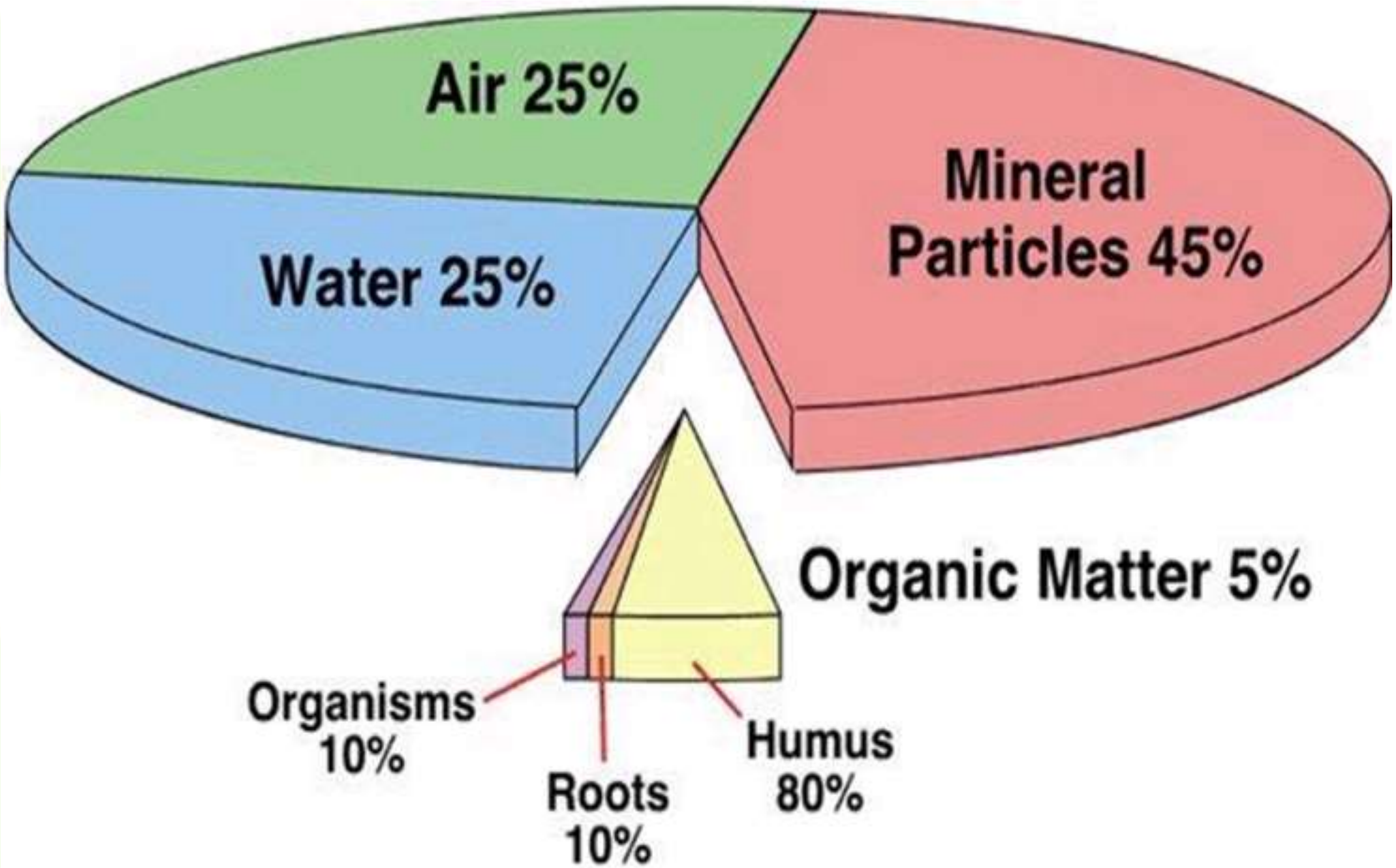
Soils and Integrated Crop Management

Dr. Paul Hargreaves, SRUC

Leading the way in Agriculture and Rural Research, Education and Consulting

What is Soil?


Air 25%
Mineral Particles 45%
Water 25%
Organic Matter 5%
Organisms 10%
Roots 10%
Humus 80%

Good soil management

- It can take 500 years to replace 25 mm of top soil
- In the UK it is estimated that 2.9 million tonnes of soil are eroded each year
- Soil quality is diminished by poor practices.

- A good drainage system relies on good soil structure

- Soils with poor structures are likely to be a source of direct surface run-off to watercourses of nutrients
- In addition to waterlogging and erosion.

VESS Score Sq1

A good soil structure has rounded aggregates that readily crumble in the fingers when moist, with many pores that allow easy root growth and passage of water throughout

VESS Score Sq5

A poor soil structure is almost always very compact with mostly large (> 10 cm) hard and sharp blocks. Porosity is very low and fissures tend to be horizontal and contain any roots. The soil can be grey or blue in colour with a sulphur smell (rotten eggs) indicating a lack of oxygen

What is a healthy soil?

Looks good
Feels good
Smells good

Easy to work
Supports lot of life

Know Your Soil

SRUC

Biological

Feed the soil regularly through plants and OM inputs

Move soil only when you have to

Diversify plants in space and time

KNOW YOUR SOILS; principles to improve soil health

Chemical

Maintain optimum pH

Provide plant nutrients – right amounts in the right place at the right time

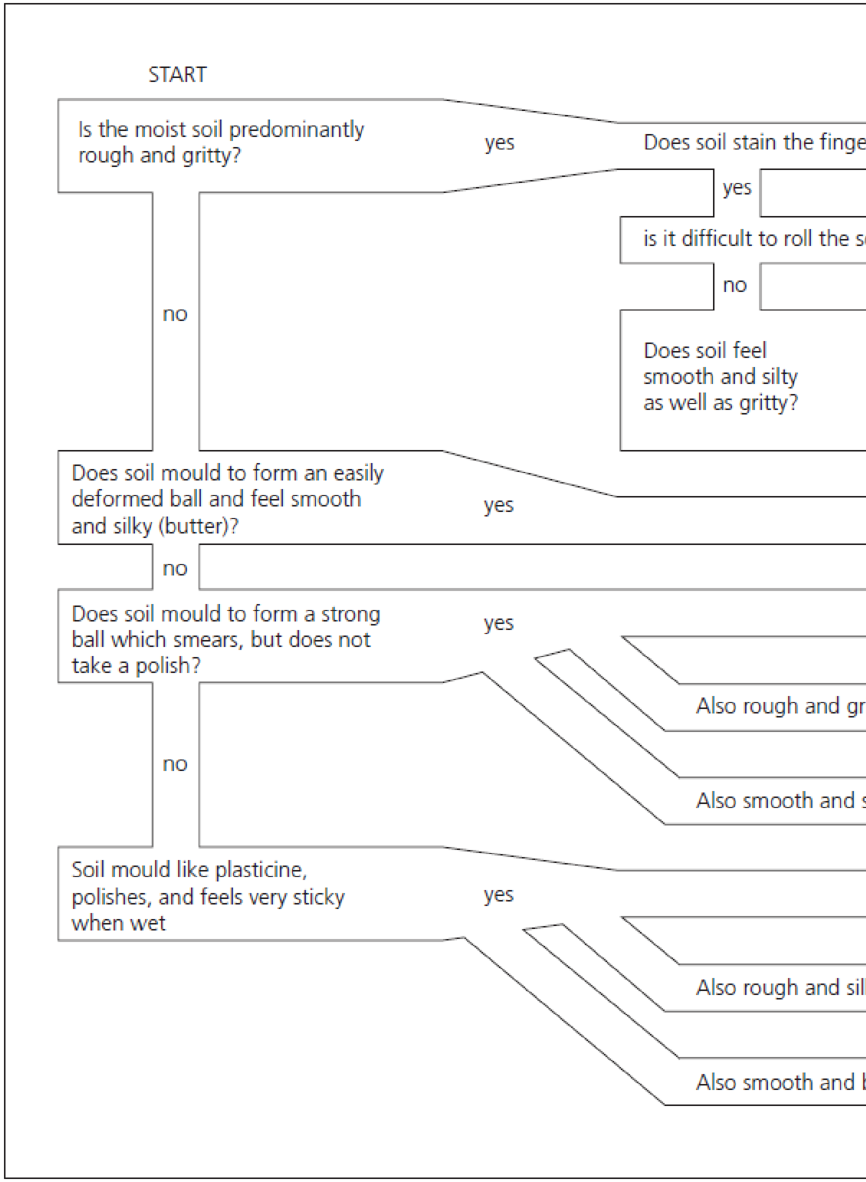
Physical

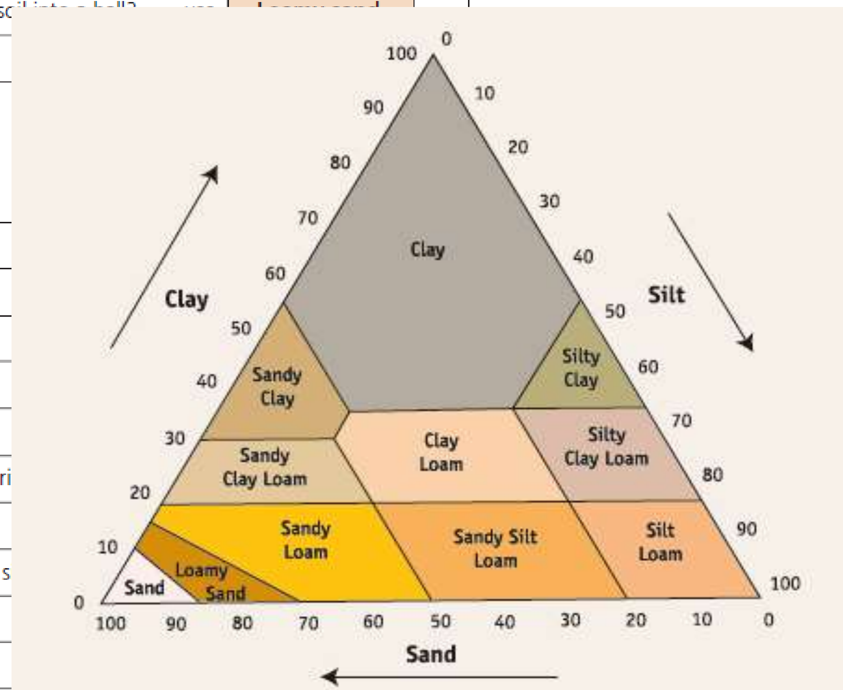
Texture and limits to workability, trafficability

Optimise water balance through drainage

Soil structure

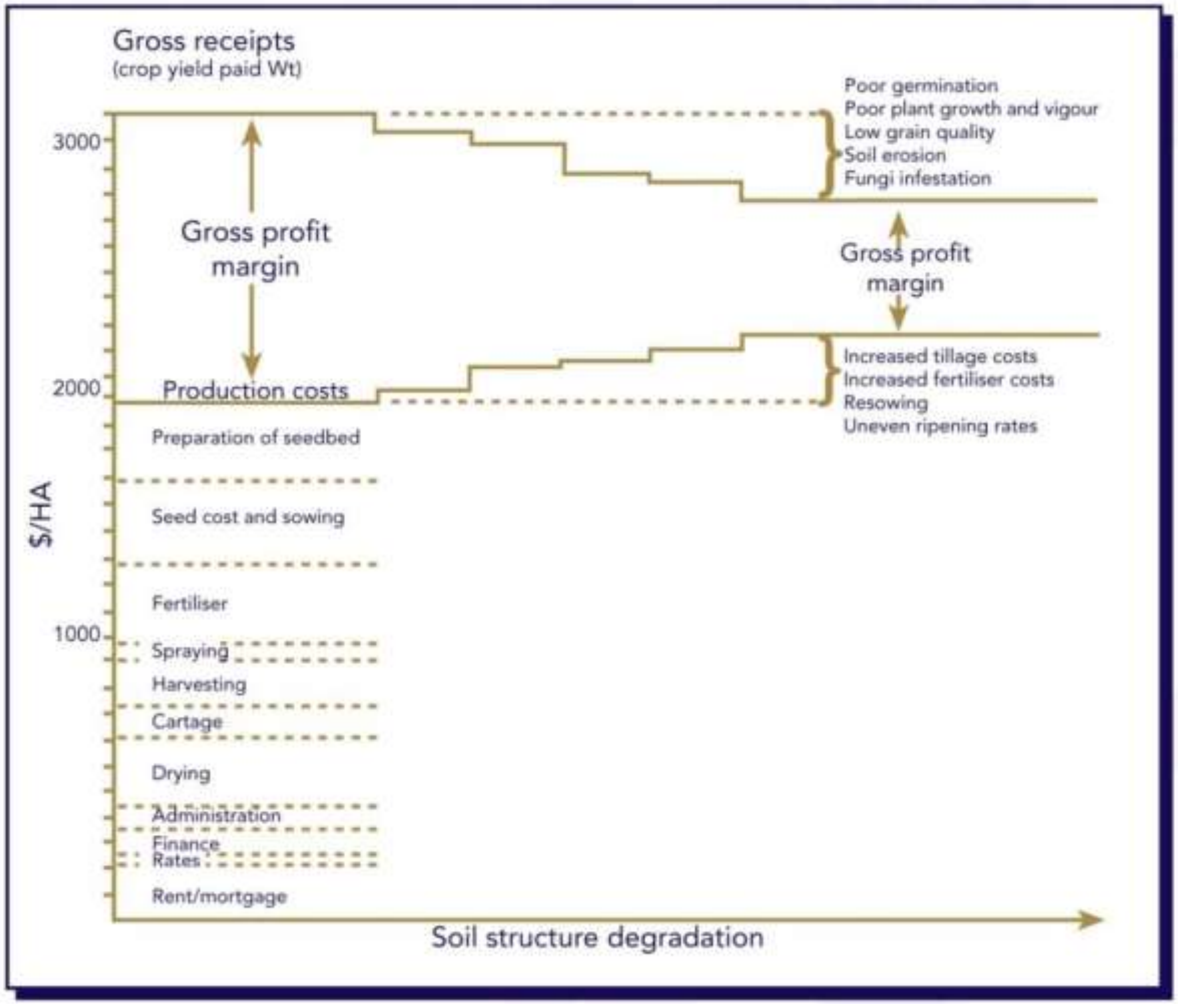
Field assessments of soil texture





Soil textural triangle showing the proportions of the three main particles in different soil textures

Reductions to Margins



Production costs ($/ha) and narrowing profit margin associated with increasing soil structure degradation.

(G. Shepherd, Bioagrinomics, New Zealand)

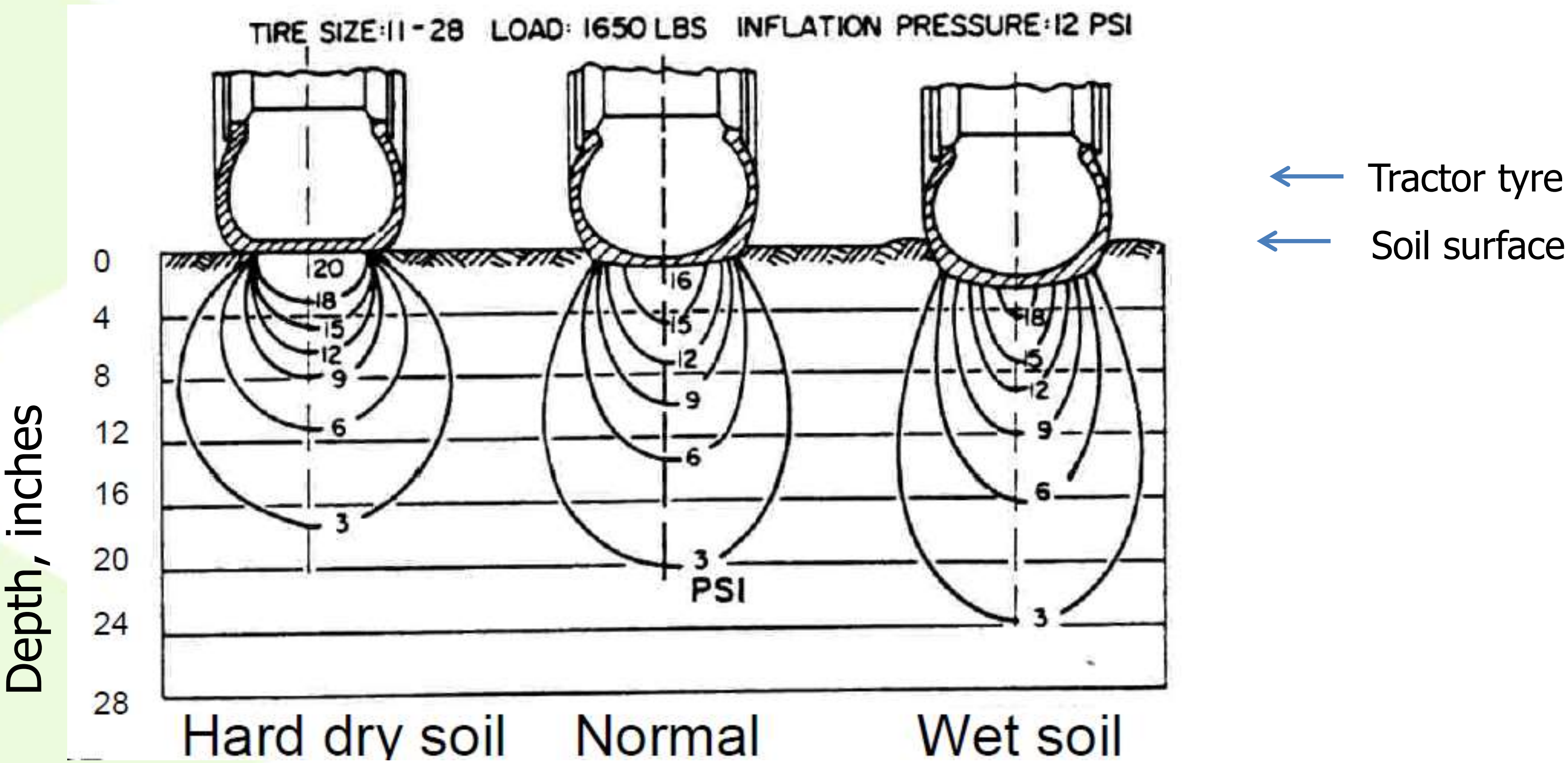
Soil Compaction

Soil Compaction Problem

- Severe or poor soil condition in 8 - 12% of grasslands*
- If moderate fields included then over 70%*
- Reduced pore space/increased water filled pore space
- Reduced oxygen diffusion
- Microbial activity decreases

* Newell-Price et al., (2013). Soil & Tillage Research, 127

Compaction and Soil Moisture

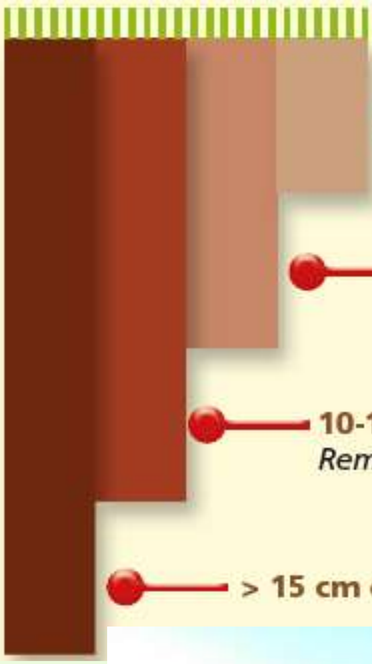


As soil moisture increases - amount and depth of compaction increases

http://www.engr.uconn.edu/~lanbo/CE240LectW041fieldcompaction.pdf

Causes of compaction

Identifying likely causes of compaction. The depth of the compaction zone gives an indication of possible causes.



Surface level capping Capping on new reseeds

0-5 cm deep Sheep trampling at high stocking densities

5-10 cm deep Cattle pressure e.g. grazing in very wet conditions

10-15 cm deep Heavy machinery trafficking e.g. silage, muckspreading
Remember: 70% of the damage occurs on the first wheelings

> 15 cm deep Plough pan due to repeated cultivation

AHDB Dairy Compaction Experiment

The compaction experiment – 2011 to 2014.

Three main treatments:

- **Trampling**
- **Mechanical load**
- **No compaction**

Sub-treatments

- **Surface aeration**
- **Sward lifting (~25cm)**

SRUC Crichton (Scotland)

and Harper Adams University (England)

Soil After Compaction Treatments

SRUC

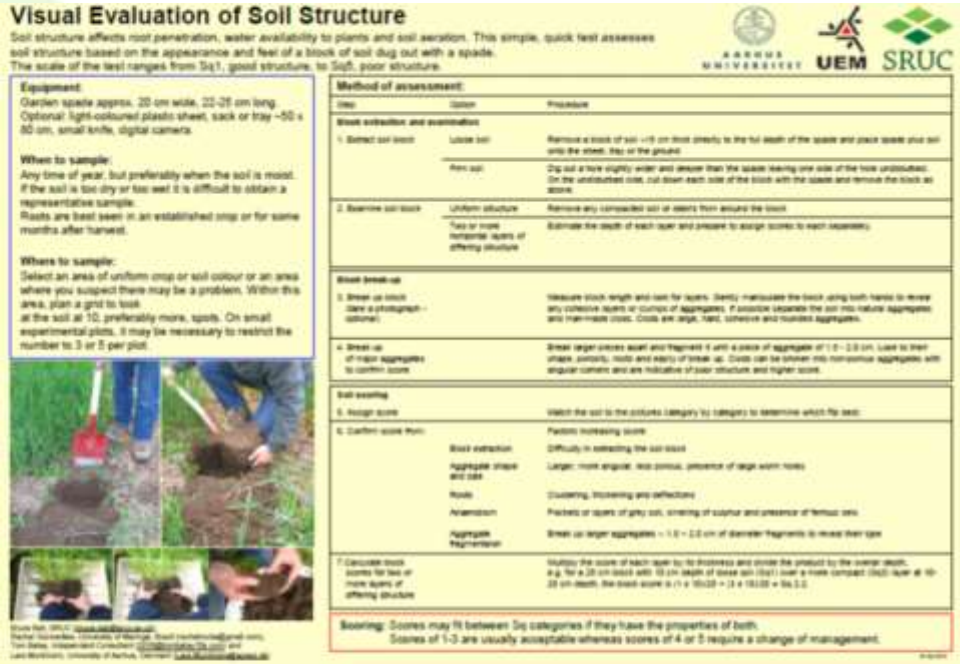
Bulk Density (g cm^3)
(soil depth 0-10cm)

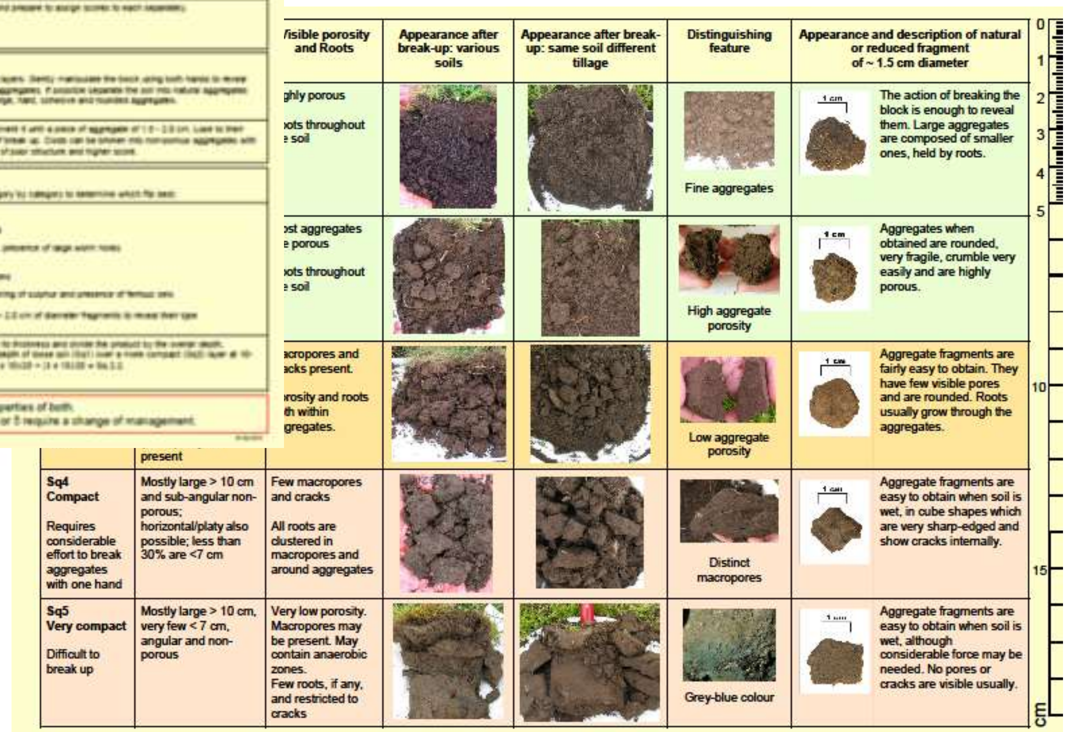
	October 2011		October 2014
SRUC	1.02	→	1.15
HAU	1.17		1.21

	October 2011		October 2014
SRUC	1.02	→	1.23
HAU	1.17		1.19

	October 2011		October 2014
SRUC	1.02	→	0.94
HAU	1.17		1.14

Visual Evaluation of Soil Structure (VESS)





Dry Matter Yield Reductions (t/ha)

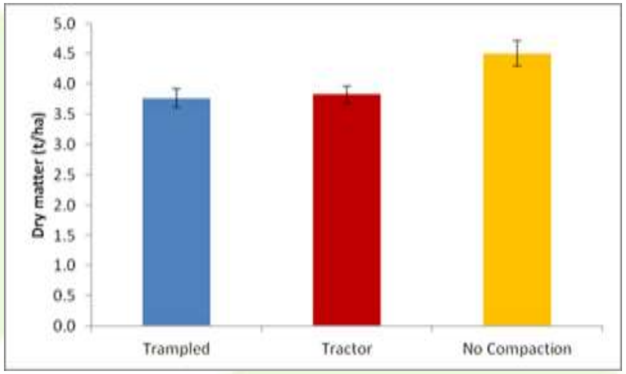
SRUC

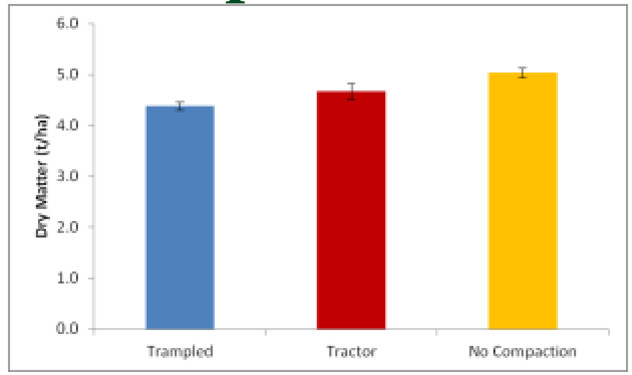
	SRUC					Harper Adams			
	Yield Reduction (t/ha)		Percent reduction (%)			Yield Reduction (t/ha)		Percent reduction (%)	
	Trampled	Tractor	Trampled	Tractor		Trampled	Tractor	Trampled	Tractor
2012	0.6	0.3	6.5	1.0		0.6	0.1	6.2	1.8
2013	0.4	1.0	5.6	11.5		0.2	0.6	1.9	-5.1
2014	1.6	2.0	11.0	14.3		2.0	2.3	12.2	14.3
All Years	2.6	3.3				2.8	3.0		

1st Cut Dry Matter Yield (t/ha)

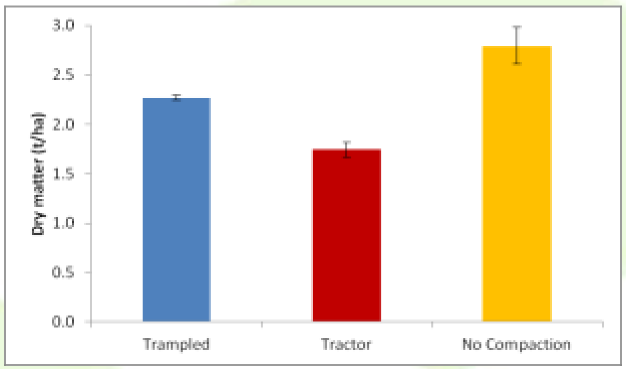
SRUC | Harper Adams

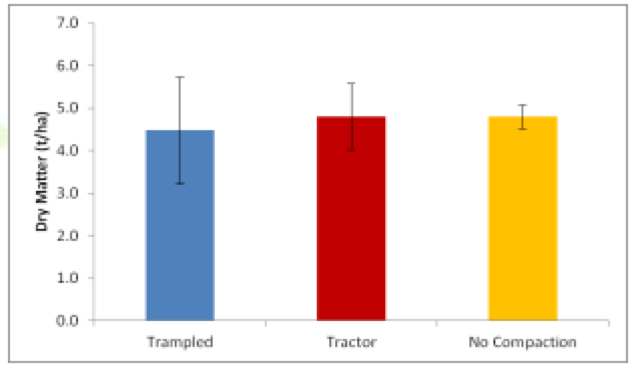
2012



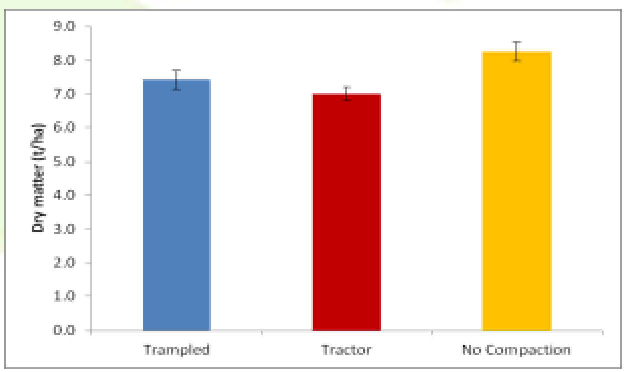


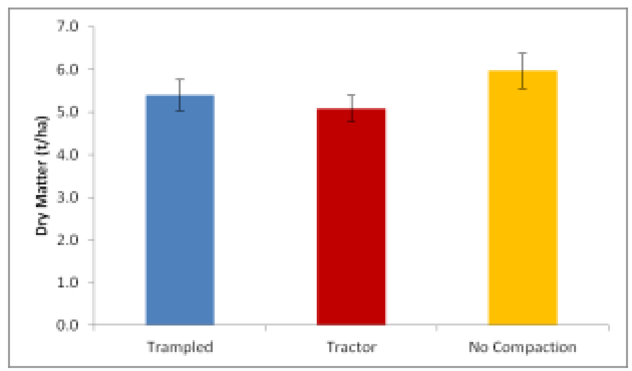
2013





2014





Natural Recovery

SRUC

Measurement	Treatment	SRUC		Harper Adams	
		Compaction	Recovery	Compaction	Recovery
Soil Bulk Density (g cm^3)					
	Trampled	1.15[a]	0.94[b]	1.21	1.22
	Tractor	1.23[a]	1.05[b]	1.06	1.08
DM Yield (t/ha)					
Total of all cuts	Trampled	11.35	11.36	11.69	12.96
	Tractor	10.93	11.53	11.42	12.10

Remediation and Working Depths

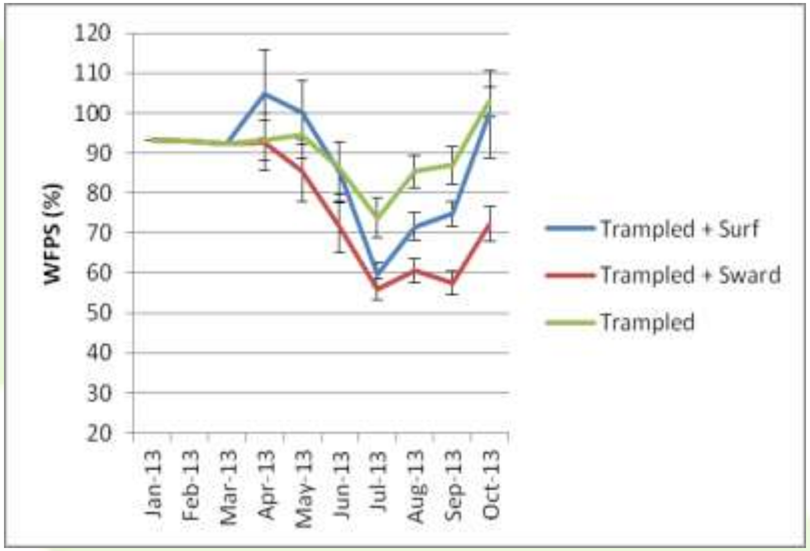
Type	Typical working depth (cm)
Aerators i.e. spikers or slitters	0 – 15 cm
Sward lifters	15 – 35 cm
Sub-soilers	35 – 50 cm

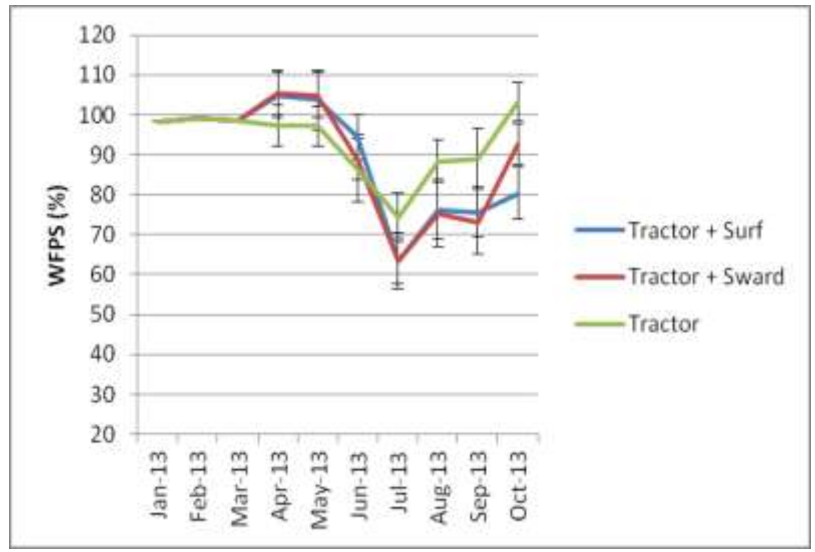

Grass DM Yield ($t\ ha^{-1}$) - Years 2013 and 2014

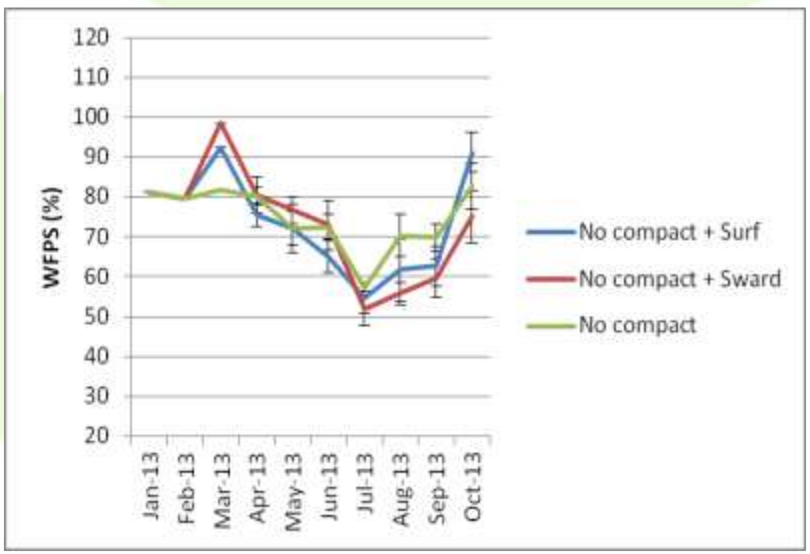
SRUC	1st Cut			2nd Cut			3rd Cut		
	No Comp.	Tramp.	Tractor	No Comp.	Tramp.	Tractor	No Comp.	Tramp.	Tractor
2013									
No Alleviation	2.7	2.2[a]	1.9	2.6	3.1	3.1	2.4[a]	2.4	2.5
Sward Lifting	2.3	1.7[b]	1.7	2.8	3.0	3.5	2.2[b]	2.4	2.5
Surface Aeration	2.8	2.0[a]	1.7	3.1	2.8	3.7	2.5[a]	2.4	2.4
2014									
No Alleviation	8.0[a]	7.4	7.0[a]	1.7	1.4	1.4	2.5	2.5	2.5
Sward Lifting	5.2[b]	5.6	5.3[b]	1.8	1.7	1.6	2.4	2.5	2.5
Surface Aeration	5.7[c]	5.7	6.0[a]	1.9	1.4	1.4	2.4	2.5	2.4

All values as $t\ ha^{-1}$

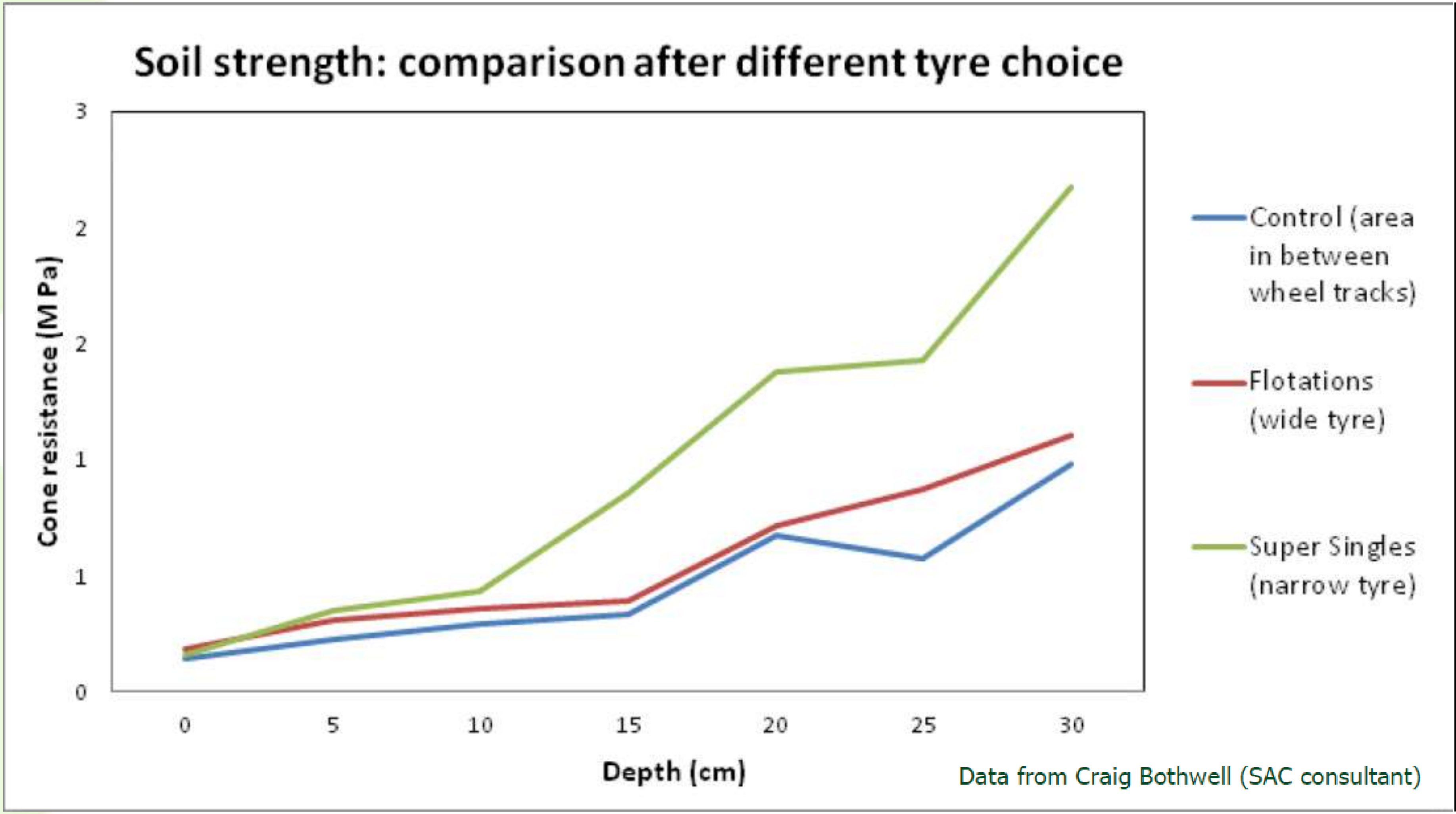
Water Filled Pore Space (%) 2013







Practical steps for avoiding compaction



Checking soil drainage status

Drainage 10 point check list

1. Investigate wet/waterlogged areas of field to assess soil structure

2. Remove soil compaction to help drainage

3. Check farm plans to see if a field drainage system exists

4. Check outflows and drains are clear, jet if necessary

5. Keep drainage ditches clear of silt and the water level at least 15 cm below the level of the outflow

6. Only use mole drains if soils > 30% clay and not too stoney

7. Make sure any new drainage system is suited to soil type and conditions

8. Lateral drains should always run across the slope

9. Backfilling drains with a permeable material helps maintain their use and allows connection to mole drains

10. Ensure the correct drainage pipe diameter/material is used

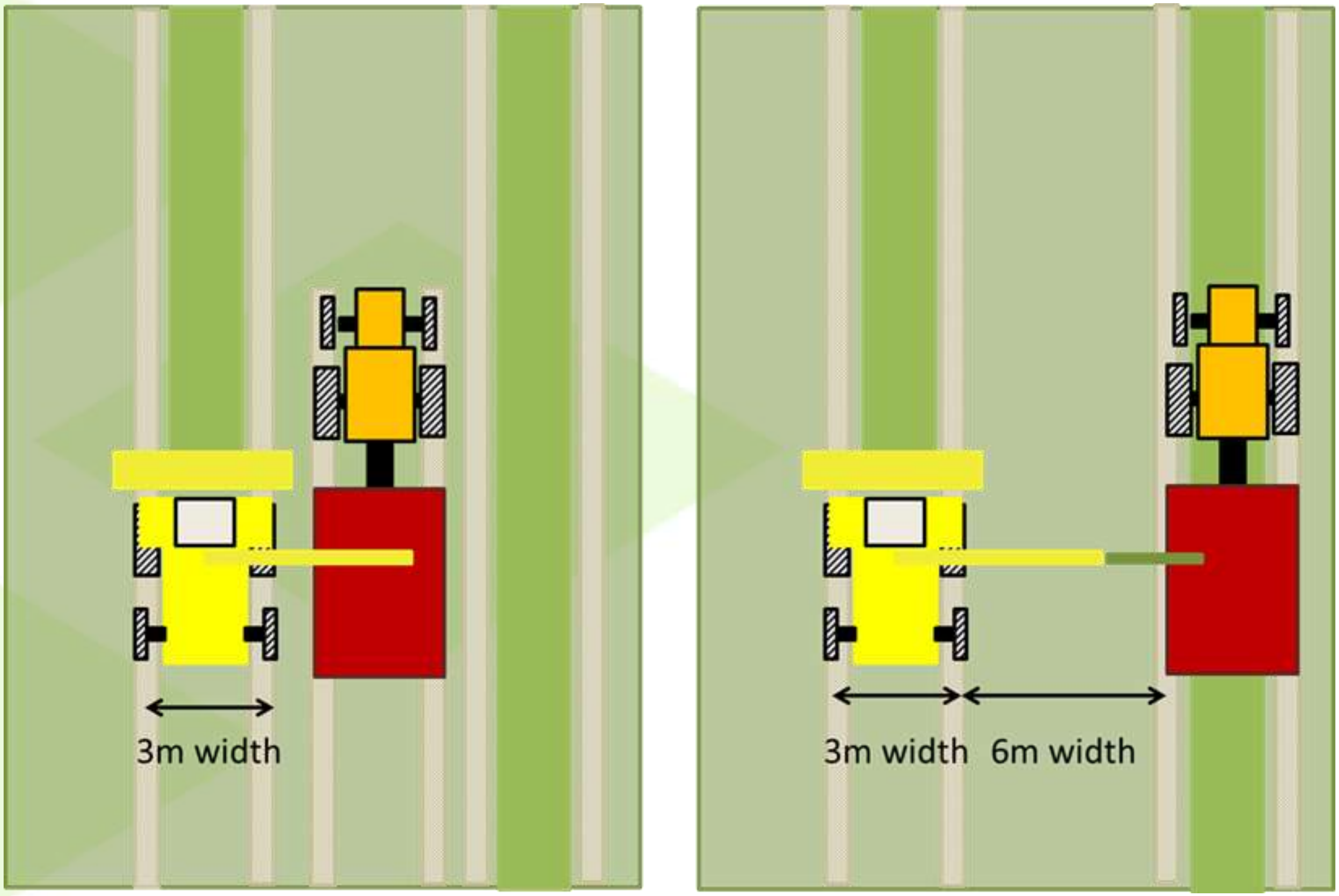
The effect of soil compaction on grass yield

- Yield decrease due to soil compaction is in the range 5 – 74%
- Long-term yield decrease for UK conditions is in the range of 5 – 20% with a mean of 13%
- Largest yield decrease generally takes place during the first cut caused by traffic either in the previous autumn or spring

Experimental Work

- An 8 ha perennial ryegrass field at SW Scotland split into two
- Two traffic management treatments: normal (N) and CTF
- 3-cut silage system
- 9 m triple gang mower (9 m working width)

Controlled Traffic Farming – Working widths



Results of Experimental Work

SRUC

Measurement	Normal Traffic	Controlled Traffic
Bulk Density (g cm^3)	1.02	0.99
VESS	1.93	1.84
pH	6.5	6.4
P (Index)	2	2
K (index)	2-	2-

Silage Cut	Normal Traffic	Controlled Traffic	Difference (t DM ha^{-1})	P-value
1^{st} Cut (t DM ha^{-1})	5.28	5.43	0.15	0.27
2^{nd} Cut (t DM ha^{-1})	3.58	3.88	0.30	0.72
3^{rd} Cut (t DM ha^{-1})	2.34	2.84	0.50	**<0.01**
2^{nd} + 3^{rd} Cut	5.92	6.72	0.80	**<0.05**
Total silage	11.29	12.15	0.96	

Soil health: organic matter

- Soil organic matter increases soil stability, drainage (reduces run-off), fertility and encourages biodiversity

- Organic matter is lost from a field as a result of continued cultivation when stubbles are not ploughed back into the soil or when organic manures are not returned

- Intensive tillage during potato cultivation increases the susceptibility of soils to organic matter loss and compaction

- Scottish agricultural soils have typical organic matter contents of 5 to 10%

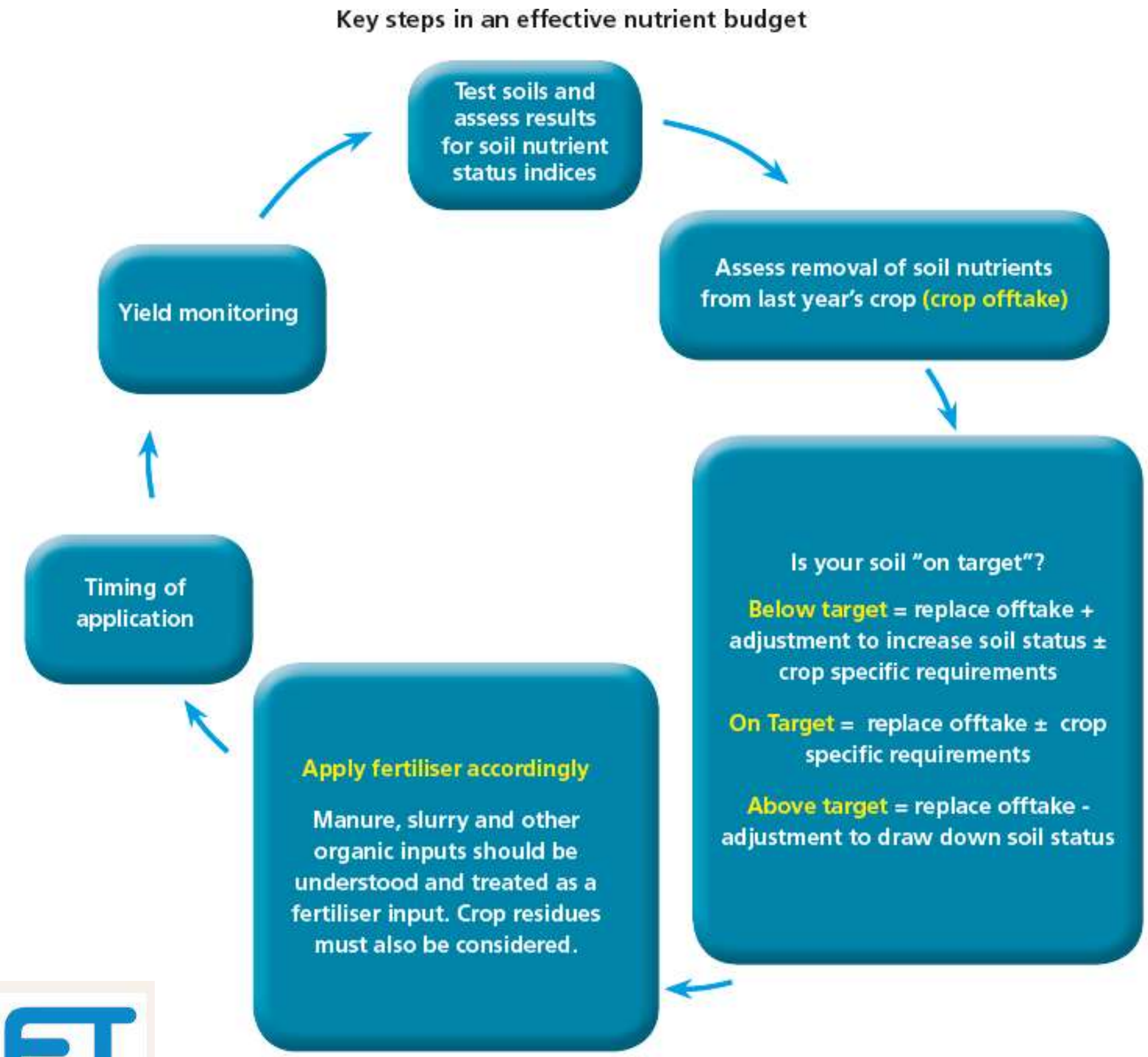
Soil health: earthworms

Earthworms burrow through soil and feed on organic matter, improving the movement of air, water and nutrients through the soil

A healthy soil would normally have 5-10 earthworms in a 10 cm thick slice of soil to spade depth

Feeding the ‘underground livestock’ is essential for productive land with healthy soil. The soil food web is part of energy, nutrient and water cycles

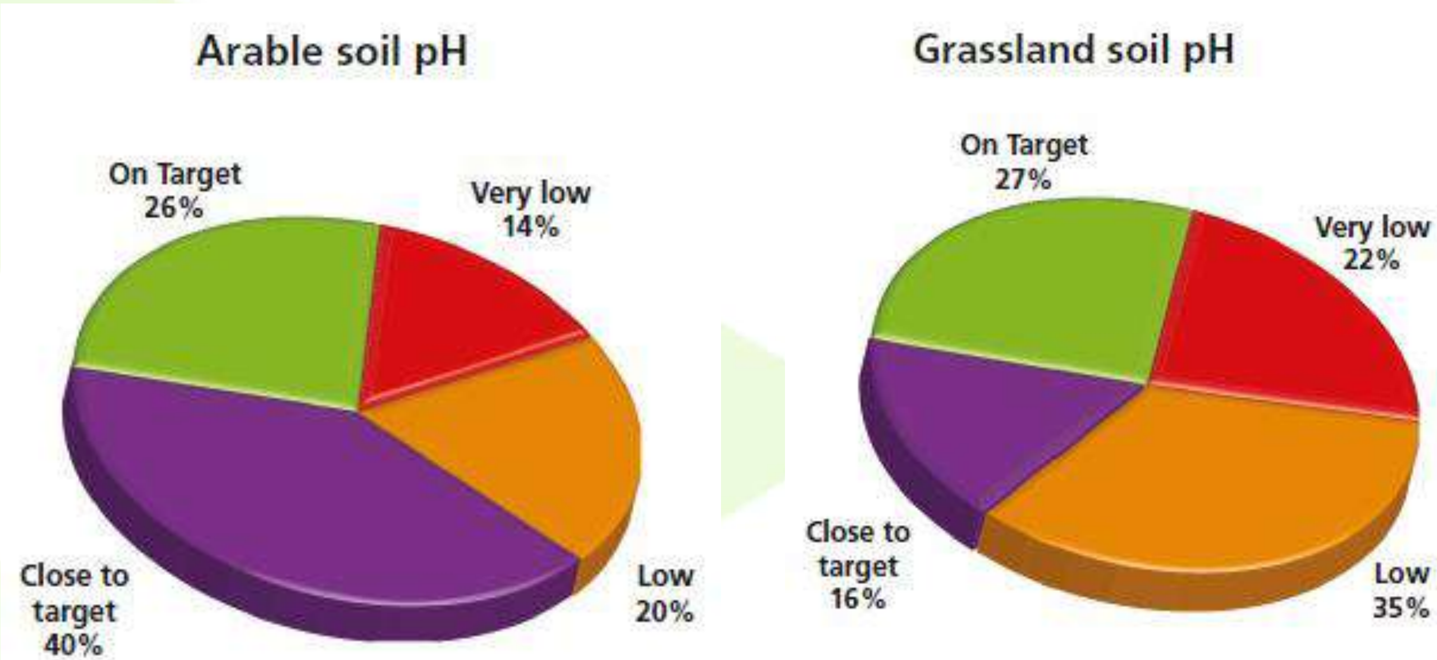
Nutrient Budgets



PLANET NUTRIENT MANAGEMENT

http://www.sruc.ac.uk/downloads/120451/crop_technical_notes

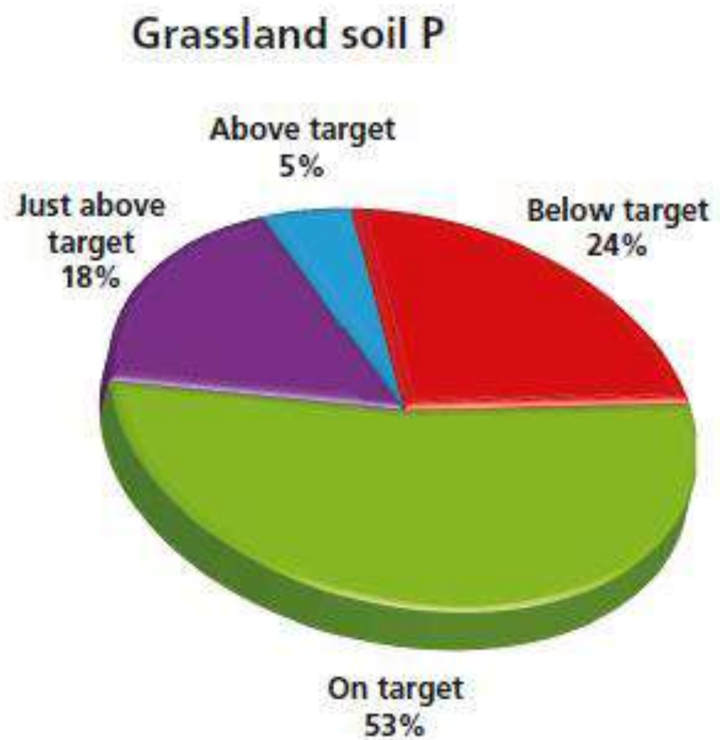
Assessments of Scottish agricultural soil pH



- Consequence – the majority of soils are being managed below optimal pH status.
- Applied fertilisers are being used less efficiently causing reduced crop production and a potential risk to the environment.

Assessments of Scottish Arable Soil P

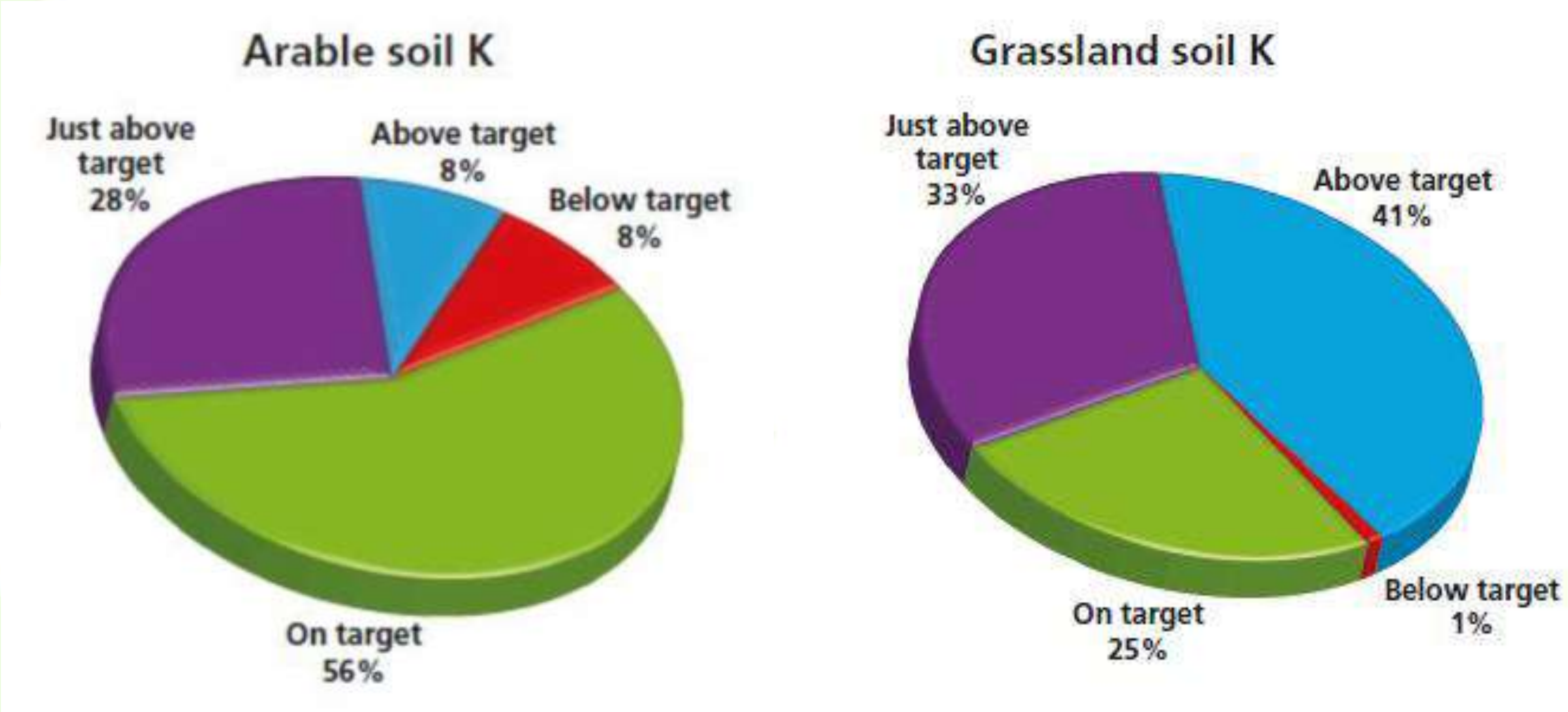
SRUC



Arable soil P levels required maintenance rather than any increase or decrease, to maintain economic and environmentally sustainable status, so future P inputs are balanced to annual crop off-take

Consequence – at or above target could save around £12/ha by making better use of soil P reserves

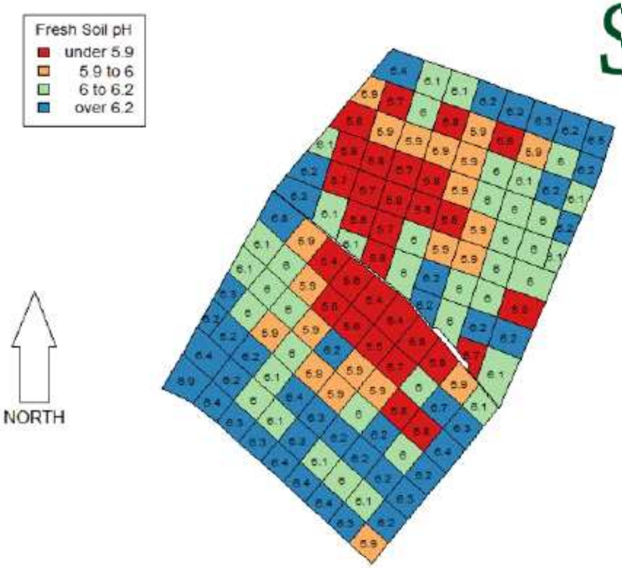
Assessments of Scottish Arable Soil K



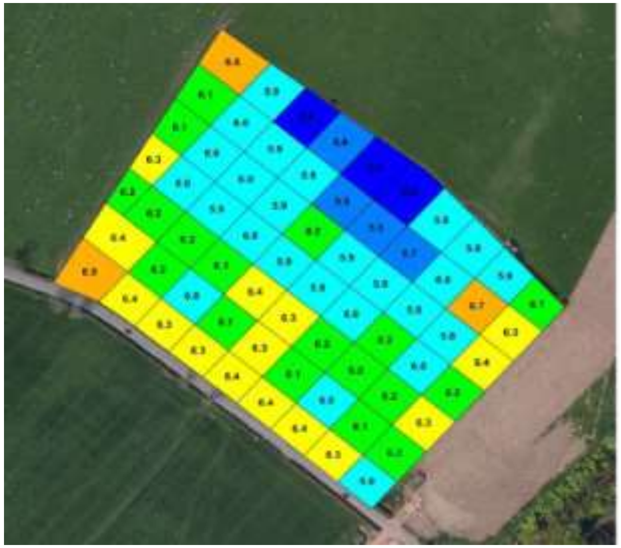
Consequence – farmers that are at or above target could save around £43/ha by making better use of soil K reserves

Soil testing - nutrient management

- Soils must be maintained at a suitable pH with adequate soil nutrients to provide fertility for growing crops
- Soil testing is an essential nutrient management tool that allows you to assess fertiliser requirements for optimal crop growth



- Where fertilisers supplement the natural fertility of the soil, it requires testing every 4-5 years (pH and extractable P, K, Mg) to be effective and efficient
- GPS sampling for soil pH and variable lime application can be an effective cost and carbon footprint reducing option



Conclusions

- Know your soil
- Compaction caused a loss of yield
- Visual Assessment helps with management
- Controlled traffic maintained yield in grassland
- Soil alleviation did increase yield
- WFPS effected by soil alleviation
- Natural recovery gave an indication of improvement
- Soil quality is important
- Maintain and manage nutrients

Thank you

Funded by the Scottish Government under the RESAS strategic research programme.