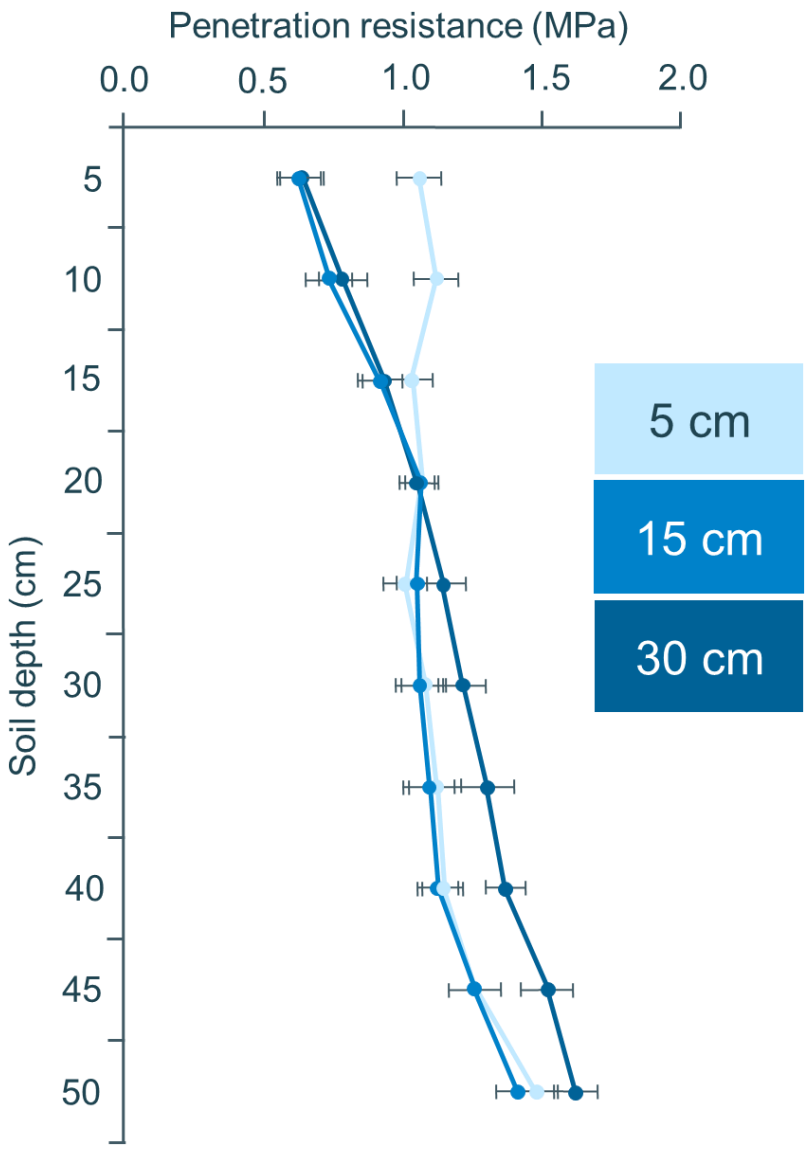
Roles: Deep burrows that improve aeration, water infiltration and root development



Structure quality	Size and appearance of aggregates	Visible porosity and Roots	Appearance after break-up: various soils	Appearance after break-up: same soil different tillage	Distinguishing feature	Appearance and description of natural or reduced fragment of ~ 1.5 cm diameter
Sq1 Friable Aggregates readily crumble with fingers	Mostly < 6 mm after crumbling	Highly porous Roots throughout the soil			Fine aggregates	The action of breaking the block is enough to reveal them. Large aggregates are composed of smaller ones, held by roots.
Sq2 Intact Aggregates easy to break with one hand	A mixture of porous, rounded aggregates from 2mm - 7 cm. No clods present	Most aggregates are porous Roots throughout the soil			High aggregate porosity	Aggregates when obtained are rounded, very fragile, crumble very easily and are highly porous.
Sq3 Firm Most aggregates break with one hand	A mixture of porous aggregates from 2mm -10 cm; less than 30% are <1 cm. Some angular, non-porous aggregates (clods) may be present	Macropores and cracks present. Porosity and roots both within aggregates.			Low aggregate porosity	Aggregate fragments are fairly easy to obtain. They have few visible pores and are rounded. Roots usually grow through the aggregates.
Sq4 Compact Requires considerable effort to break aggregates with one hand	Mostly large > 10 cm and sub-angular non-porous; horizontal/platy also possible; less than 30% are <7 cm	Few macropores and cracks All roots are clustered in macropores and around aggregates			Distinct macropores	Aggregate fragments are easy to obtain when soil is wet, in cube shapes which are very sharp-edged and show cracks internally.
Sq5 Very compact Difficult to break up	Mostly large > 10 cm, very few < 7 cm, angular and non-porous	Very low porosity. Macropores may be present. May contain anaerobic zones. Few roots, if any, and restricted to cracks			Grey-blue colour	Aggregate fragments are easy to obtain when soil is wet, although considerable force may be needed. No pores or cracks are visible usually.

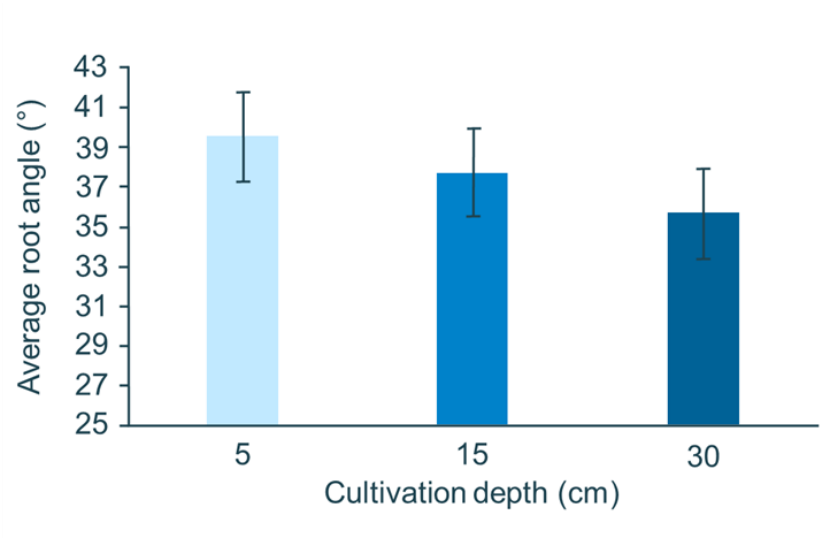
Results – harvest 2019
Penetration resistance

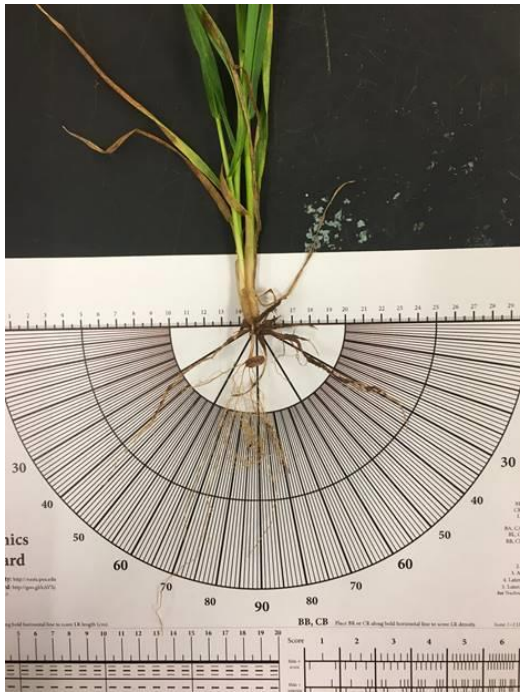
- 5 cm cultivation had significantly (P<0.05) greater penetration resistance in the top 10cm of soil
- Increased topsoil resistance had no significant impact on aboveground biomass assessed at GS31, 39 and 61



Results – harvest 2019
Root angle

- Crop root angle was steeper in the shallow cultivation depth
  - The angle from the horizontal of the outermost roots on both sides of the crown at approximately 5 cm from the shoot base

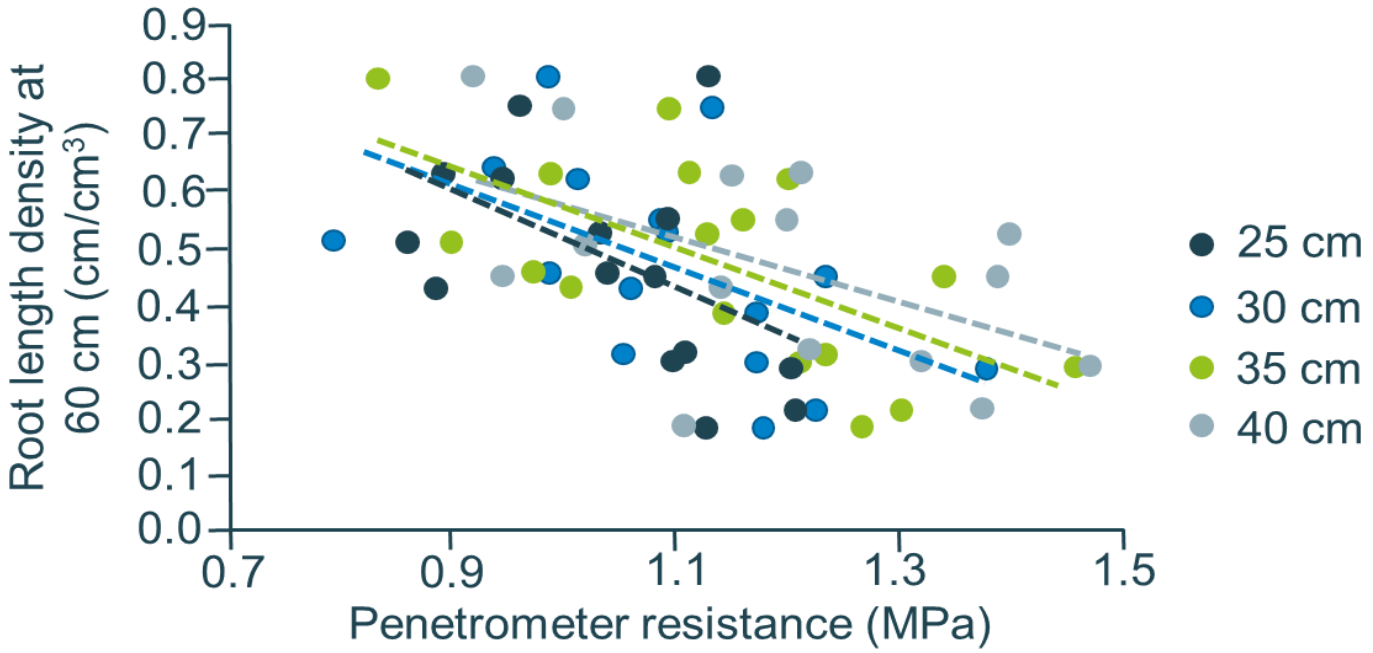




Increased consolidation in the topsoil promoted downward growth of roots

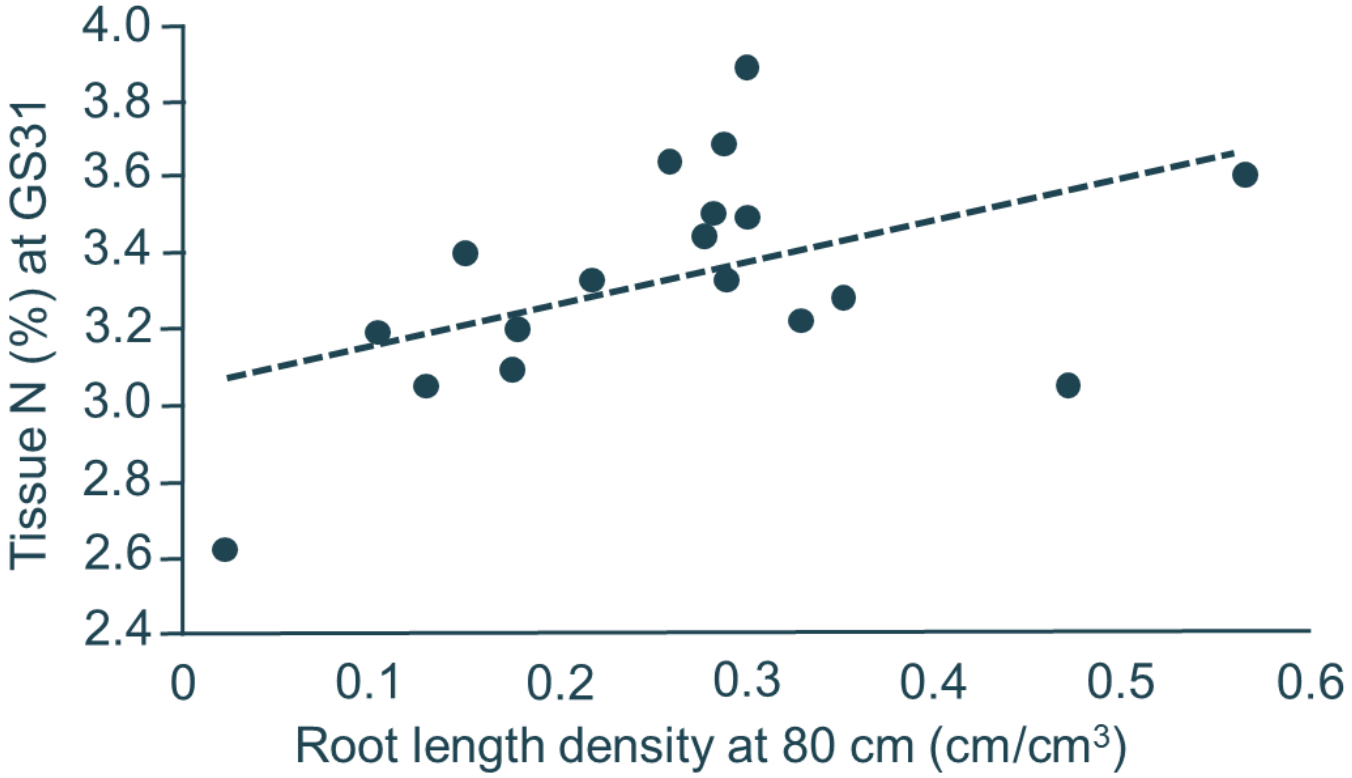
Results – harvest 2019
Rooting and subsoil compaction

- Increased soil strength 25 - 40 cm soil depth was associated with less rooting (RLD cm/cm^3) at 60 cm soil depth
- This negative association was statistically significant (P<0.05) (r =-0.67 to -0.75)



Results – harvest 2019
Root and shoot associations

- Improved rooting in the subsoil was positively associated (*P*<0.05) with aboveground crop biomass at anthesis and increased tissue N concentration at GS31 (r=0.64)



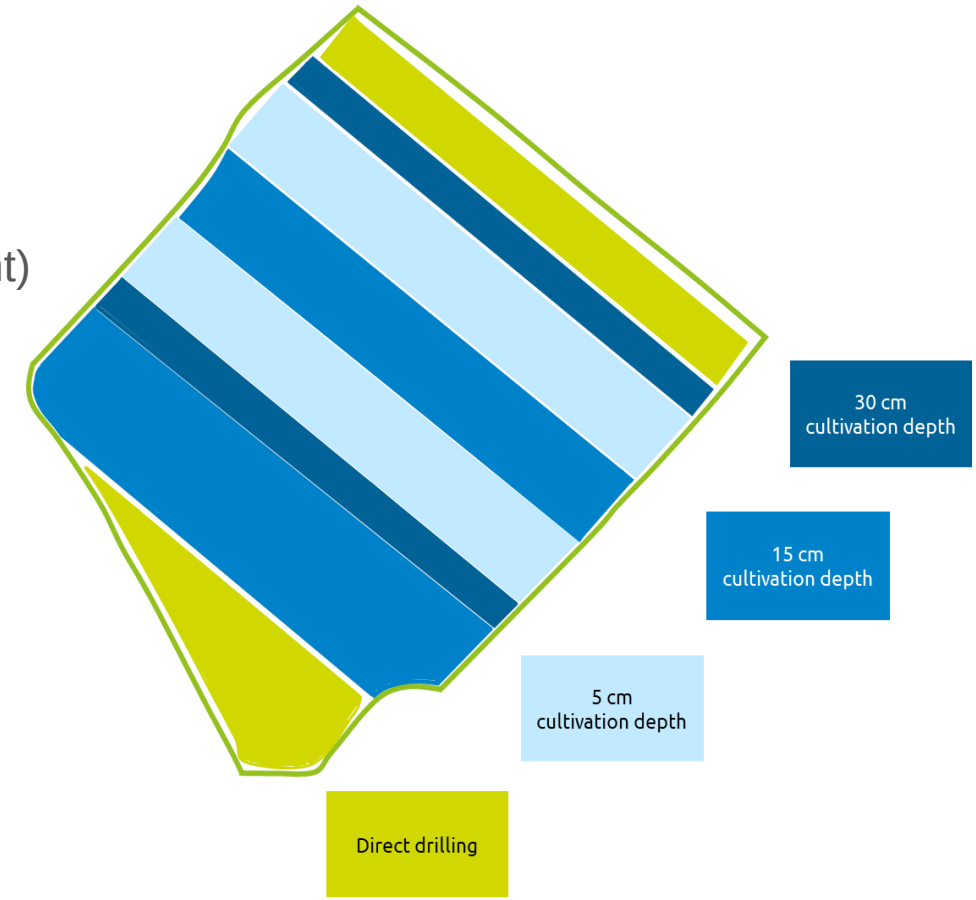
Results – harvest 2019
Cost of production

	5 cm	15 cm	30 cm
Yield (t/ha)	10.90	11.61	11.10
Variable Costs			
Total seed costs (£/ha)	77	77	77
Total fertilisers (£/ha)	183	183	183
Total crop protection (£/ha)	205	205	205
Total variable costs (£/ha)	464	464	464
Fixed costs			
Total labour, machinery and equipment (£/ha)	486	499	532
Total property and energy costs (£/ha)*	73	77	71
Total administration costs (£/ha)*	30	32	29
Cost of production (per hectare)			
Full economic cost of production (£/ha)	1,053	1,072	1,096
Cost of production (per tonne)			
Full economic cost of production (£/t)	97	92	99

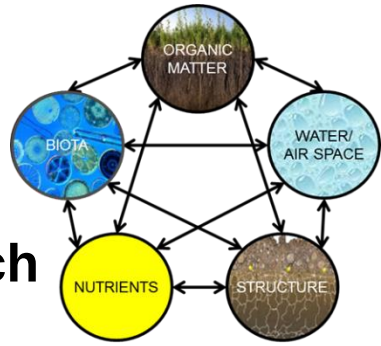
*These costs are the West regional averages from Farmbench for harvest 2018

Trial design – harvest 2020

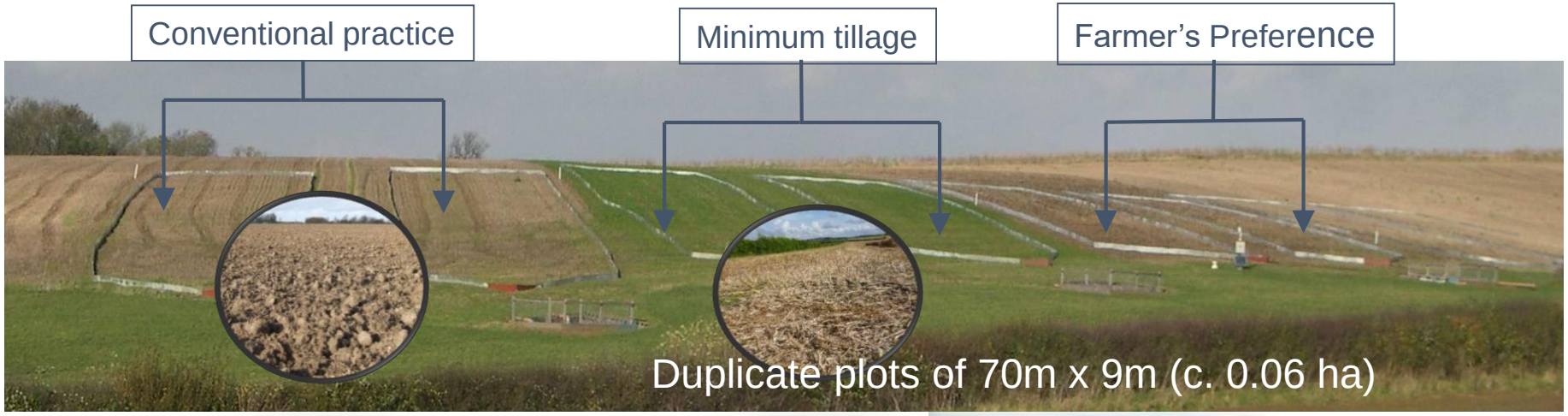
- Drilled in oilseed rape 24 August 2019
- Assessments:
  - Plant establishment
  - Adult feeding damage (% leaf area lost)
  - Larvae pressure (no. larvae per plant)



3. Soil management trials on Strategic Cereal Farm West: implications

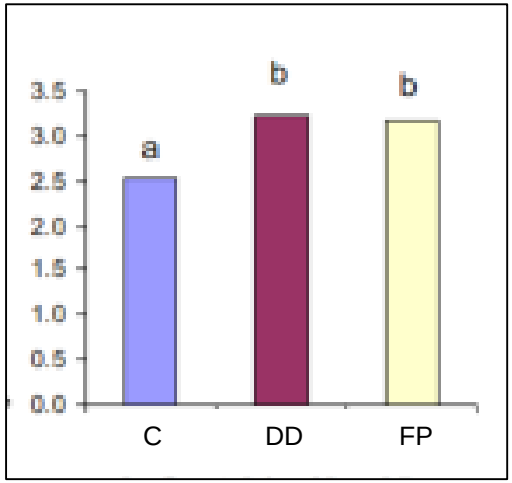


Putting the trials into context with other soil health research

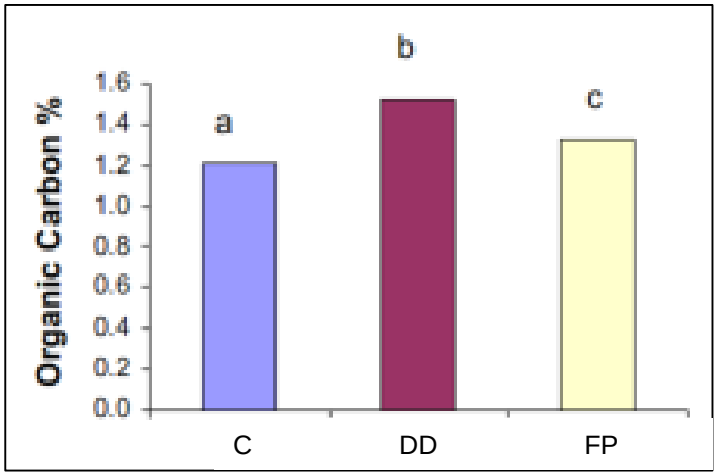


Soil management trials on Strategic Cereal Farm West: implications

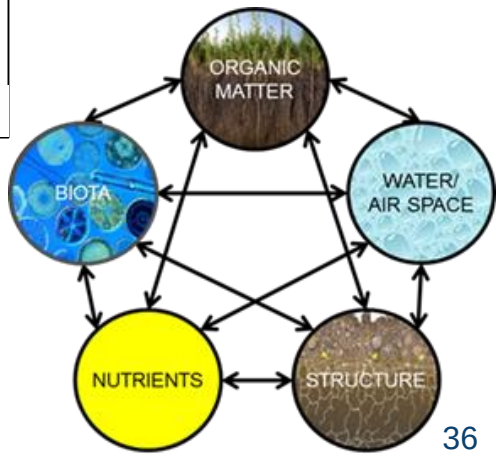
- Soil type of trials – medium to heavy clay (38% - 39% clay content)
  - Effect of soil type on ‘conservation tillage’ performance
    - SOWAP field trials: Loddington (clay) versus Tiverton (sandy clay loam)



Heavy soil



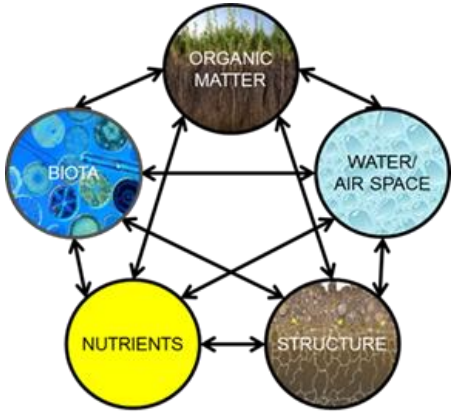
Light soil



- ‘one size does not fit all’…need for farm / field guidance

Soil management trials on Strategic Cereal Farm West: implications

- Cultivation depths: 5 cm, 15 cm and 30 cm
  - Cultivation depths can be as little as 2.5 cm (see later slide)

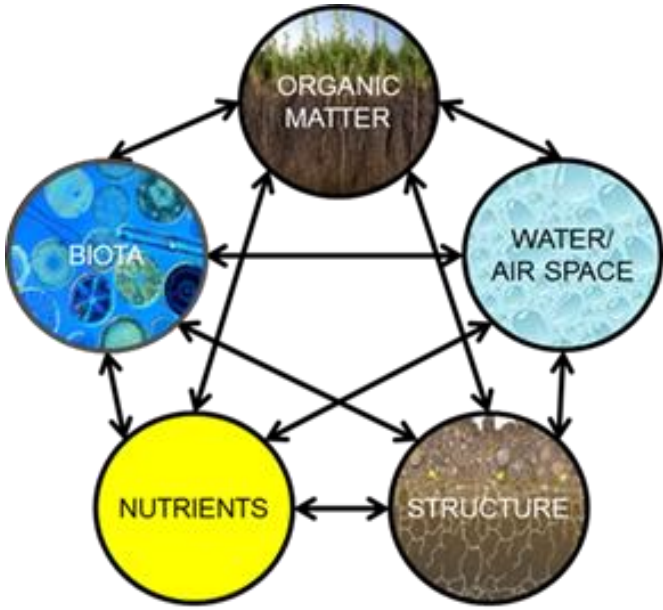


Tillage treatment	Implement type	Depth of pass (mm)	Seed depth (mm)	Width of soil disturbance [c] (mm)
Farm System[a]				
Sumo Trio	Tine	200	25	465
Followed by Kuhn HR	Combi-drill	100	25	>465[c]
Sumo DTS	Tine	177	25	~ 200[c]
Claydon Hybrid	Tine	150	25	235
Mzuri Pro-Til	Tine	150	25	300
Low Disruption[b]				
Horsch Sprinter	Tine	100	25	< 100[c]
Väderstad Rapid	Disc	25	20	87
Väderstad Seed Hawk	Tine	25	12	83

- Area of disturbance: cultivation widths important too
  - e.g. cereals v OSR (row width – see later)

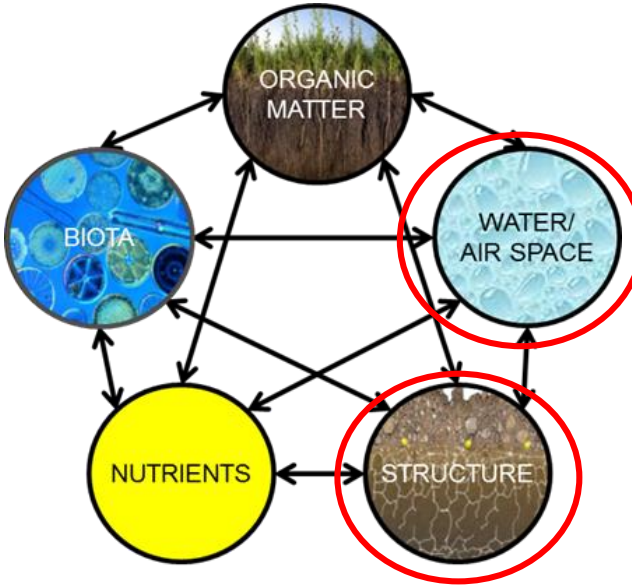
Soil health score card

- Indicators of soil health / soil quality
  - Which to choose?
- When to measure?
  - Summer v. winter
  - pre- v. post-cultivation/ drilling
  - when in the rotation (e.g. after 'hungry' crops – maize, potatoes; or rejuvenating crops - grass leys; legumes; cover crops) – a fair test?
- Changes in scores from baseline are important, not just absolute numbers
  - When is a 'change' meaningful or significant*?
    - When change leads to higher yields, less pest damage, less flooding etc.
  - Will score cards be part of ELMS???



Treatment (cultivation depth)	5cm	15cm	30cm
Texture	Clay	Clay	Clay
% clay	38	39	39
SOM (%LOI)	4.1	4.1	4.1
pH	7.2	7.0	7.7
Ext. P (mg/l)	20	26	16
Ext. K (mg/l)	192	199	216
Ext. Mg (mg/l)	712	821	902
VESS score (limiting layer)	4	3	3
Bulk density (g/cm^3)	1.38	1.33	1.37
Earthworms (total number)	2	3	4
PMN (mg/kg)	50	45	65
Respiration (mg CO_2-C/kg)	121	121	110

Soil health score card



Soil structure (physical soil health)

- VESS score
  - What does a change mean (e.g. 3 to 4)?
  - Can't test change statistically (scores, not actual numbers)

- Bulk density
  - Picked up in penetration resistance too
  - May increase under CT in short term?
  - Implications for runoff, erosion?
  - Limiting bulk densities for roots
    - Root growth becomes restricted at >1.5 MPa (Whalley et al. 2008).
    - But more vertical growth to extract water, nutrients?
  - May be reversed in time…
    - Organic matter from residues
    - Soil (micro)biology
      - Earthworms as 'engineers of the earth'
      - Creation of peds and pores (porosity and aggregate stability)
    - Root penetration and growth

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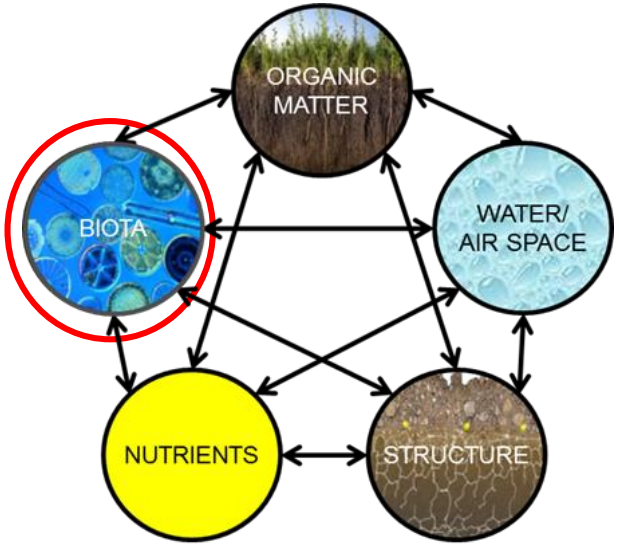
Soil health score card



Soil biology (biological soil health)

- Earthworms – ??? expect more in shallower cultivations (less disturbance)
  - Other studies (later slide) – least disruption → highest density
  - Type of earthworm important too
    - Vertical v horizontal
- Respiration (microbial)
  - Community biomass (carbon) and type important too
    - e.g. fungi good at aggregation (hyphae) compared to bacteria

Treatment (cultivation depth)	5cm	15cm	30cm
Texture	Clay	Clay	Clay
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Soil management practices for healthy soils: Reduced tillage systems (Giannitsopoulos et al., 2020. Soil Use and Management, 36(1), pp.139-152)


Control Treatment: Two Pass

Claydon Hybrid

Sumo DTS

Mzuri Pro-Til 3

Vaderstad Seed Hawk

Vaderstad Rapid A

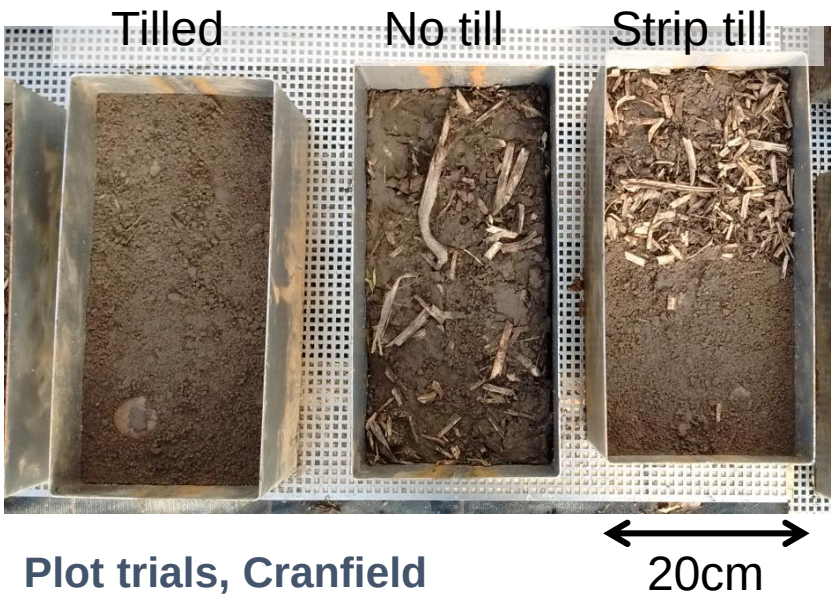
Results: How tillage affects soil health

Different letters show statistically significant differences

	Cultivation depth	Penetration resistance MPa	Organic carbon (%)	Microbial biomass carbon (µg C g soil^{-1})	Earth worms / m^2
Control (Sumo Trio 2 passes)	20 cm	0.50 ^{c}	2.710 ^{b}	339.1 ^{b}	75.0 ^{c}
Sumo DTS	18 cm	0.61 ^{abc}	2.714 ^{b}	379.8 ^{ab}	103.1 ^{bc}
Claydon Hybrid	15 cm	0.60 ^{bc}	2.789 ^{ab}	321.8 ^{b}	118.8 ^{b}
Mzuri Pro Til	15 cm	0.70 ^{ab}	2.829 ^{ab}	380.2 ^{ab}	137.5 ^{b}
Vaderstad	2.5 – 10 cm	0.76 ^{a}	2.985 ^{a}	443.8 ^{a}	187.5 ^{a}

Soil management practices for healthy soils: Can strip tillage improve soil health? (Dr. Iain Dummett)

Field trials, Lincolnshire



Plot trials, Cranfield

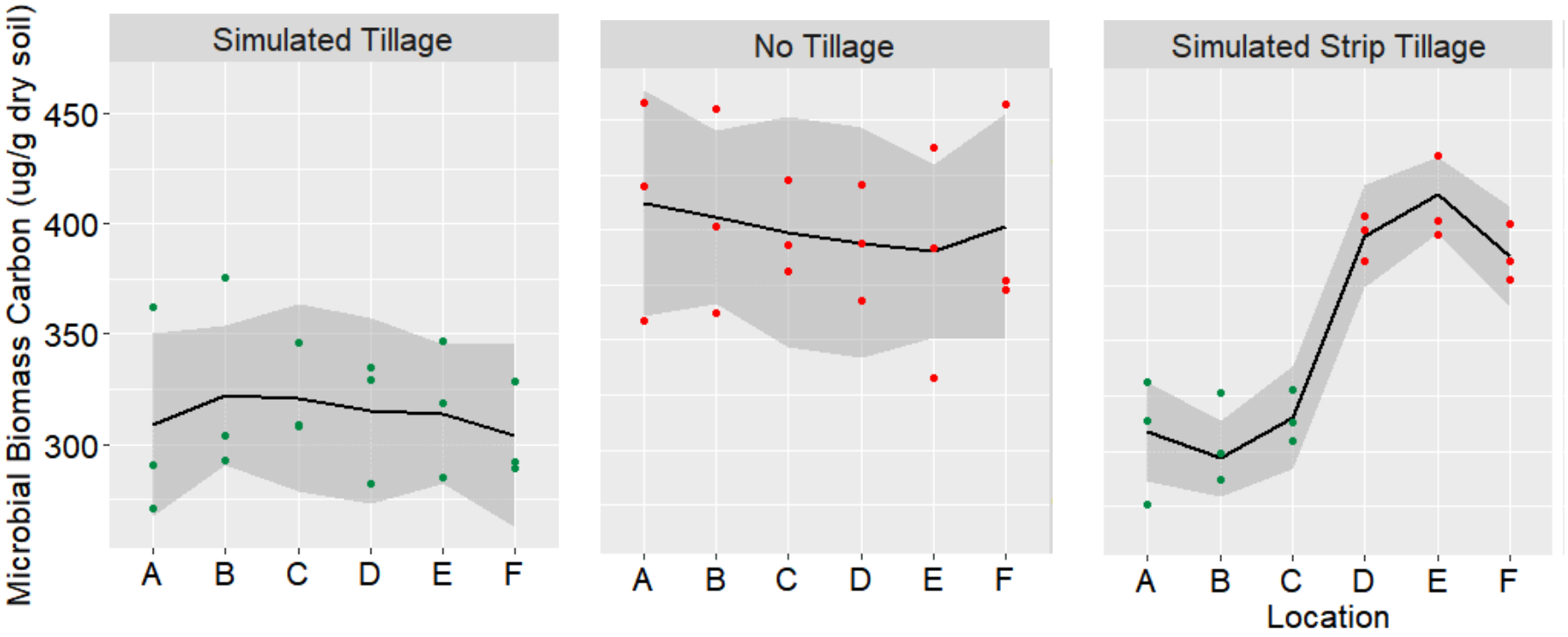
Disturbed v undisturbed areas at field and row width scale

- Does tillage reduce soil biology (fungi, bacteria, earthworms)?
- Does the rate of soil biology recovery increase nearer the untilled plot?
- Can soil microbes recolonise from untilled plots to tilled plots?

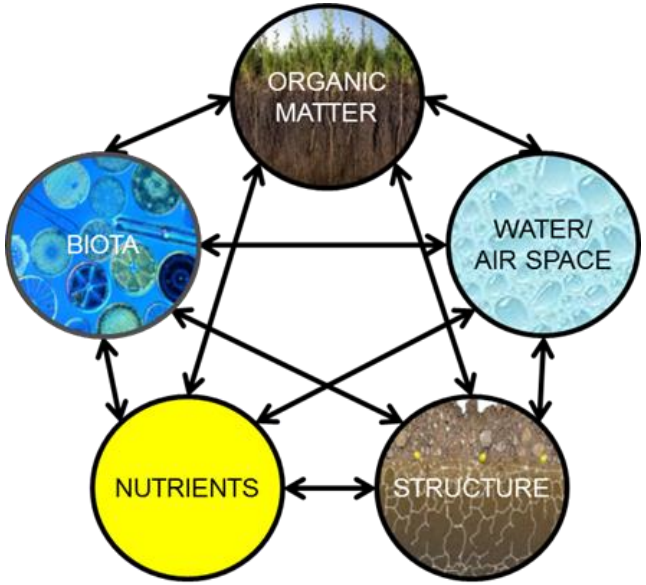
Subsoiler

Specialist strip tillage implement

3. Soil management practices for healthy soils: Can strip tillage improve soil health? (Dr. Iain Dummett)



4. Take home messages



- Soils are under pressure to increase food, fodder, fibre and (bio)fuel production without damaging the environment
- Soil management can improve soil health and crop productivity
- Cost effectiveness of practices will be site specific and must fit into current farming practices
  - socio-economic context
  - infrastructure / machinery available
  - farmer perception/ psychology / planning horizon
- Ultimate goal is economically, socially and environmentally acceptable food production

= “sustainable intensification”

Harvest 2020 update and next steps for the trial at Strategic Cereal Farm West

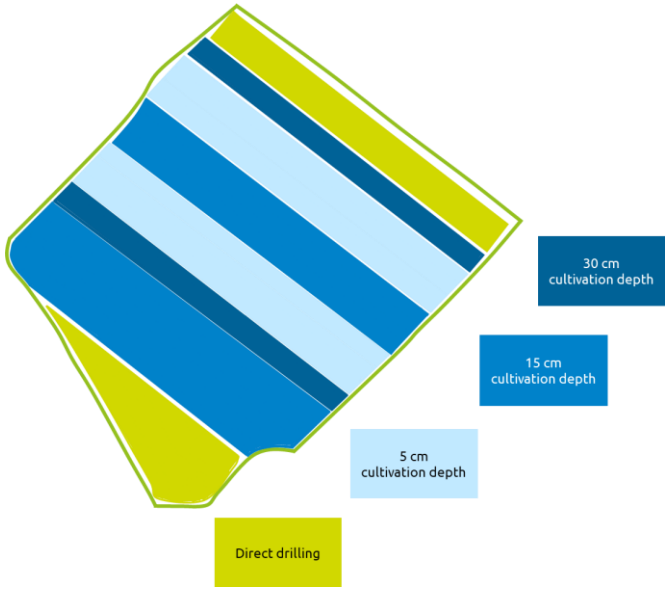
Emily Pope Senior Knowledge Transfer Manager

@emilypope_KT

CEREALS & OILSEEDS

Trial design – harvest 2020

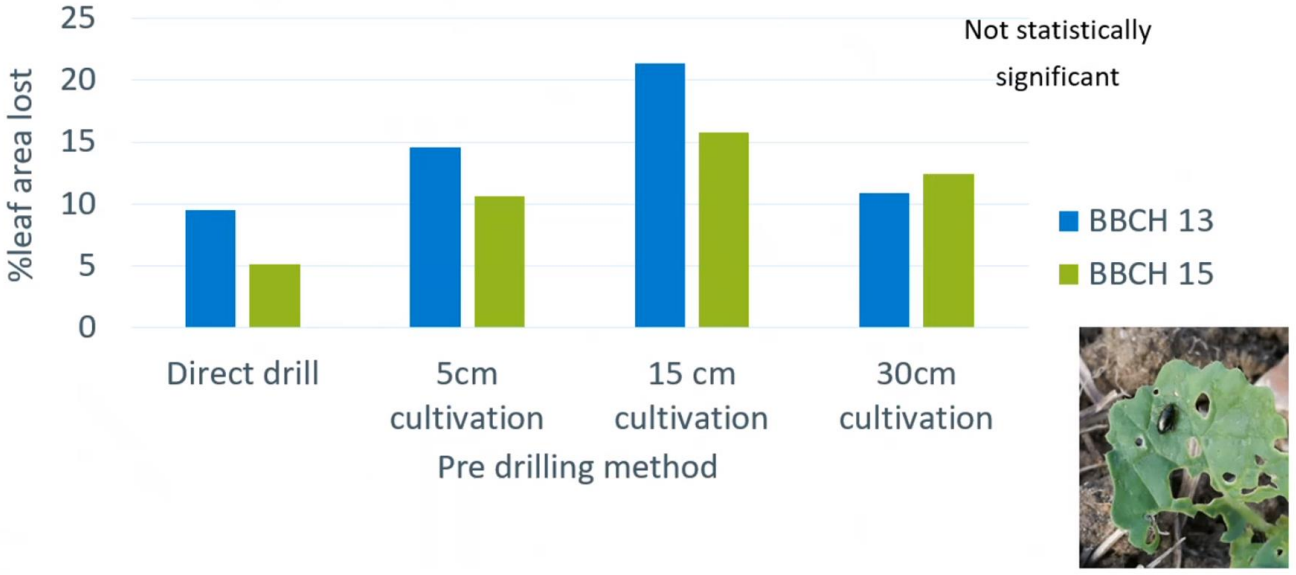
- Drilled in oilseed rape 24 August 2019
- Assessments:
  - Plant establishment
  - Adult feeding damage (% leaf area lost)
  - Larvae pressure (no. larvae per plant)



Results – harvest 2020
Crop establishment and size

- Poorer plant establishment and fewer plants in 15 cm and 30 cm compared to shallow (5 cm) and direct drill
- By November, there was a large difference in crop size
  - Likely to be due to dry weather conditions at drilling

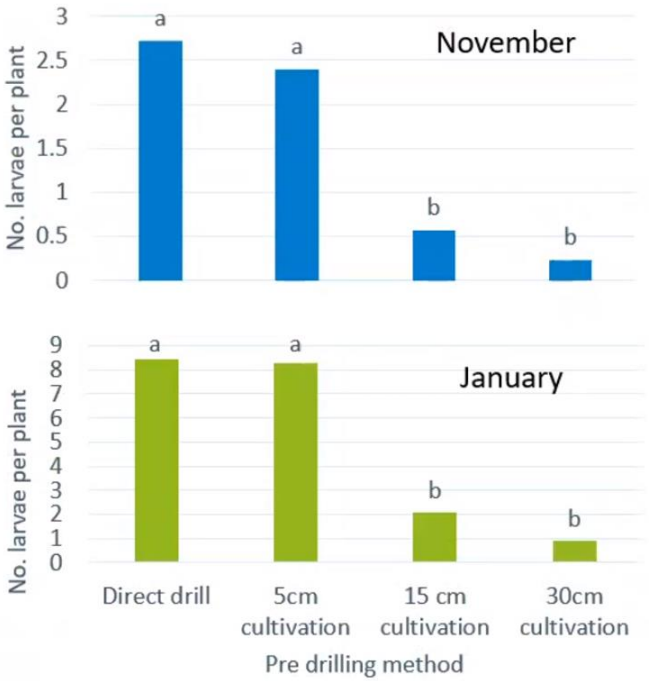
Results – harvest 2020
Adult damage



For more information on AHDB CSFB research visit **ahdb.org.uk/csfb**

Results – harvest 2020
Larvae

- Significantly fewer number of larvae in the deep cultivation treatments compared to direct drill and 5 cm
- It is possible that adults preferentially lay eggs at the base of the larger plants, resulting in higher larvae pressure in the direct drill and shallow cultivation treatments
- Alternatively, smaller plants cannot support as many larvae
- Relationship between number of larvae and yield is poorly understood



Questions and discussion

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Strategic Farm Week 2020

Watch Strategic Farm research videos

Take part in the webinars

Listen to the podcast special

Download the ‘how to’ resources

ahdb.org.uk/sfweek2020

Still to come in Strategic Week 2020…..

All available at **ahdb.org.uk/SFweek2020**

Thursday 4 June

09:00 – 10:30 Crop establishment **considerations**

12:00 – 13:30 Soil structure assessments **masterclass**

19:00 – 20:30 Mole drainage and soil loosening **masterclass**

Friday 5 June

- Strategic Farm Week closing video with Martin Grantley-Smith
- Strategic Farm resources

Previous Strategic Farm webinars

- How to monitor crop development and disease
- How to monitor for key insect pests and beneficials
- How to decide when to lower inputs

Videos and resources

- Trials and demonstrations for harvest 2020 at Strategic Cereal Farm East
- Trials and demonstrations for harvest 2020 at Strategic Cereal Farm West
- Introduction to Strategic Cereal Farm Scotland
- Strategic Farm Week podcast with Paul Temple, Rob Fox, David Aglen & Brian Barker

Also coming up…

- Regional Monitor Farm webinars
- Recommended List webinars
- AHDB Cereals monthly webinar

Information and register at **ahdb.org.uk/events**

Thank you

REC ●

If you have any questions or would like to follow up, please get in touch:

Email richard.meredith@ahdb.org.uk

ahdb.org.uk/sfweek2020

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