Stranraer Soil Nutrient Network

FARM ADVISORY SERVICE

Balwherrie Farm, Leswalt
Thursday 19th July 2018

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Stranraer Soil & Nutrient Network Farm

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Funded by Scottish Government under the Farm Advisory Service and delivered by SAC Consulting

- One of a network of 12 farms across Scotland taking a before and after look at how to protect and improve soils:
- Campbeltown, Ayr, Stonehaven, Kirkwall, Stirling, Elgin, Benbecula, St Boswells, Angus, Turriff, Dumfries
- The aim is to improve farm profitability through improved soil and nutrient use, lower carbon footprints and reduce diffuse pollution risk.
- Series of 3 meetings - July and November 2018 & Summer 2019
- Topics for meetings 2 & 3 to be decided by you
- Opportunity to link up with the other network farms to share information

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Agenda

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- Soil sampling – what's it all about!
- Phosphate
- Lime as a Key Nutrient
- Introduction to Soil Structure
- LUNCH
- Balwherrie – practical soil assessments
- Working demonstration
- Summary and finish

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Soil sampling

What is it all about?

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What is soil?

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"Soil is a dynamic mix of minerals, organic matter, air and water, which changes in response to cropping, cultivation, nutrient applications, weather and the activities of soil organisms. Good soil management starts with assessment and then managing it to maintain good structure, balanced chemistry and healthy biology."

ADHB Improving soils for Better Returns

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Soil sampling

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- Why ?
- Measures the plant available nutrients in the soil
- Gives you information to manage deficits and surpluses in soil nutrients
- Measures the acidity of the soil - pH will dictate what is actually available to the plant
- Corrections of low pH and nutrient deficits will improve the productivity of your crop and save you money!

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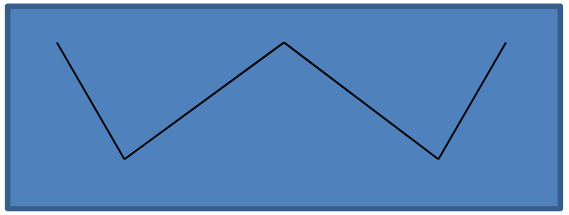
How to sample

- Twist a gouge or pot corer down to 7.5cm
- Walk the field in a ‘W’.



- Avoid gateways, feed areas or former muck-heap sites
- Collect 25 plugs of soil in a clean bucket
- Seal a well-mixed sub sample in a plastic bag or box and label
- Send to an accredited soil testing laboratory (either direct to the laboratory or via a local co-op, fertiliser merchant or independent company)

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Value for money

- £10 per field Basic Sample
- pH
- Phosphorus
- Potassium
- Magnesium
- Calcium } SAC
- Sodium }

Additional charges for Selenium/Cobalt/OM/soil texture

- £30 for Broad Spectrum
- pH
- Phosphorus
- Potassium
- Magnesium
- Manganese
- Calcium
- Copper Sulphur
- Sodium
- Zinc
- Boron
- Iron

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Small print

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- Avoid sampling when soil is waterlogged….or too dry!
- Sample amalgamated fields separately
- Sample problem areas or known soil types separately
- Try to sample at least 2 months after slurry/manure/fertiliser or lime applications
- Sample at least every 4 years
- For fields underperforming start with a soil sample
- Try to sample the year before sowing a crop to allow time to correct any deficits

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LIME AS A KEY NUTRIENT

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Where we're at

63% of soils sampled in N Ireland are below 5.9

56% of soils sampled in Stranraer are below 5.8

27% of soils sampled in Stranraer are below 5.5

pH status in the catchment

	Average	Range	< 5.6	5.6 – 5.8	5.8 – 6.0	6.0 – 6.2	> 6.2
Silage	6.06	5.3-6.9	28%	13%	18%	18%	23%
Grazing	5.81	5.2-6.5	33%	14%	18%	16%	18%

Catchment Fertility Summary – pH Status

- 1 in every 3 fields sampled are critically short of lime (< 5.6)
- Beef farmers are more likely to be in the low pH status (20 out of 30)
- Dairy farmers are more likely to be in the mod/high pH status (> 6.0)
- 2 in every 3 fields need lime

Why bother to lime?

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To Maintain Soil pH which:

- Encourages soil microbiology (worms + N bacteria)
- Increases utilisation of nutrients by plants
- Increases availability of nutrients in fertiliser
- Enhances availability of phosphate in the soil
- Reduces risk of Aluminium toxicity
- Helps breakdown of Organic Matter
- Provide Calcium and Magnesium which help balance soil structure

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Why do we need to lime?
To replace losses

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- Leaching
- Crop Uptake
- Impact of Ammonium Nitrate Fertiliser
- Acid Rain

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How much lime?
Where does it go?

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E.g. Silage Land

Acidic effect of Fertiliser	175kg
Crop Removal 1st cut	80kg
Crop Removal 2nd cut	45kg
Leaching/Drainage	100-250kg
	400- 550kg/ac/yr

So 2 ton /Acre every 5 years to standstill !!!

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Why do we need to lime?
Nutrient availability

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% Nutrient Availability at different pH

	N	P	K
pH 5 (very strong acidic)	53%	34%	52%
pH 5.5 (strong acidic)	77%	48%	77%
pH 6.0 (medium acidic)	89%	52%	100%

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What is pH?

Soil pH is a Logarithmic scale to measure acidity (Concentration of H+ ions)

pH3	pH7	pH11
Acid	Neutral	Alkaline

pH = -log 10 (H+ Concentration)

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What happens?

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$$CaCo^3 + 2H+ \longrightarrow Ca^2+ + HCO^3$$

$$HCO^3 + H+ \longrightarrow H^2O + CO^2$$

$$CaCO^3 + 2H+ \longrightarrow Ca+2 + H^2O + CO^2$$

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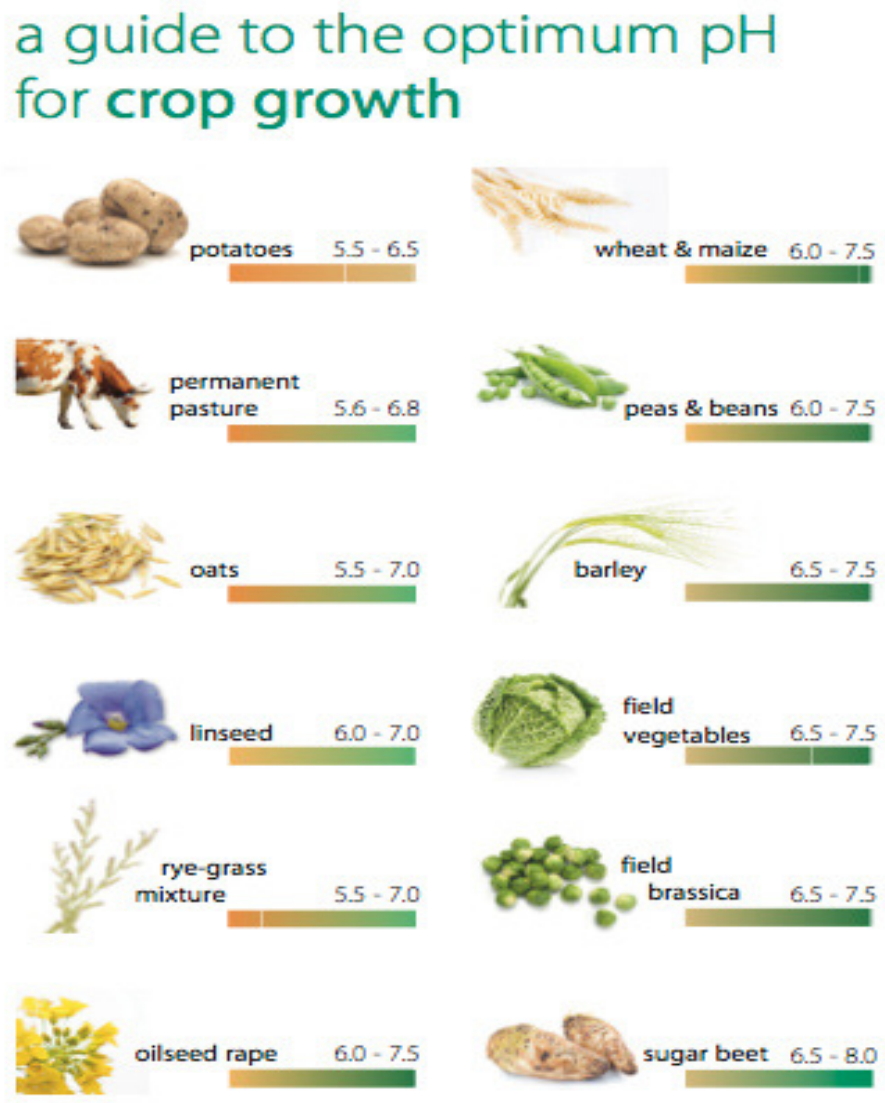

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What is the right pH?

Correct pH depends on:

- Crop
- Soil Type
- Organic Matter Content

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What's the right pH?

Below 5	–	risk of failure of all arable crops
5 – 5.4	–	risk of failure of barley/OSR
5.5 – 5.9	–	barley, wheat, swedes, clover may suffer from acidity (pH patches)
6 – 6.5	–	Optimum pH (watch scab in potatoes)
Above 6.5	–	Induced Trace element deficiency risk

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What's the right pH?
Grassland mineral soil

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	pH
• Intensive TGRS/dairy grazing/silage	> 6.2
• Less Intensive	> 6.0

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What's the right pH for soil type?

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Soil Type	pH
Sands	6.1
Sandy Loam	6.2
Silty Clay	6.3
Humose	6.0
Peats	5.7

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Benefits of liming

- Improved Plant growth
- Efficient use of fertiliser
- Promotes Bacterial activity in soil
- Supports Soil structure
- Animal health e.g. Johnes
- Water quality in streams etc.
- Efficacy of Agrochemicals improved in neutral soils

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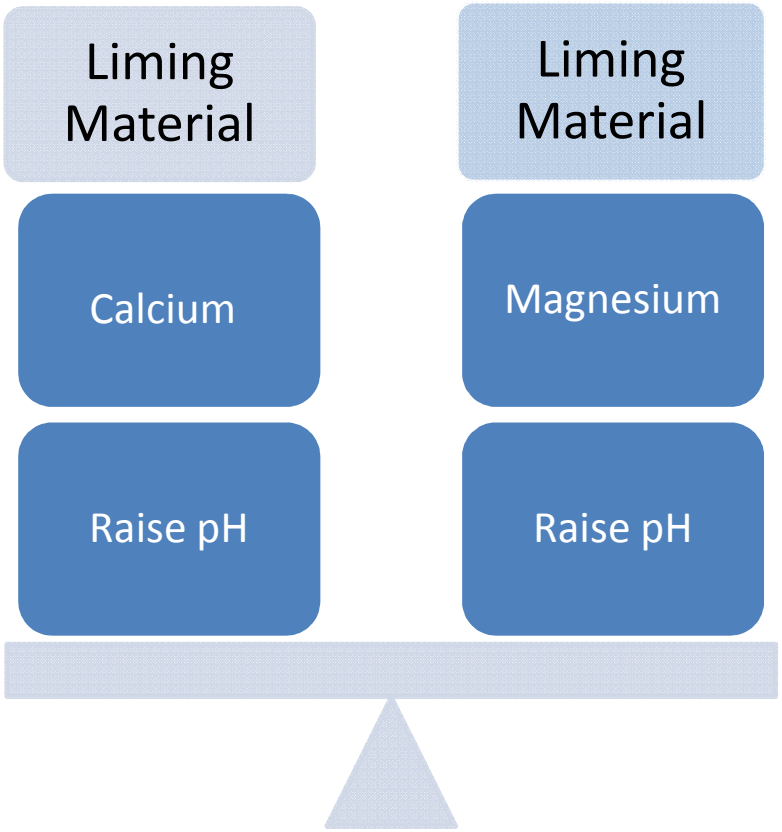
Liming materials to raise pH / add nutrients



Benefits of calcium

- Root Development
- Cell Walls
- N^2 fixing bacteria
- Protein

Benefits of magnesium

- Reduces risk of Tetany

(but availability in herbage decreases if Nitrogen and Potassium levels increased)

- Advisable to maintain high level of soil magnesium for intensive grass

Comparing liming materials - effectiveness

Legal Requirement to provide:

Neutralising Value (NV)

"Liming value expressed as a % of liming potential of Calcium Oxide"
Eg NV 45 = 45% as effective

Finess of Grinding

"Size of particles present and is measured through a series of standard sieves"

Finer the material the quicker it will act, but too fine – dusty or can wet up.

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What's available?

Liming Material	Neutralising Value of % of CaO
Calcium Carbonate	56%
Magnesium Lime (dolomitic)	56%
Ground Limestone	48%
Hydrated Lime (Ca OH^2)	70%
Burnt Lime (Industrial)	90%
Shell Sand	30%
Waste Paper (High Calcium)	7%

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What's available?

- Thompson's Yorkshire Calcium White Lime NV 55%, 98% Calcium.
- Prudoe Magnesium Lime NV 55%, 52% Calcium, 18% Magnesium,
- Lugton Calcium Lime NV 51%, (- Harder Lime)
- Irish Lime (grey colour) NV 49%
- Prillied Lime NV 51%

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How much lime? ‘rules of thumb’

- pH drops 0.1 unit/year on Intensive land
- Need 1t/ha to lift 0.1 unit pH

pH	Lime Required	
5.5	8t/ha	3.2t/acre
6.0	4t/ha	1.6t/acre

Acidic Effect of Fertiliser

Every 50kg of 34%N needs 25kg of lime to neutralise.

How much to spread

pH 5.5

Crop Requirement 9t/ha or 3.6t/acre

Safe maximum at one go 2-2½t/acre

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When to spread

Autumn before ploughing

or

After field ploughed

(watch ground pressure tyres 18psi)

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Liming timing

Don’t apply Urea within 8 weeks after Liming

BUT can spread Lime 1 week after applying Urea

Don’t apply Slurry within 10 weeks after Liming

BUT can spread Lime 3 weeks after applying Slurry

Don’t apply Lime to Silage fields within 6 weeks of cutting (or between cuts?)

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Liming,timing

If low pH and also low Phosphate – apply lime first (unless using Rock Phosphate)

No need to leave a gap between spreading lime and CAN or NPK Compound fertilisers

Advisable to keep stock of limed paddocks until lime washed off the leaves

Risk of over-liming?

Too much lime can lift pH and reduce uptake of

* Copper
* Cobalt
* Selenium
* Manganese

but increase availability of Molybdenum

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Take home messages

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- Work a year ahead for lime (and phosphate)
- 2 ton/acre or 5 ton/hectare every 5 years to maintain pH
- Don't lime within 3 weeks of spreading slurry—to avoid ammonia release into atmosphere/loss of N
- In Spring apply Urea first then lime at least 7 days later to reduce loss to volatilisation

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PHOSPHATE and Practical Nutrient Budgeting

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Phosphate

- Phosphate stimulates root development and encourages early growth.
- Cereals and newly sown grass and clover benefit from applied soluble phosphate because their root systems are insufficiently developed to tap the main P reserves in the soil.
- Clover more susceptible than grass to P deficiency due to having less extensive roots system, so grass out competes.
- Target is M- (M+ for clover)
- Plants get phosphate from the soil but it must be converted to a soluble form before being absorbed by roots.
- There is a lot of insoluble phosphate in the soil – a small proportion is soluble at any time and used by plants.

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Sources of phosphate

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Phosphate Sources

- Slurry/FYM
- Water Soluble (TSP 45%)
- Fibrephos (0 16 16)
- Rock Phosphate (27 – 33%)
- Basic slag (2 – 22%)
- DAP (18% N + 46% P)
- MAP (12% N + 52% P)

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P Status in the catchment

	Average	Range	L	M-	M+	H	VH
Silage	9mg/l	2.1-31	15%	28%	40%	14%	2%
Grazing	12mg/l	3.7-44	4%	48%	18%	23%	7%

Catchment Fertility Summary – P Status

- M+ silage and M+ grazing – can reduce applications
- 56% of silage fields DON'T need P
- 15% of silage fields need extra P
- 4% of grazing fields need extra P
- 48% of grazing fields DON'T need extra P

Balwherrie “Tank Field”

Silage field sown in 2016 – 2 cuts
2018 soil sample show Low P and Moderate K
2015 showed Moderate P and Low K

	N	P	K	S
Bagged Fert (units/acre)	150	12	78	42
Slurry (6000gal/acre) (units/acre)	21	24	110	
Total Applied (units/acre)	171	36	188	42
Total Required (untis/acre)	170	80	150	30
	+1	-44	+38	+12

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Soil Care - Reducing Soil Compaction

- Seamus Donnelly BScHons Soil Science
- SAC/SRUC Senior Consultant
- Stranraer

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Stranraer Rainfall Figures

17 year average annual rainfall = 47”

June 2017 – January 2018 = 47”

8 consecutive months of almost 6” rain per month

	Annual	June - October
2002	57”	20”
2012	53”	27”
2014	56”	16”
2017	56”	29”

What causes compaction?

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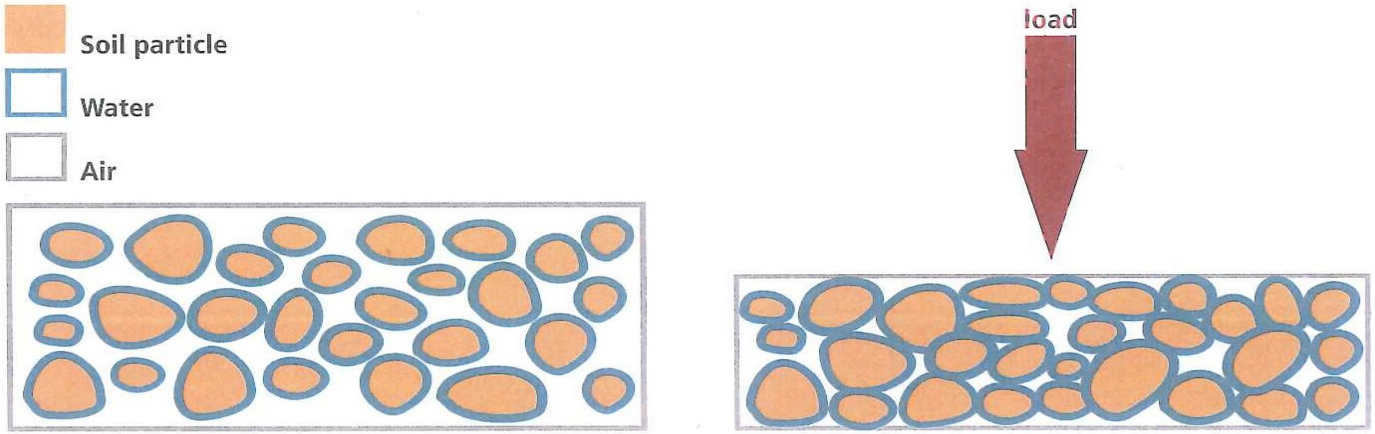
- Soil compaction is...

the consolidation of soil particles as a result of animal or vehicular traffic.



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Compacted layers

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- Restrict movement of water/air/nutrients
- Prevents good root development
- Impedes Drainage
- Increases release of Nitrous Oxide
- Reduced Nutrient efficiency

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Impact of soil compaction

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Poor plant growth

Lower Yields

Poorer Utilisation of fertiliser

Increased runoff and ponding

Increased anaerobic conditions

Increased soil erosion

More greenhouse gas emissions

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Which soils are at risk?

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WET SOILS

High Clay content

Peaty

Poor soil structure

Low Crop cover

Heavy Stocked

Heavy Trafficking

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Identifying compaction

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Use a spade to dig a hole at least 30 cm deep - examine for:

- Blocky platy vs crumb structure
- Horizontal layers (hard pan)
- Poor root penetration and roots running horizontally
- Lower earthworm populations
- Grey mottling

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Soil structure

Structure is the how the particles bind together to form aggregates that allows:

- roots to anchor the plant
- water to drain through pores and cracks
- water retention
- air to roots for favourable gas exchange
- mineralisation of nutrients and release to crop roots
- biodiversity of microbes

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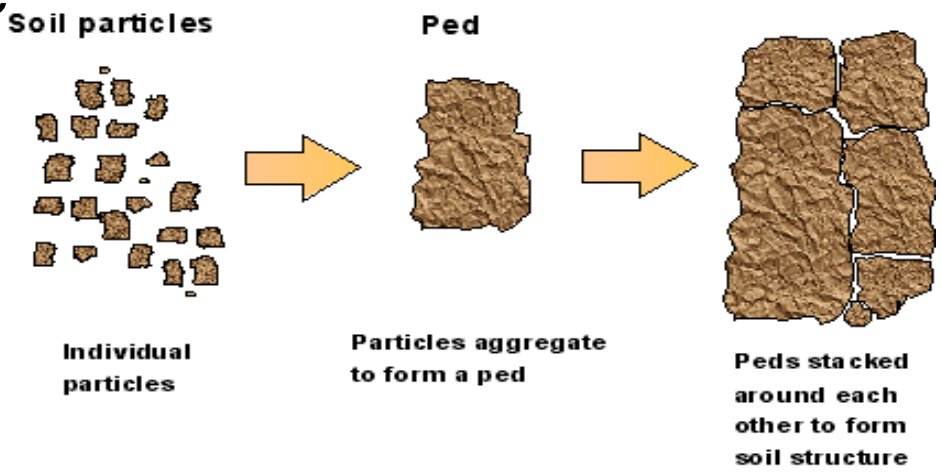
Aggregation

- A grouping of particles joined together or a grouping of aggregates (from pinhead to hand size)
- Joining is by ‘glues’ of clay and organic matter and binding by roots and fungal hyphae



Aggregate sizes

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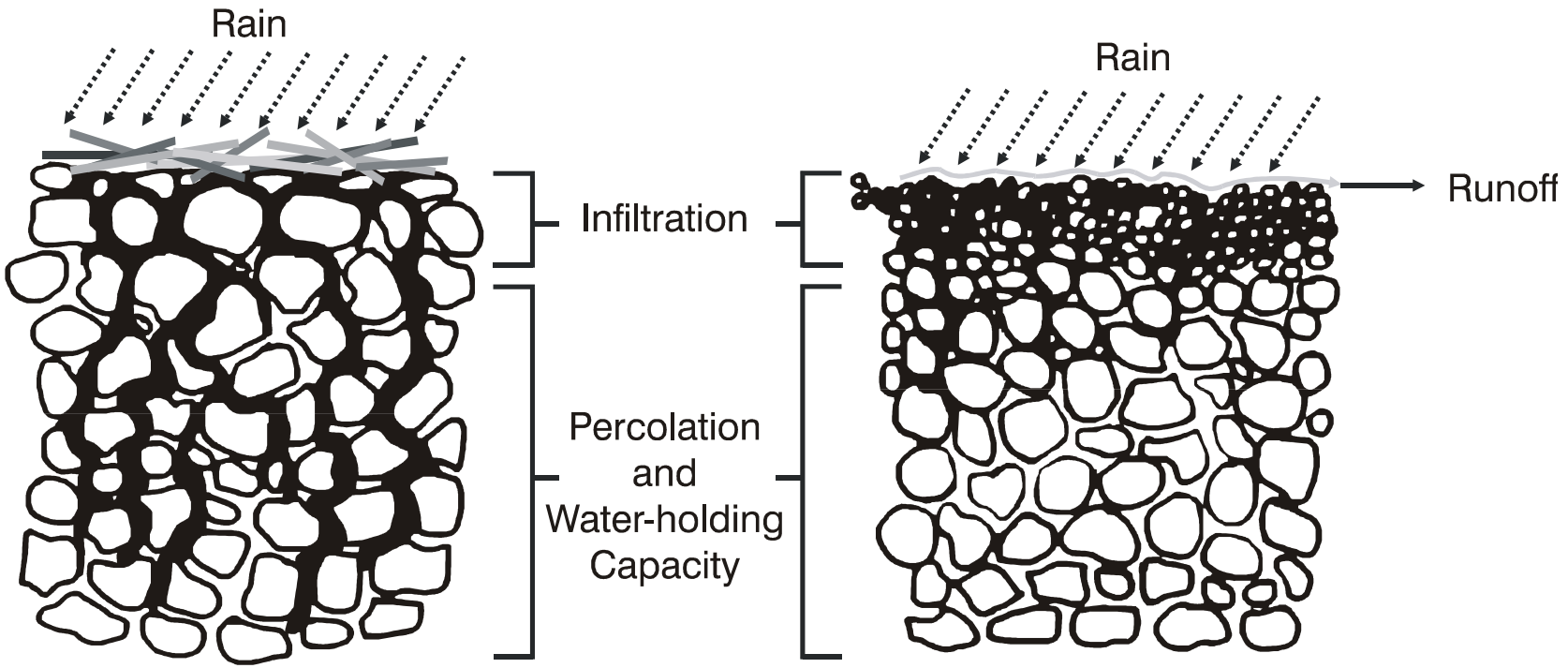
Structure affected by compaction



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SMI Soil Management Initiative

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Visual evaluation of Soil Structure (VESS)

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What is needed?

- A Spade!
- Show if aeration or sub-soiling is needed and how successful it has been
- Monitor soil health – take photographs

- Areas of field with suspected compaction
- Topsoil assessed with spade
- Subsoil and topsoil assessed by digging pits

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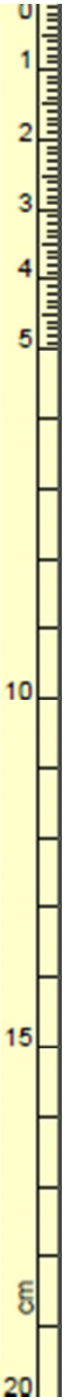
Structure quality	Size and appearance of aggregates	Visible porosity and Roots	Appearance after break-up: various soils	Appearance after break-up: same soil different tillage	Distinguishing feature	Appearance and description of natural or reduced fragment of ~ 1.5 cm diameter
Sq1 Friable Aggregates readily 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.



Good soil structure (Sq1)

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Good but larger aggregates (Sq2)

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Signs of compaction (Sq3)

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Compaction issues (Sq4)

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Very compacted (Sq5)

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Management from VESS scores

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Threshold Sq values for sustained agricultural productivity

Sq score	Soil structural quality	Management needs
1-2	Good	No changes needed
3	Fair	Long-term improvements
4-5	Poor	Short-term improvements

Types of compaction

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Animal trampling effect the upper layer of the soil (0-10cm).

Mechanical compaction – much heavier and effects of compaction are further down the soil profile (0-20cm).

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What does the most damage?

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Tractor vs Sheep vs Cattle

Tractor	Sheep	Cattle
12 psi	Standing 12 psi	Standing 25 psi
12 psi	Walking 29 psi	Walking 55 psi

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Compaction by livestock

At or near Surface—usually less than 4”.

Affected by:

- Mass of Animal
- Stocking Density
- Rate of Rotation
- Sward Type
- Local Issues e.g. troughs / shelters / gates

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What *is* he trying to do?!

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Compaction by farm vehicles

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Impacts on surface and subsurface

Affected by:

- Total axel weight
- Tyre width/diameter & type
- Inflation Pressure
- Wheel Slip
- Number of Passes
- Moisture content of the soil

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The wetter the soil, the greater the impact

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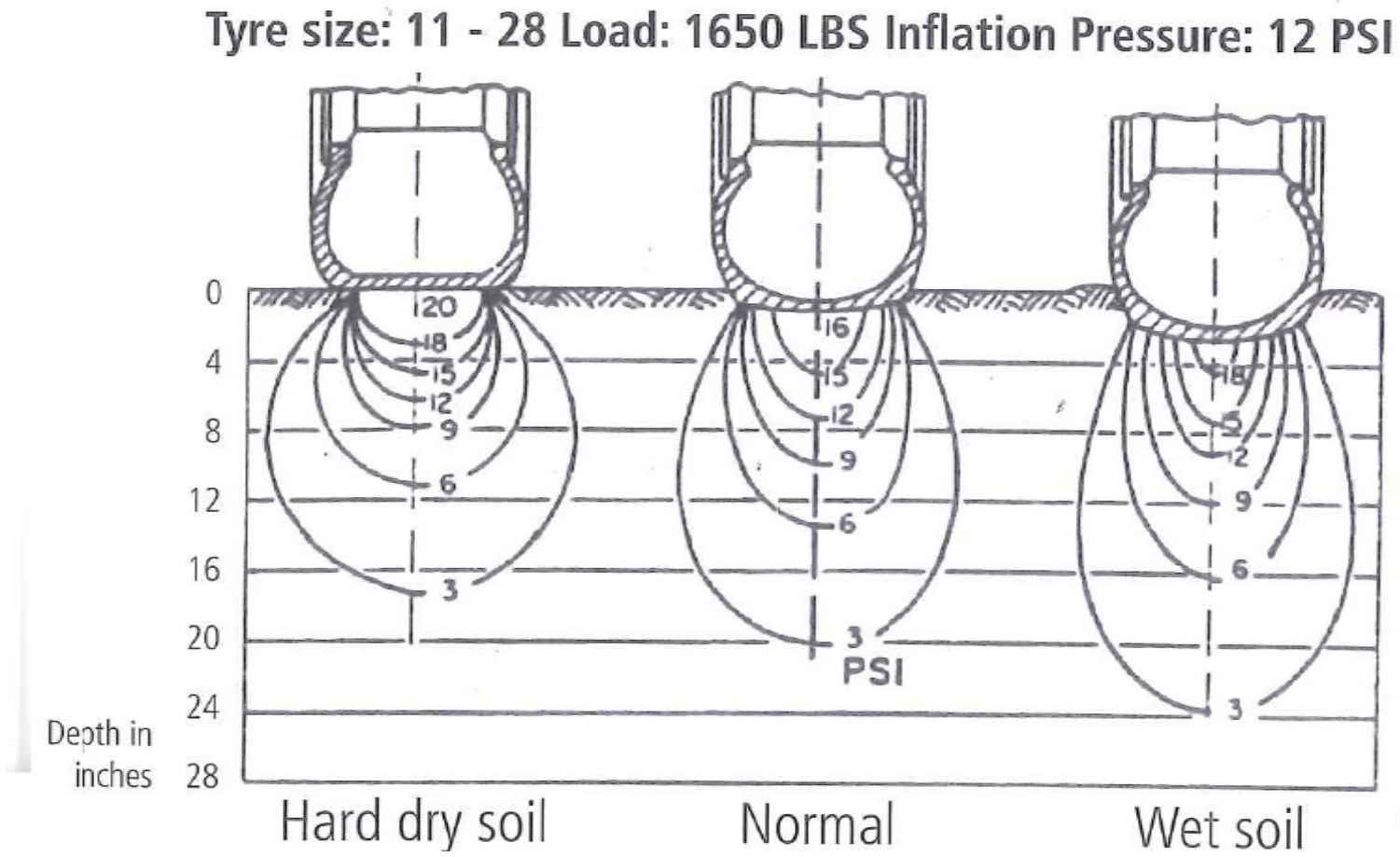

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Spread the load

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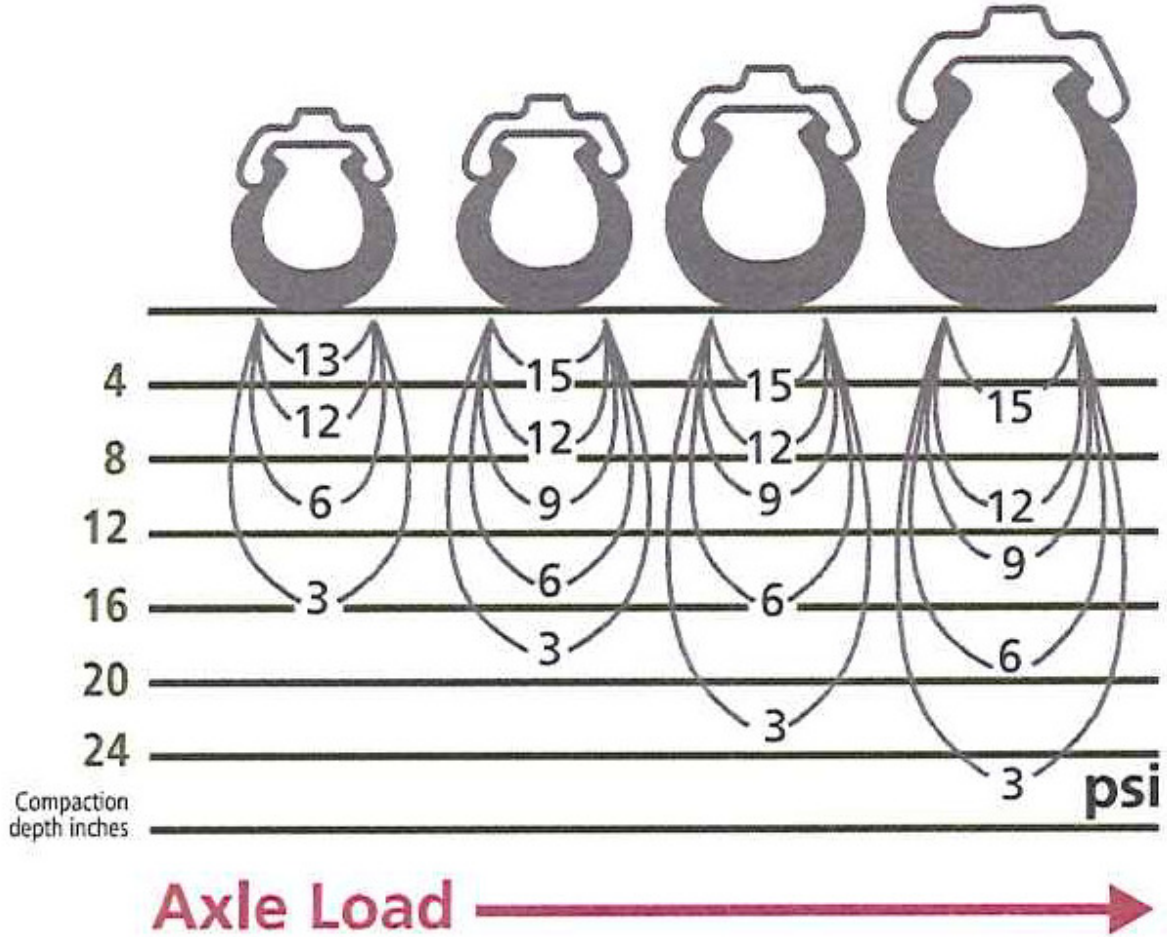

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Increase the footprint, reduce the compaction

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Grassland Soil Compaction: Effects on Yield and Nitrous Oxide Emissions

- Paul Hargreaves, Bruce Ball and Dave Roberts, SRUC

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DairyCo compaction experiment

The compaction experiment has three main treatments:

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

These treatments are related to measurements of grass yield and nitrous oxide (N_2O) emissions.

Sub-treatments

- **Surface aeration**
- **Sward lifting (~20cm)**
- **Nitrification inhibitor**

Two sites – Crichton (Scotland) and Harper Adams (England)

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Compaction treatments

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Heifers (12) trampled area for 1 hour on two separate occasions – one week apart.

Weighted tractor (10,200kg). Driven over the area once on two separate occasions - one week apart.

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Compaction treatment effects

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Soil after compaction treatments

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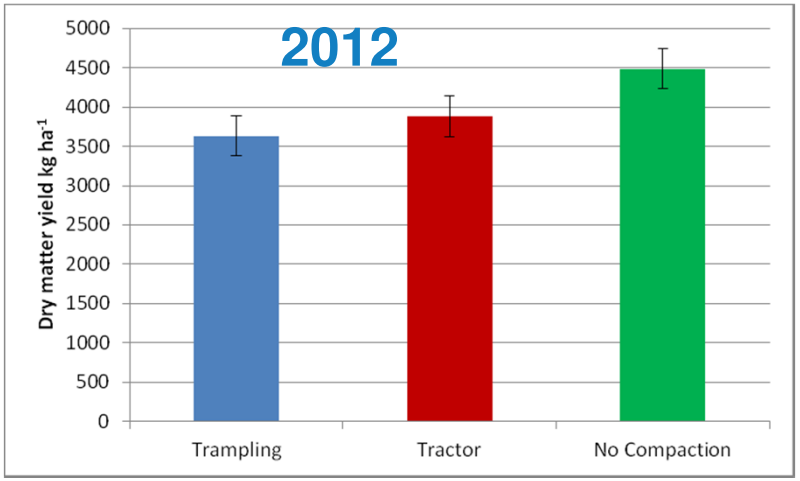
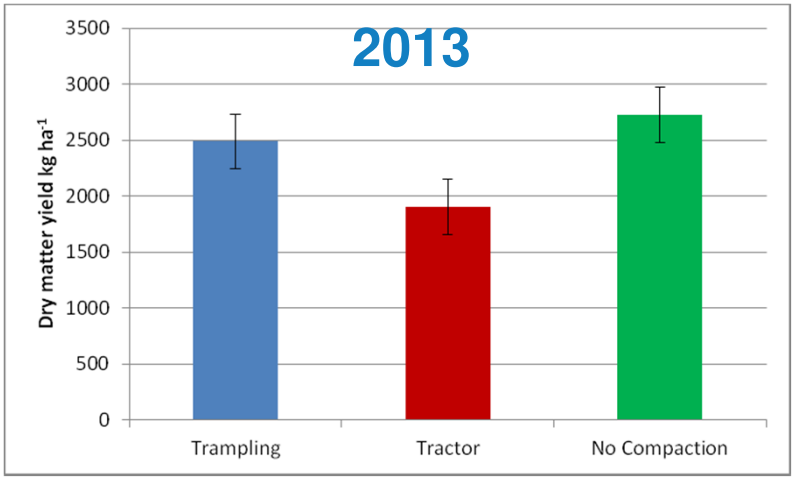
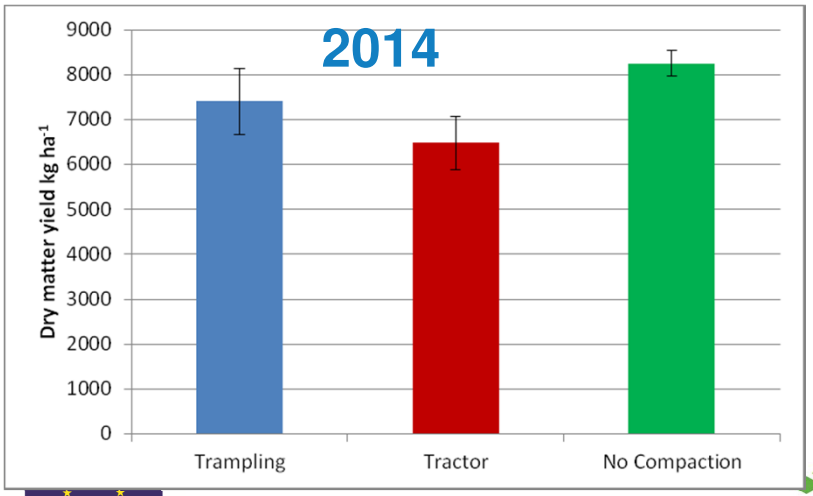
Compaction results – 1st silage cut







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Soil after compaction treatments

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

	October 2011	October 2014
SRUC	1.02	1.15
SRUC	1.02	1.23
SRUC	1.02	0.94

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Dry matter yield reductions (t/ha)

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	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		

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Compaction and nitrogen use

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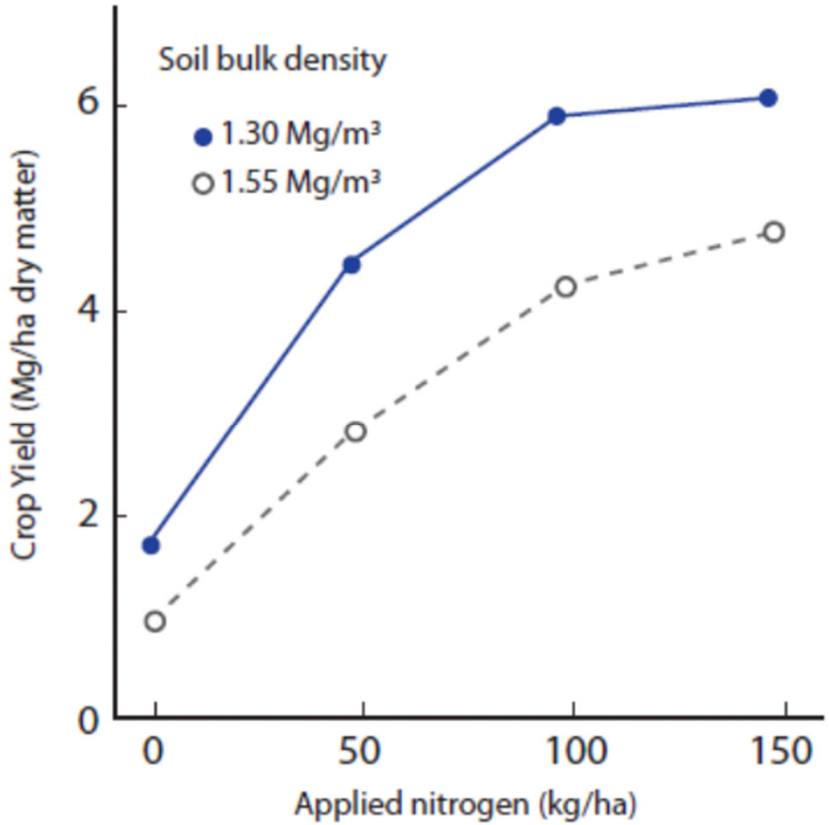

Figure 8.3: The relationship between the amount of nitrogen applied and crop yield under different compaction regimes. A compacted soil (bulk density of 1.55 Mg/m³) may require more nitrogen to obtain a similar yield to a non-compacted soil (bulk density of 1.30 Mg/m³). From Soane and Vanouwerkerk (1995)

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Prevention is better than cure

Stay off wet soils

Sort drainage issues

Know where your driest grazing fields are

Wetter fields –rest/graze with sheep/youngstock

Outwintering –when do you bring cattle in ?

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Prevention is Better than Cure

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Reduce weight

- Minimise loads, remove weights
- Light machines, more axles

Reduce ground pressure

- Wider tyres, low inflation pressure
- Tandom or Dual wheels, Tracked vehicles
- Specialised low ground pressure machines

Sacrifice yield for timeliness

Choose crops to suit your soil type

Avoid uphill operations

Use Tracks/Endriggs/Tramlines

Gates at bottom of field ?

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Spread the load

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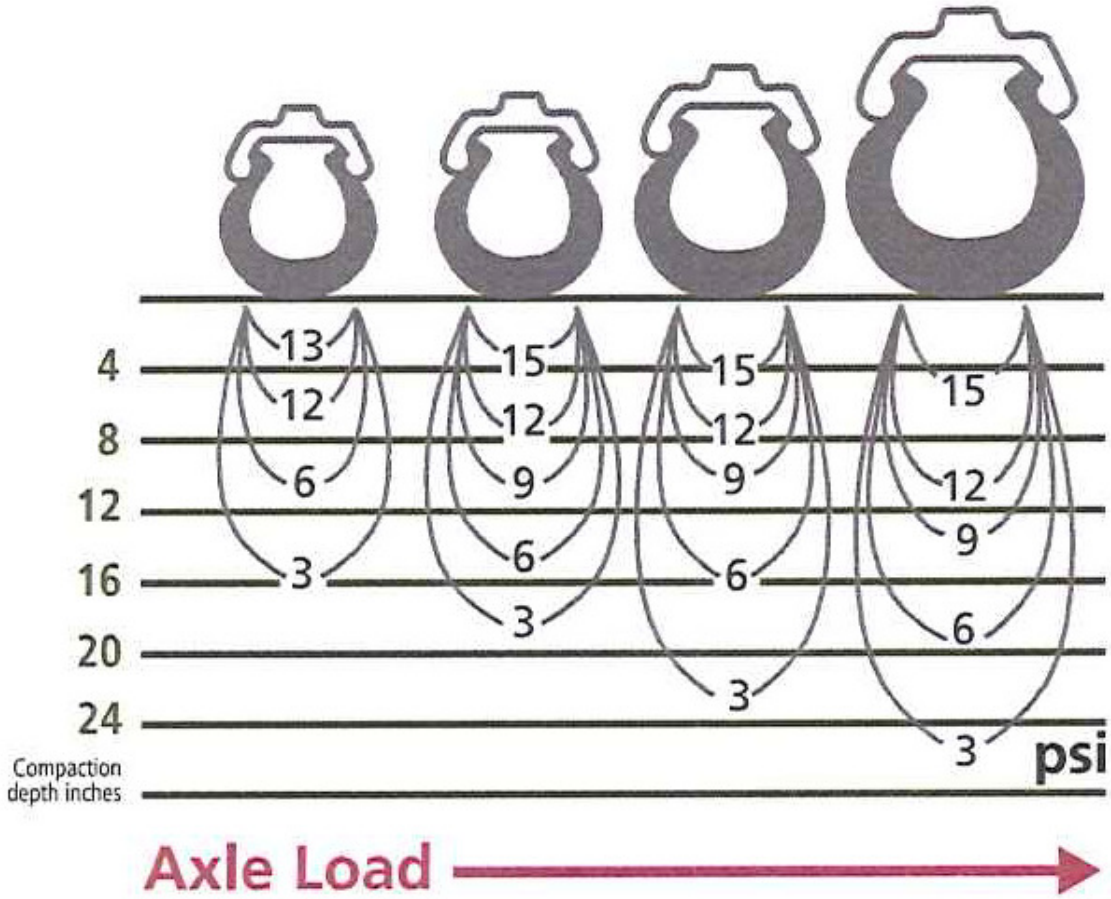

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Sorting compaction problems

Must use:

Right treatment
at the Right depth
at the RIGHT time

or else – WASTE OF TIME & FUEL

- Spike /Aerator
- Flat-Lifter
- Plough
- Subsoiler
- Mole Plough

Remediation and working depths

(Critical Depth 6x Leading tine width)

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Type	Typical working depth (cm)
Aerators i.e. spiking or slitting	0 – 15cm
Sward Lifters	15 -35cm
Sub-soilers	35 – 50cm

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Soil aerators

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Sward lifter

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Flat lifter

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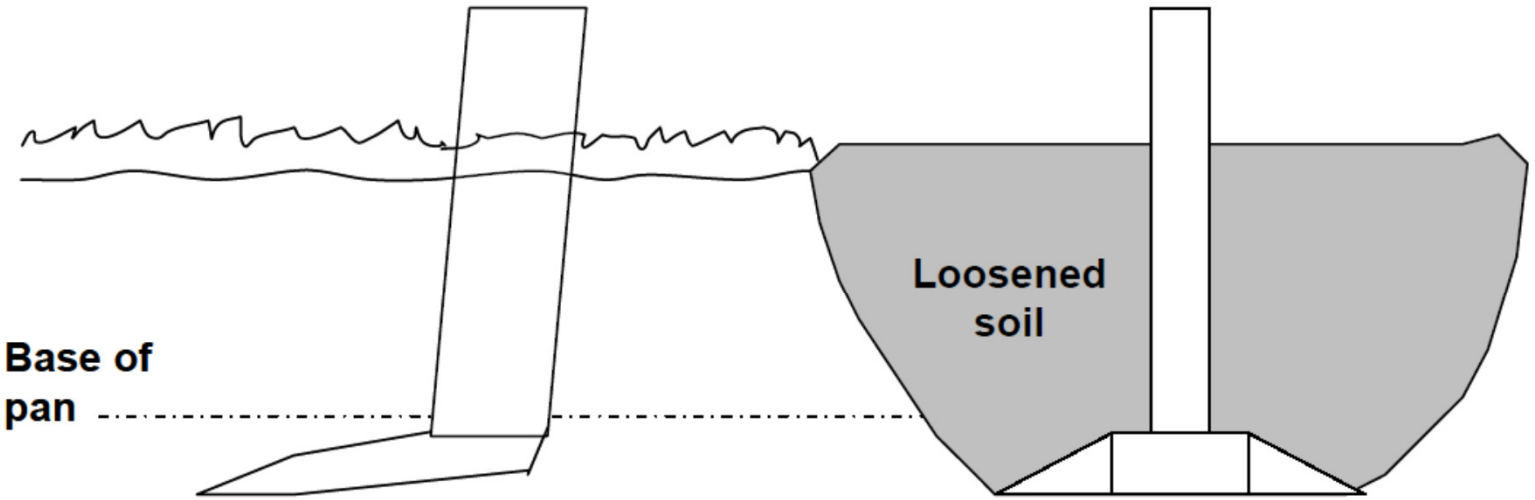
Sward lifters

Loosening a compaction pan with a sward lifter (adapted from NSRI, 2002).



Note: the working depth has to be just below the zone that needs to be broken up.

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Sward lifters

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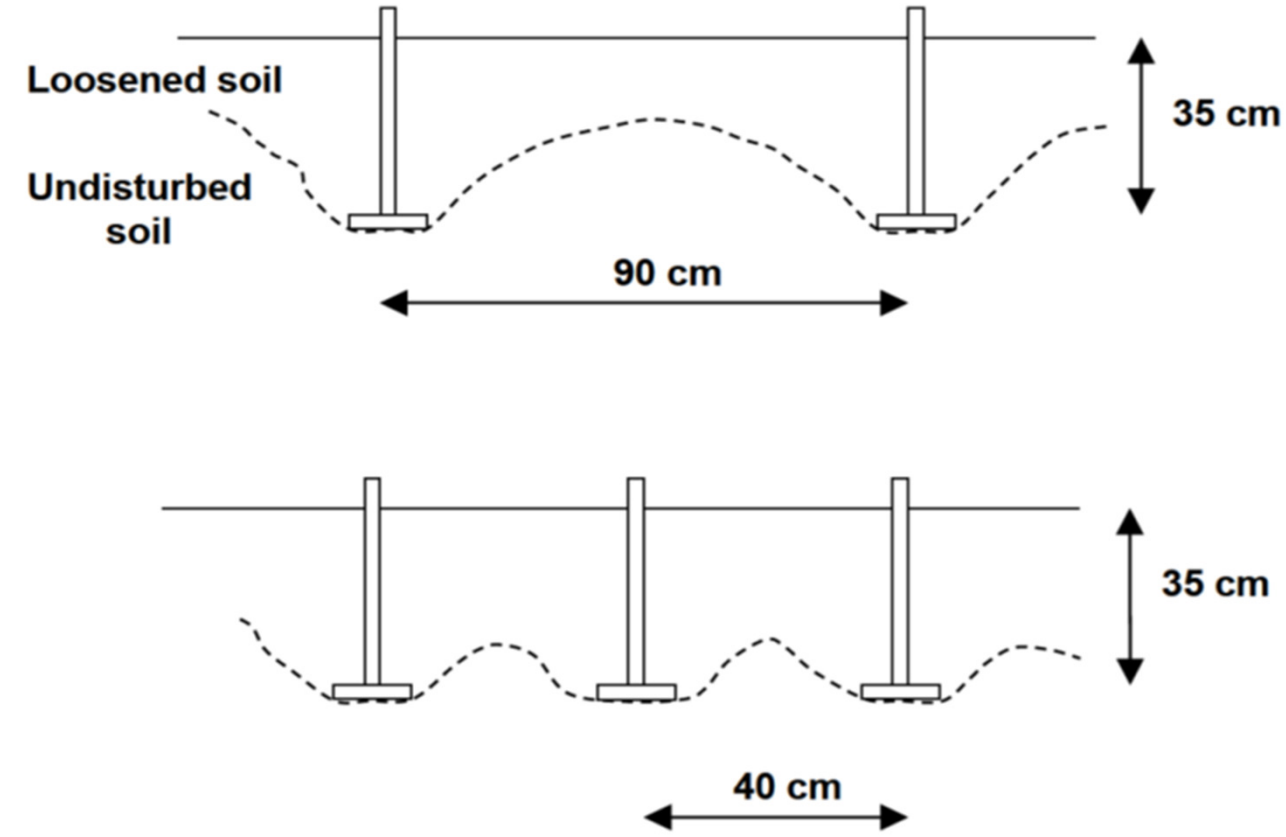
Soil disturbance profiles for a winged tine at different tine spacings.



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Flat lifters / mini subsoilers

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Remediation of severe wheel rutting

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- Make fissures across the ruts
- Allows water to drain into the adjacent uncompacted soil

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Subsoiler

Subsoiler tine

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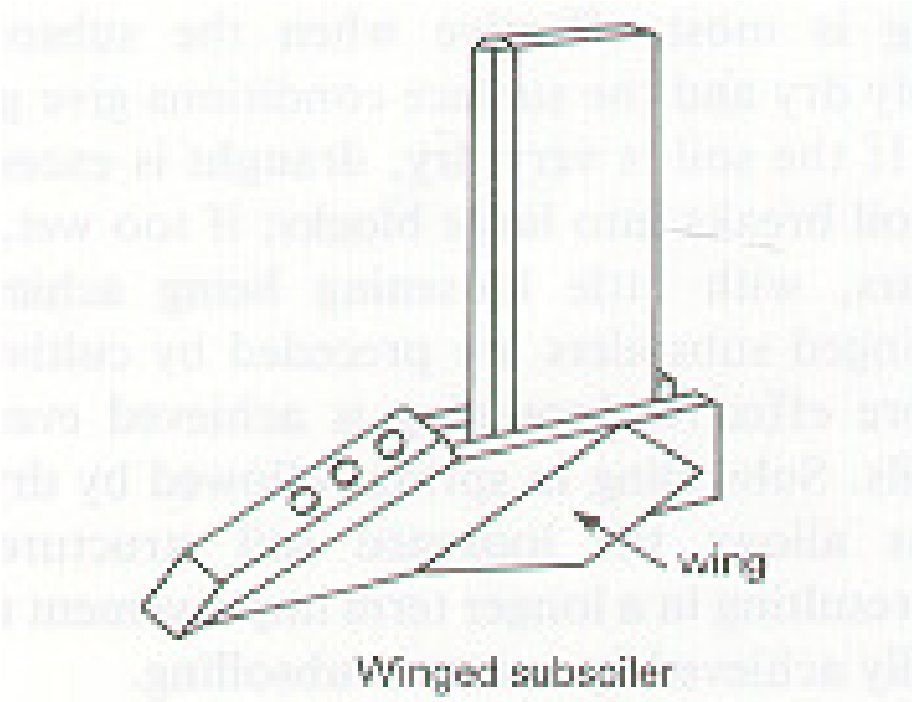

Winged subsoiler

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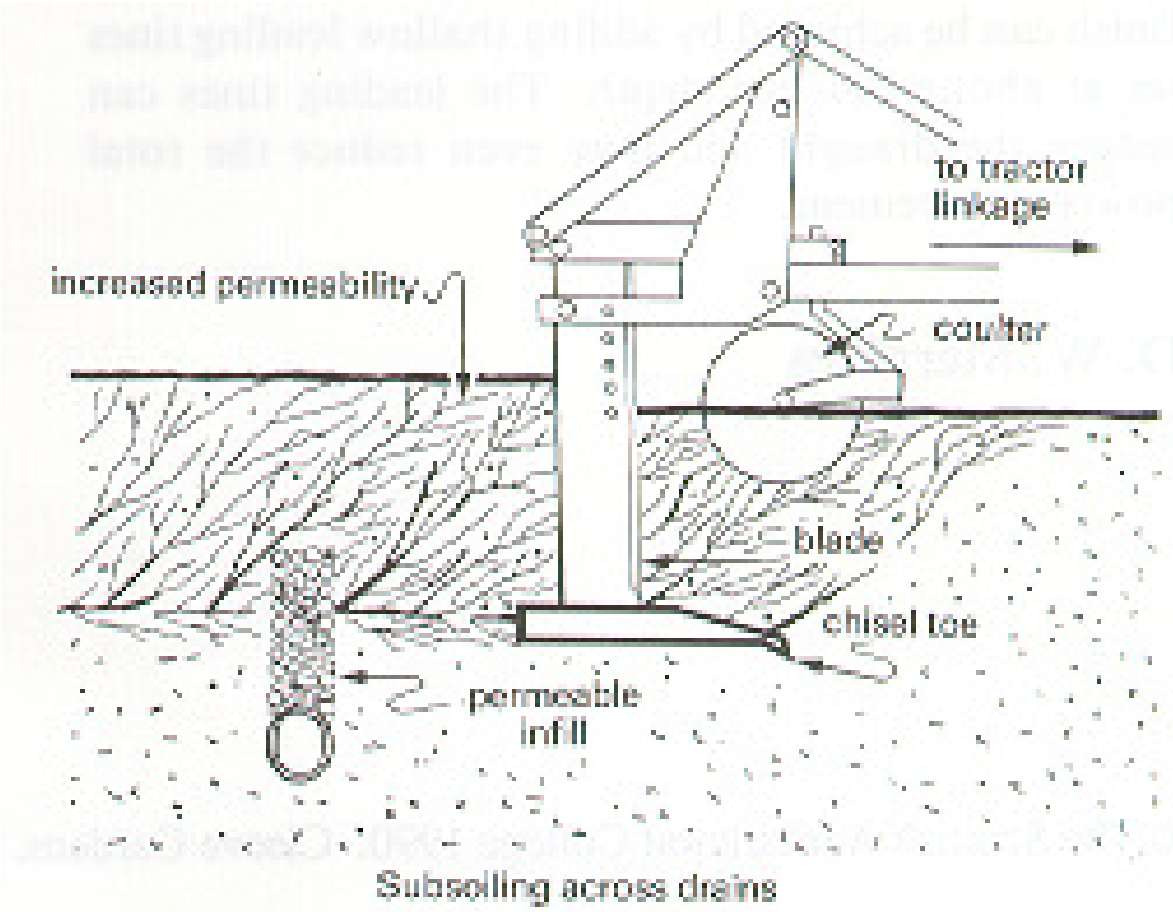
Subsoilers open up the soil



Subsoil shatter

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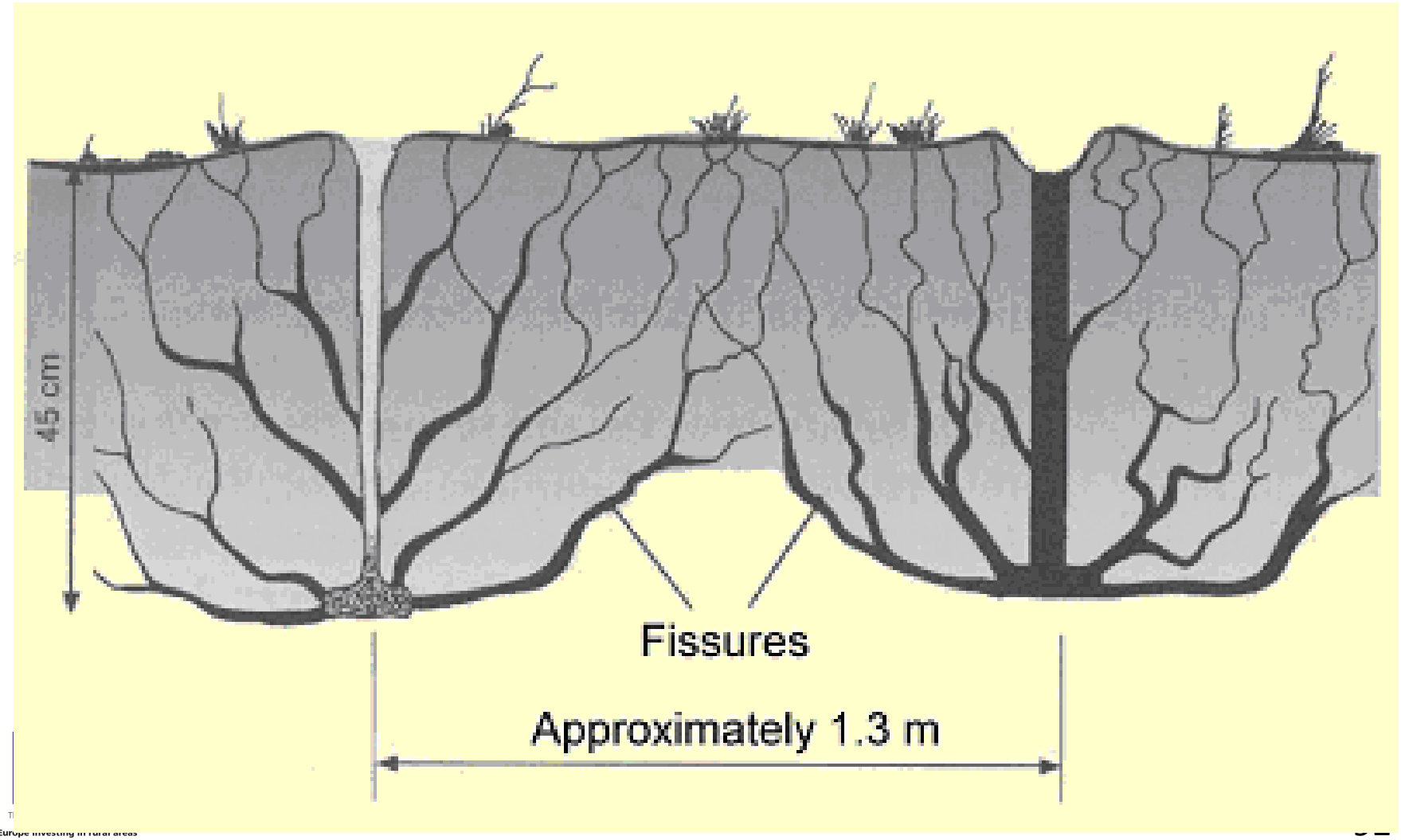
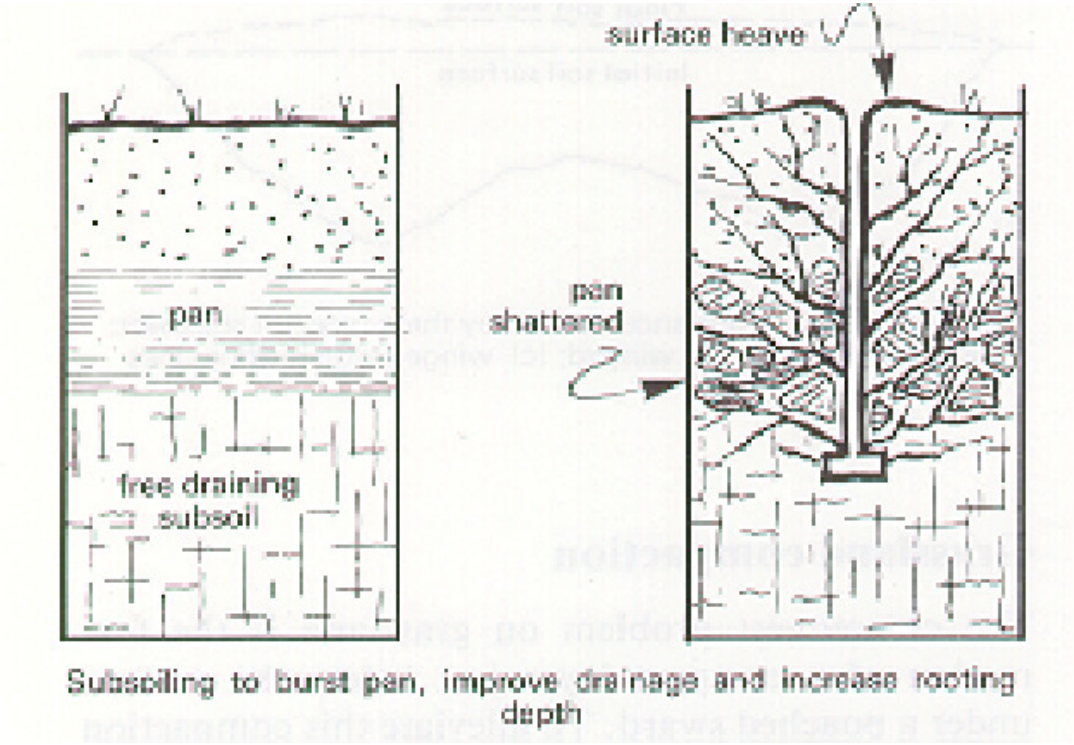


Subsoilers break up pans



Subsoiling to burst pan, improve drainage and increase rooting depth

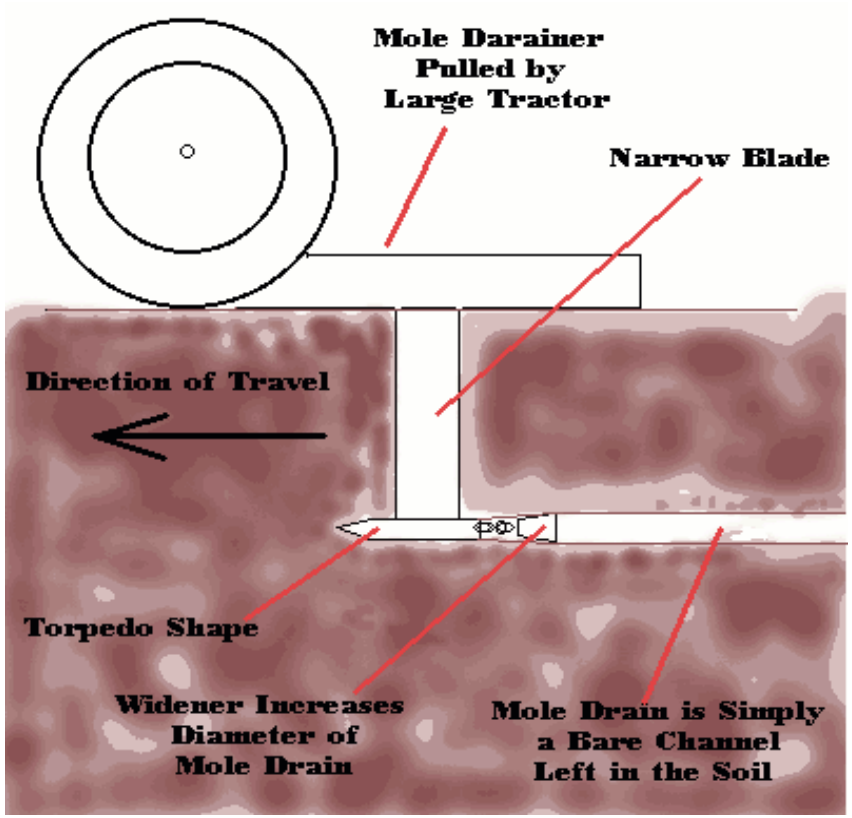
When to subsoil

- Only when necessary - check the subsoil for compaction
- When the subsoil is brittle i.e. not too dry or too wet
- Post Harvest subsoiling is usually best in terms of land access and soil suitability (but not in 2007 or 2008 or 2012)

How to subsoil

- Set the subsoiler below the compact layer if possible or around 16-18”
- Subsoil across the field drains
- Subsoiler should be at least 10cm above the drains
- Check to see if the operation has worked after the first pass
- Use shallow leading tines with the subsoiler
  - if soil above is too compact then shatter does not happen and the result is an inferior ‘mole’ drain

Moling – secondary drainage



- Very closely spaced drains are uneconomic
- Use short lived mole drains to connect permanent drains
- The mole plough has to pass through the permeable fill
- At least 35% clay in the soil and must be **Stone Free**
- The soil should be *plastic* when the mole is pulled

Beam mole plough

Mole plough

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Take home messages

Wetting/drying and frosts may remedy surface compaction

Don't assume compaction is the problem (dig a hole)

Avoid working when soil is too wet

Machinery can alleviate compaction in the topsoil and subsoil

- Spiking/aerating can disrupt shallow pan (variable response)
- Soil loosening – only recommended where compaction is evident
- Soil loosening – not a substitute for field drainage
- Soil should be dry to working depth
- Best time is autumn but not always
- Only loosen as deep as required (not below an implement's critical depth) Don't run a soil loosener too deep
- Loosened soils can be easily re-compacted

Ensure future compaction is avoided

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The next meeting - Nov 2018

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- Topics—Nutrient Budgeting to save fertiliser
- ----Drainage??
- ----Trace Elements??
- Benchmarking –Your Slurry Analysis
- Benchmarking –5 of your Soil Samples

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Where to Start - Slurry Analysis

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	SAC Average	A	B	C	D	E	F	G	Rhoin
DM %	**6**	3.6	4.3	5.6	6	6.2	7.8	8.2	4.7
Total N	**0.26**	0.21	0.21	0.35	0.26	0.28	0.41	0.39	0.15
Total P	**0.12**	0.09	0.09	0.13	0.11	0.11	0.1	0.15	0.08
Total K	**0.22**	0.24	0.23	0.37	0.25	0.29	0.28	0.36	0.22

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Organic Waste Slurry Report

M & C Ralston
Rhoin
Campbeltown
ARGYLL
Argyll PA28 6NT

Your reference:	G03939
Farm Sampled:	
Client Sample ID:	Rhoin Slurry

Lab sample no:	17400149
Case no:	ASD-2017-329
Date received:	23/01/2017
Date reported:	09/02/2017

	Determination	Result	Units
*	Dry Matter	4.73	%
*	Total Nitrogen (Kjeldahl)	0.0887	%
	Aqua Regia Phosphorus	0.757	%DM
*	Total Phosphate (P2O5)	0.0820	% by Wt
	Aqua Regia Potassium	3.94	%DM
*	Total Potash (K20)	0.224	% by Wt
	Aqua Regia Magnesium	0.560	%DM
	Aqua Regia Calcium	1.20	%DM
	Aqua Regia Sodium	0.840	%DM
	Aqua Regia Copper	21.4	mg/kgDM
	Aqua Regia Zinc	129	mg/kgDM
	Aqua Regia Iron	898	mg/kgDM
	Aqua Regia Sulphur	4830	mg/kgDM
	Aqua Regia Manganese	301	mg/kgDM

* Not UKAS accredited

Contact:J Forster
Campbeltown FRBS

Authorised by June Gay (Client Manager)

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Know the value of your slurry/m^3

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		Total Nutrients	Available Nutrients
Value of Slurry (3.9% DM)	0.23% N	2.3kg	0.8kg
	0.09% P	0.9kg	0.45kg
	0.22% K	2.2kg	2kg
Value in 2000 gallon tanker	N	£19.87	£6.91
	P	£5.99	£3.00
	K	£11.29	£10.26
		£37.15	£20.17
Value of 1.1million gallons		£20,227	£10,981

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Thank You

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