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Soil Care - Reducing Soil Compaction

- Seamus Donnelly, BSc Hons 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”

Deciding the real problem

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What causes compaction?

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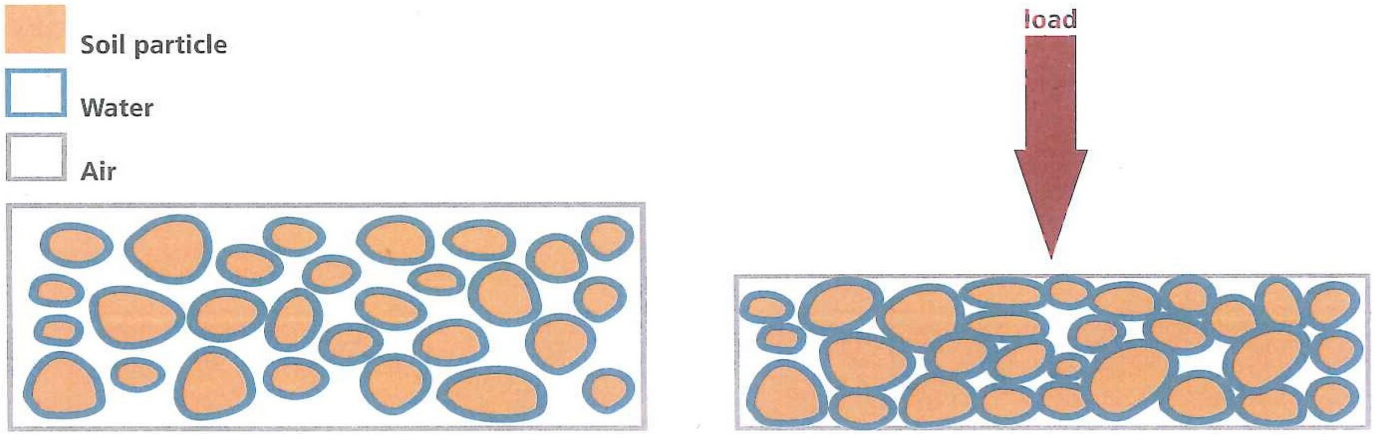
- Soil compaction is...

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

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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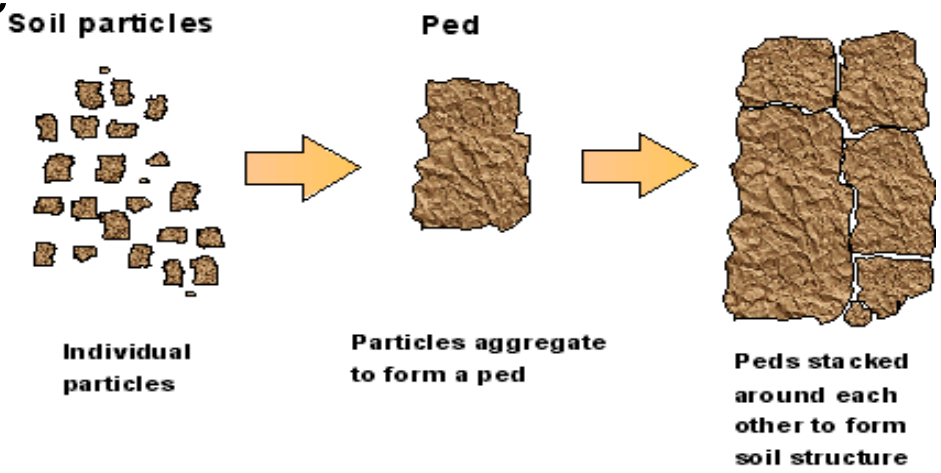
Soil structure

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 favorable gas exchange
- mineralisation of nutrients and release to crop roots
- biodiversity of microbes

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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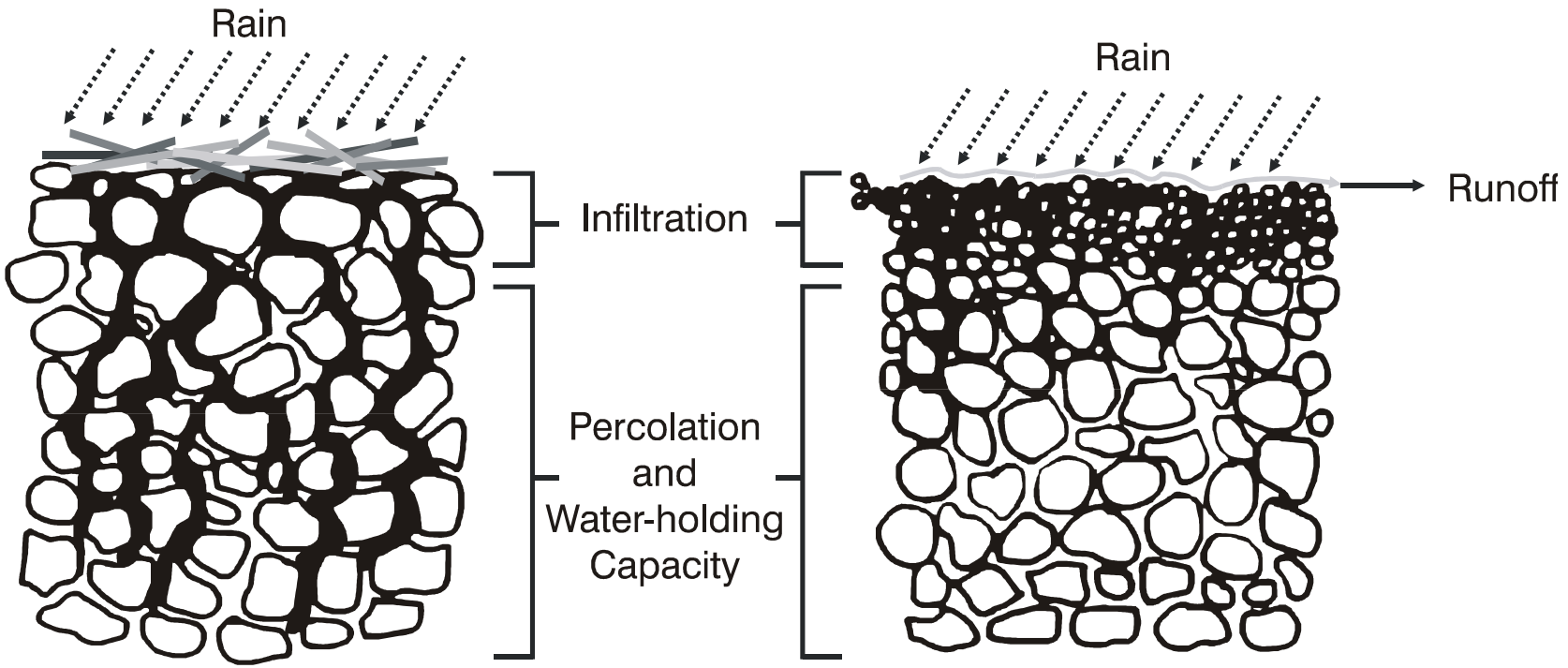
Structure affected by compaction



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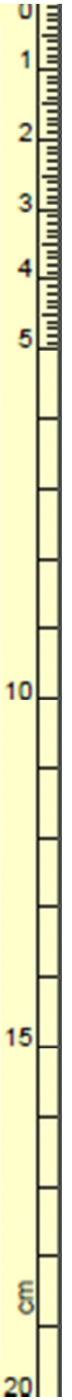
Structure quality	Size and appearance of aggregates	Visible porosity and Roots	Appearance after break-up: various soils	Appearance after break-up: same soil different tillage	Distinguishing feature	Appearance and description of natural or reduced fragment of ~ 1.5 cm diameter
Sq1 Friable Aggregates readily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

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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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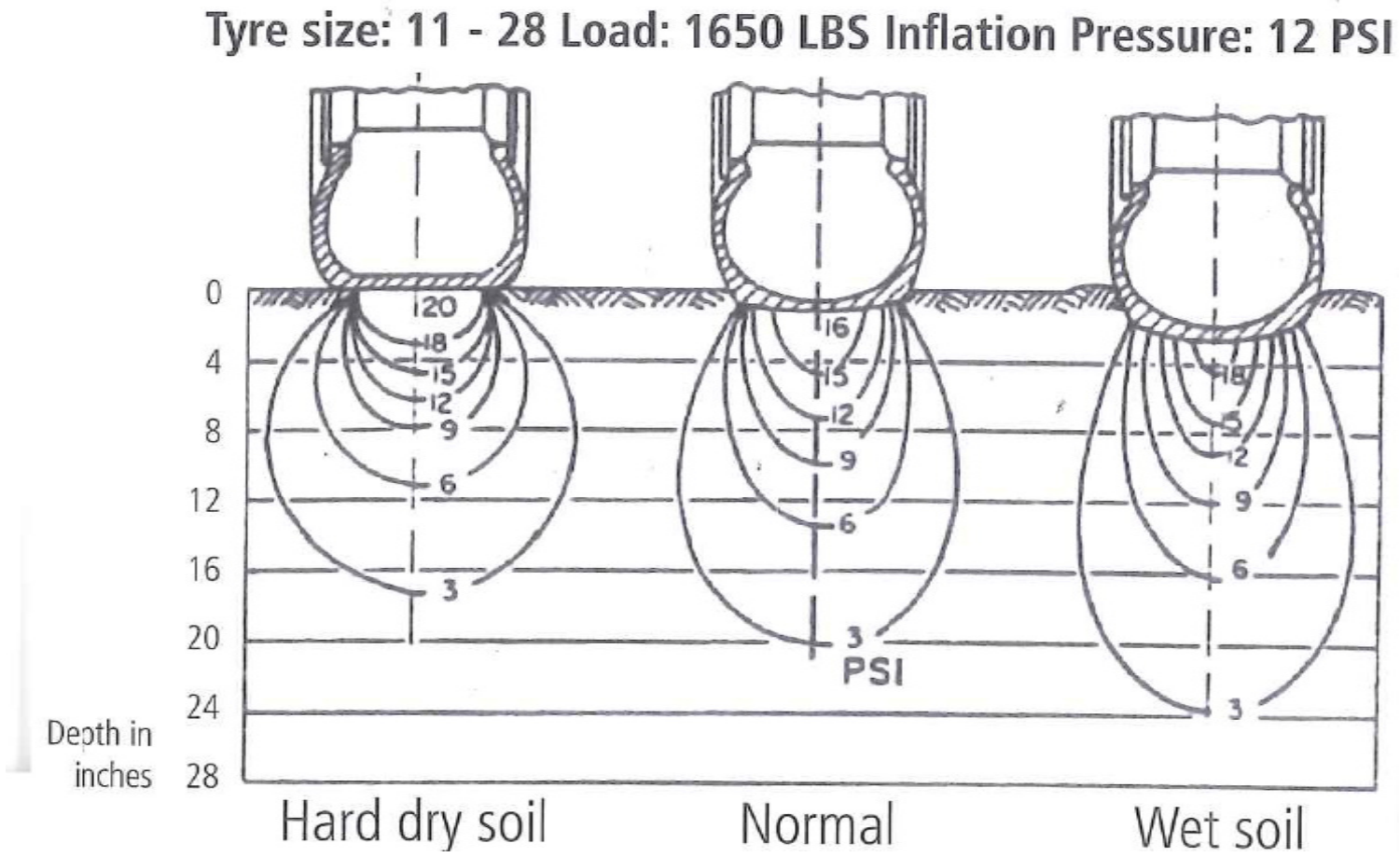

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Spread the load

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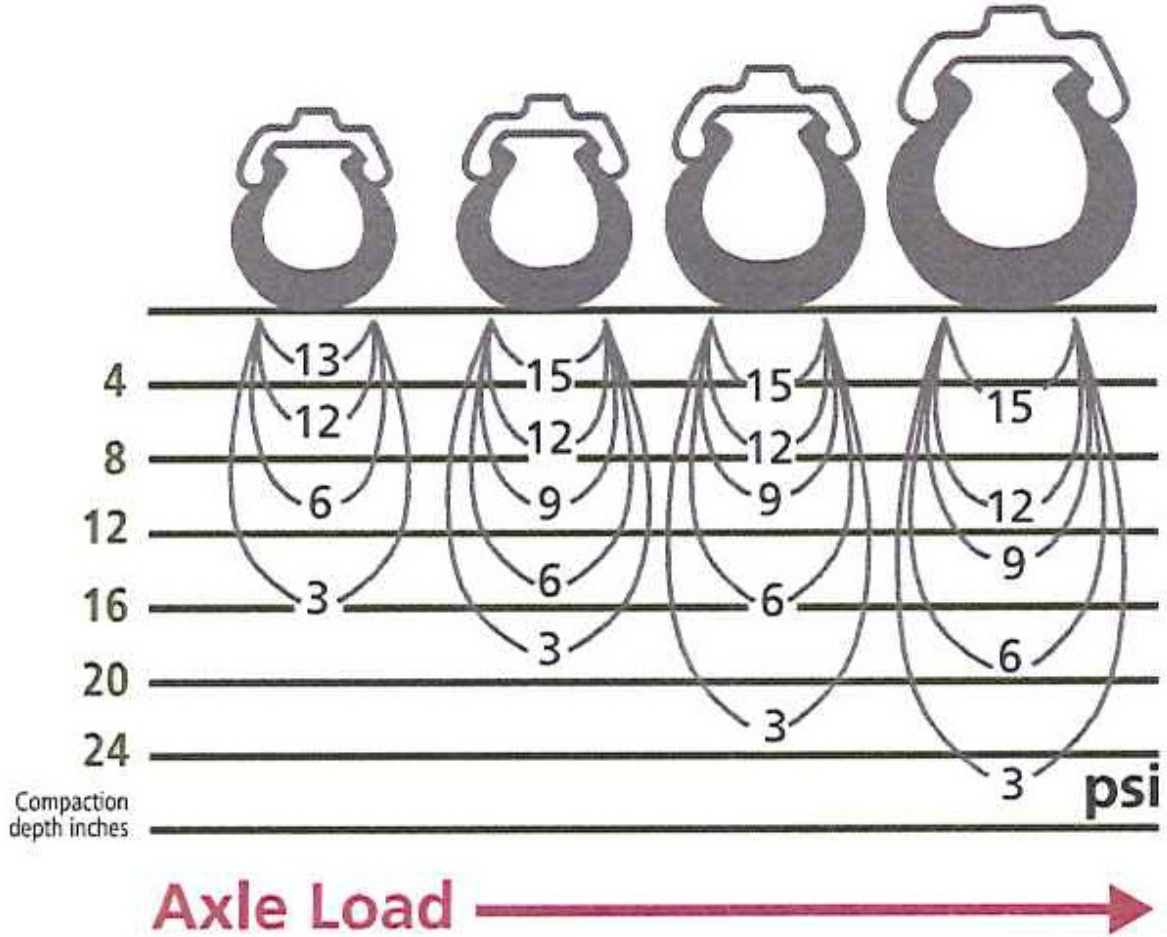

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Increase the footprint, reduce the compaction

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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)

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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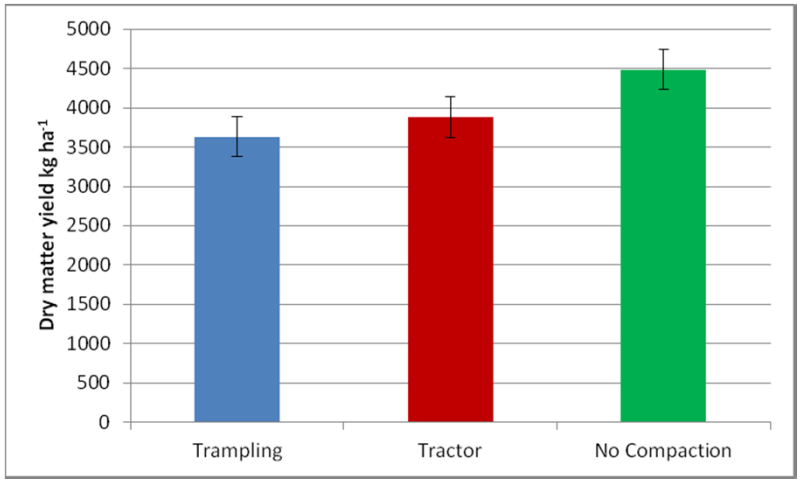
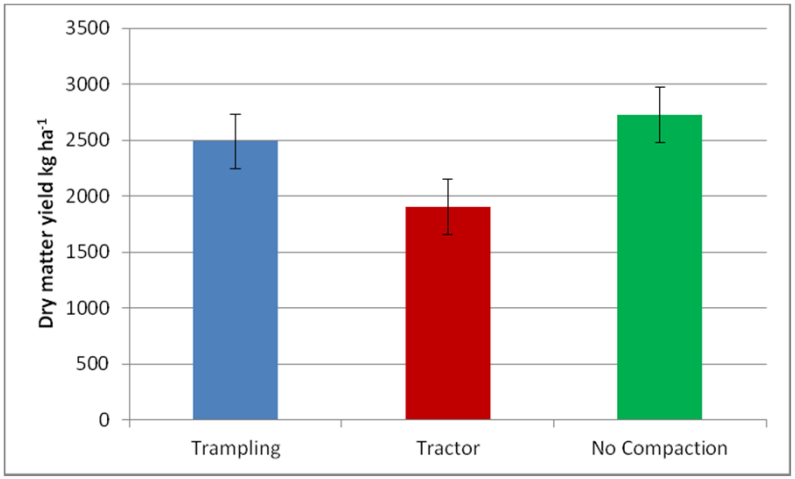
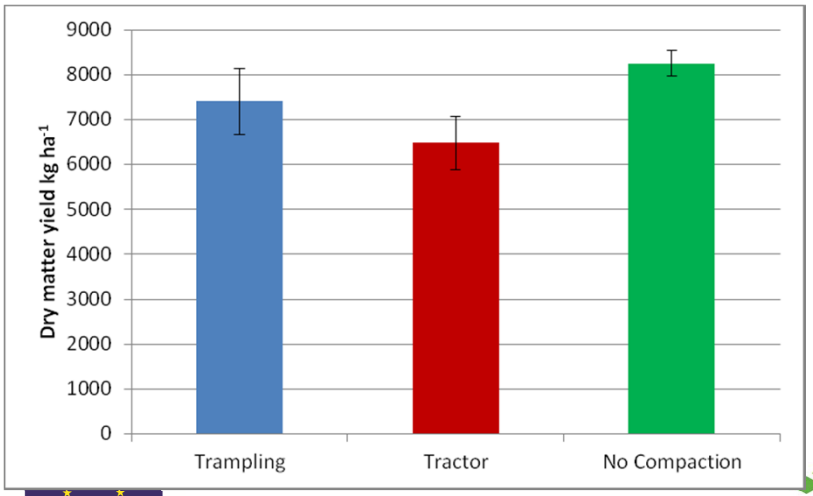
Compaction Results – 1st Silage Cut



2012



2013



2014

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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

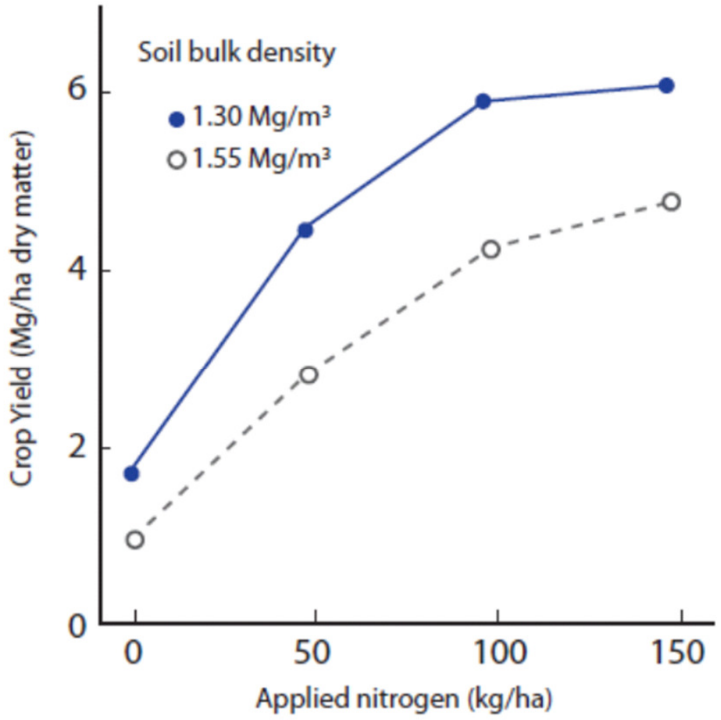

Figure 8.3: The relationship between the amount of nitrogen applied and crop yield under different compaction regimes. A compacted soil (bulk density of 1.55 Mg/m³) may require more nitrogen to obtain a similar yield to a non-compacted soil (bulk density of 1.30 Mg/m³). From Soane and Vanouwerkerk (1995)

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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/End-riggs/Tramlines

Gates at bottom of field ?

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Spread the Load

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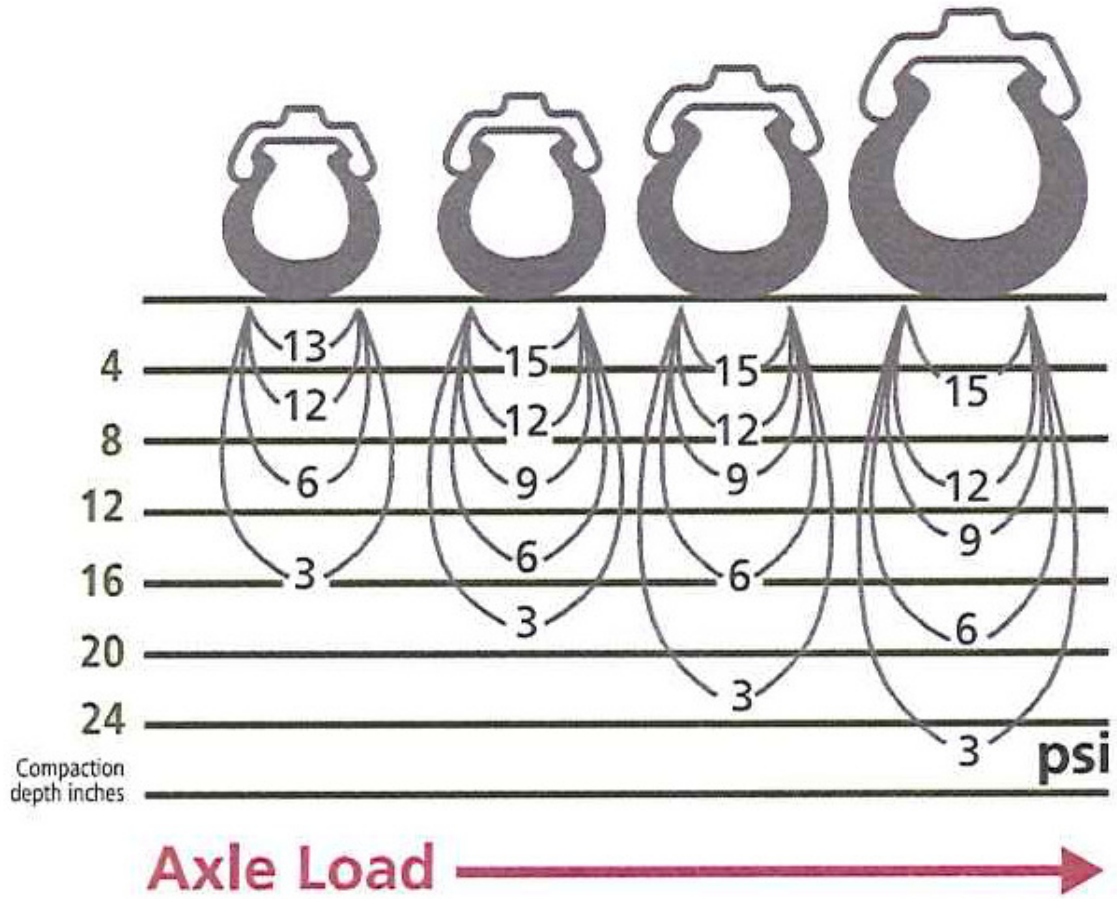

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Sorting compaction problems

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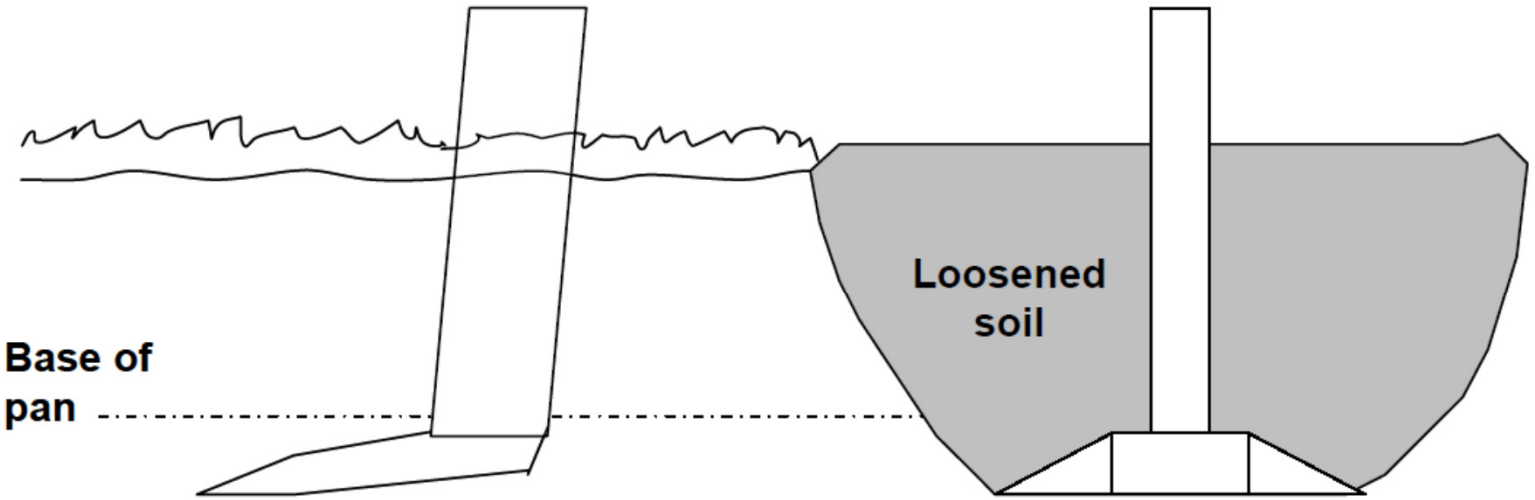
Loosening a compaction pan with a sward lifter (adapted from NSRI, 2002).



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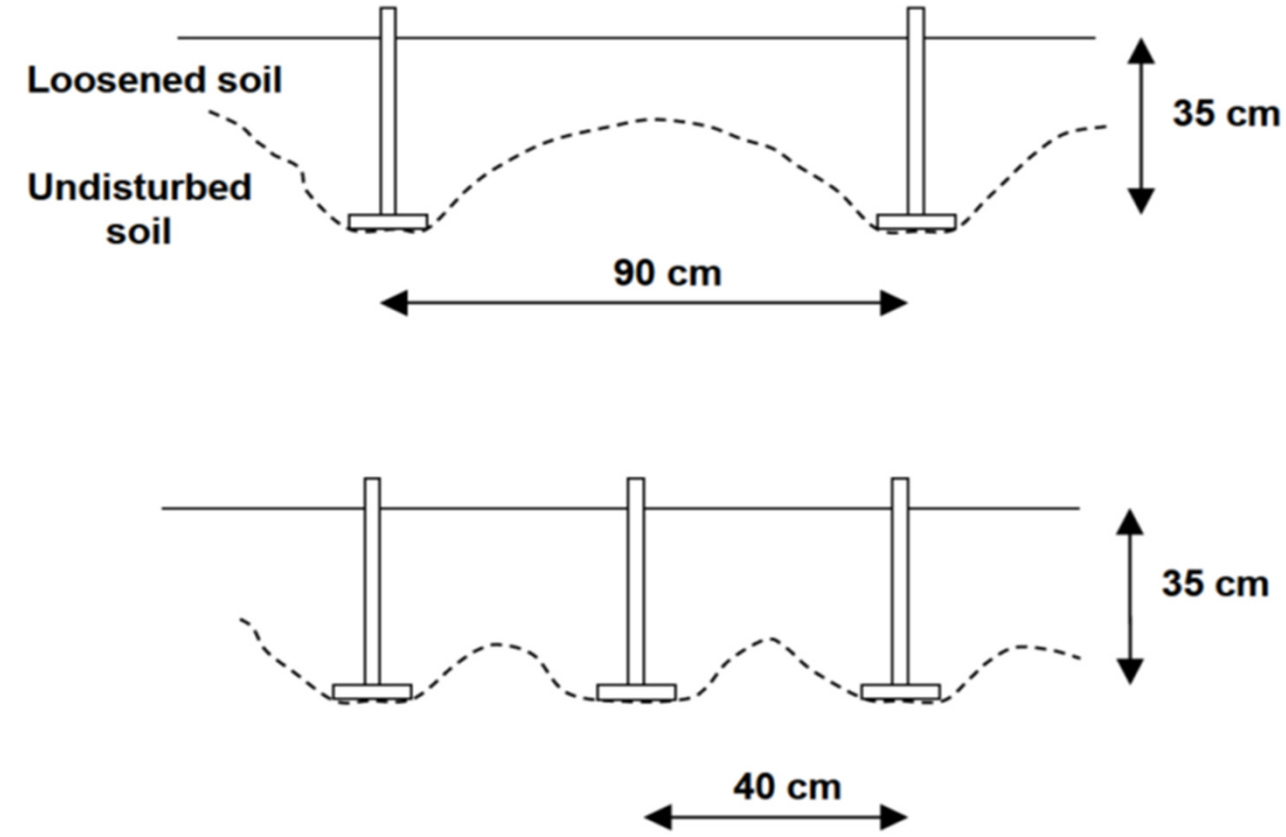
Soil disturbance profiles for a winged tine at different tine spacings.



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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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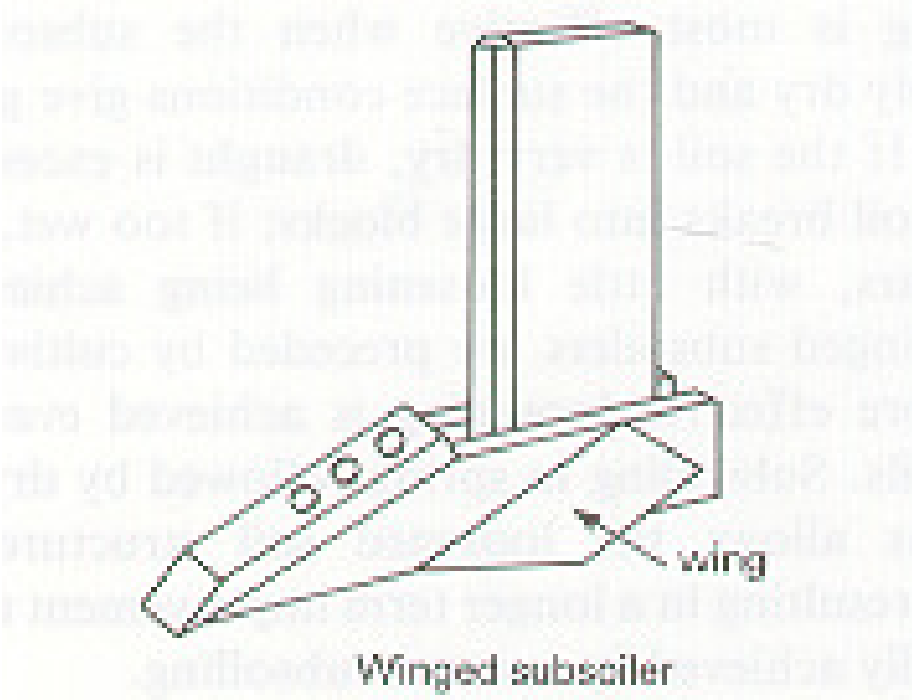
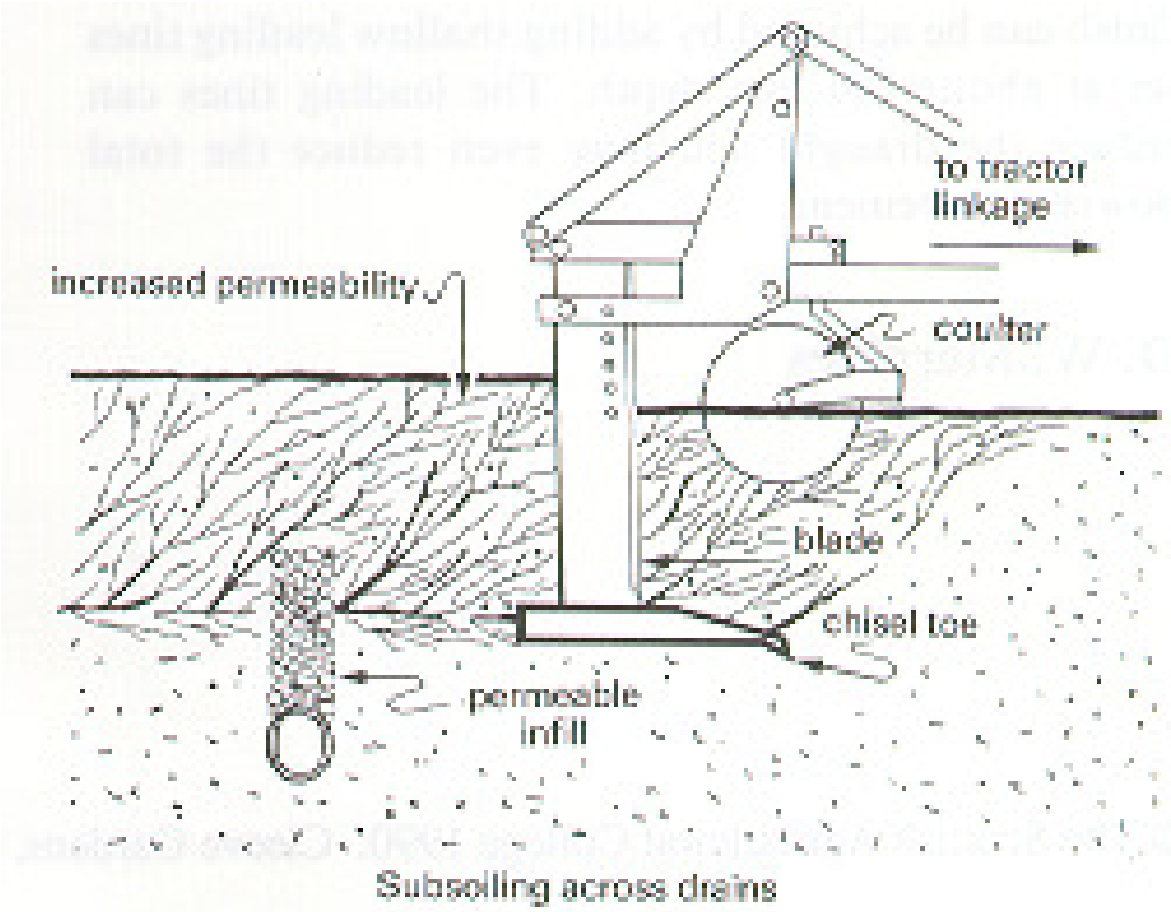
Subsoiler

Subsoiler tine



Winged subsoiler

Subsoilers open up the soil



Subsoil shatter

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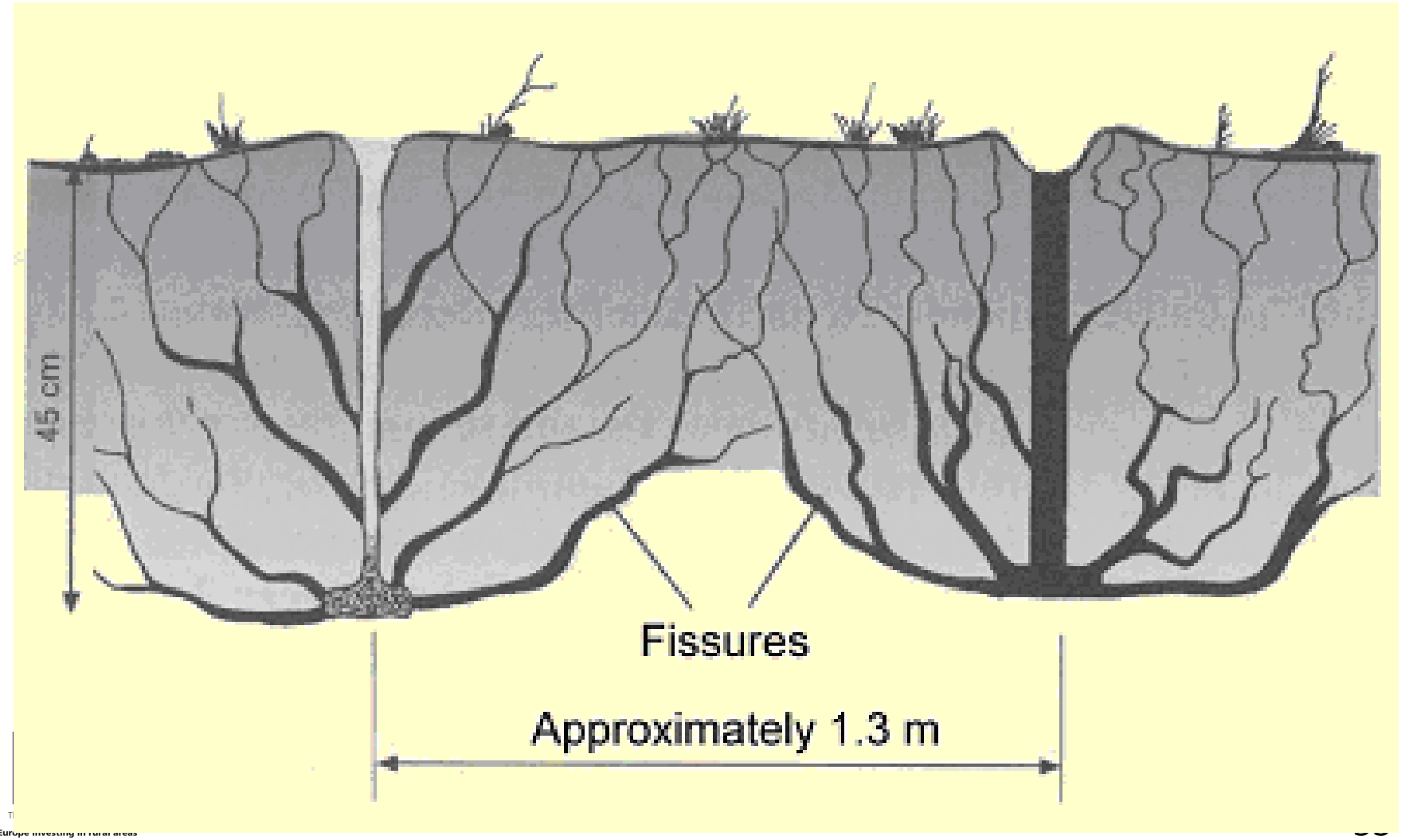
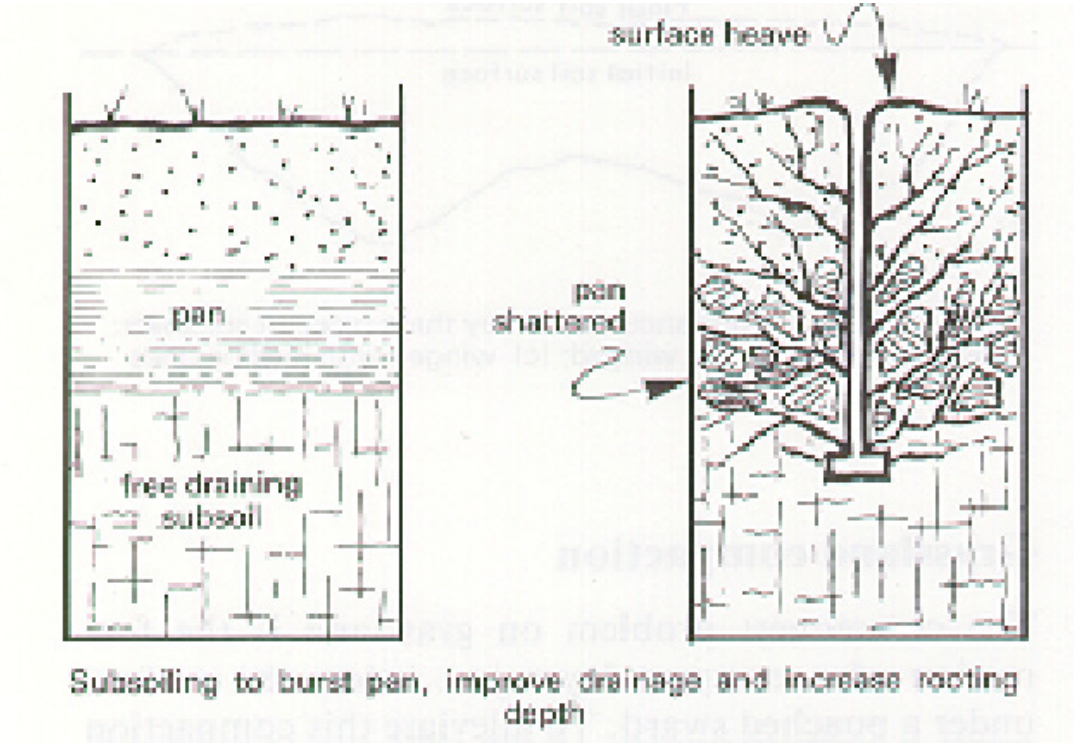


Subsoilers break up pans



Subsoiling to burst pan, improve drainage and increase rooting depth

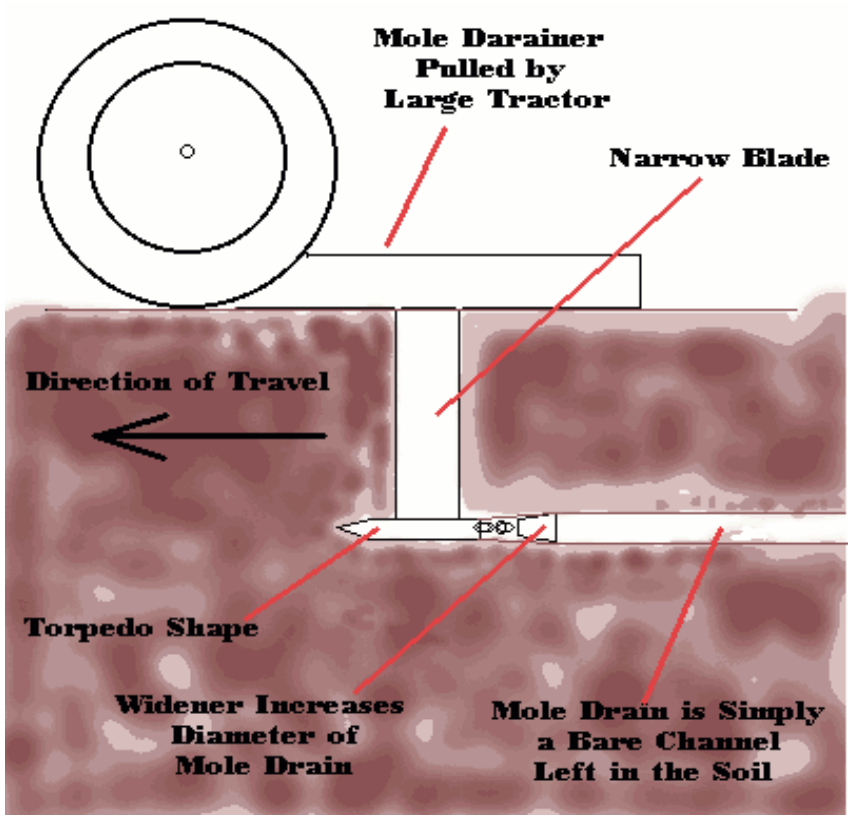
When to subsoil

- 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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Sward lifter

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Flat lifter

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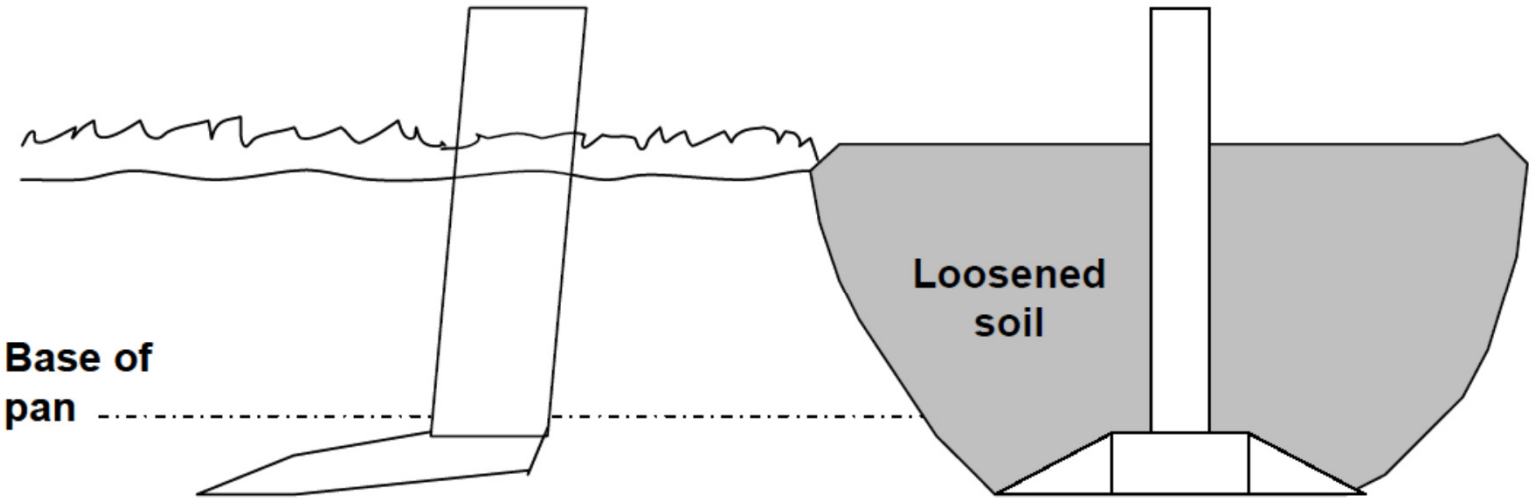

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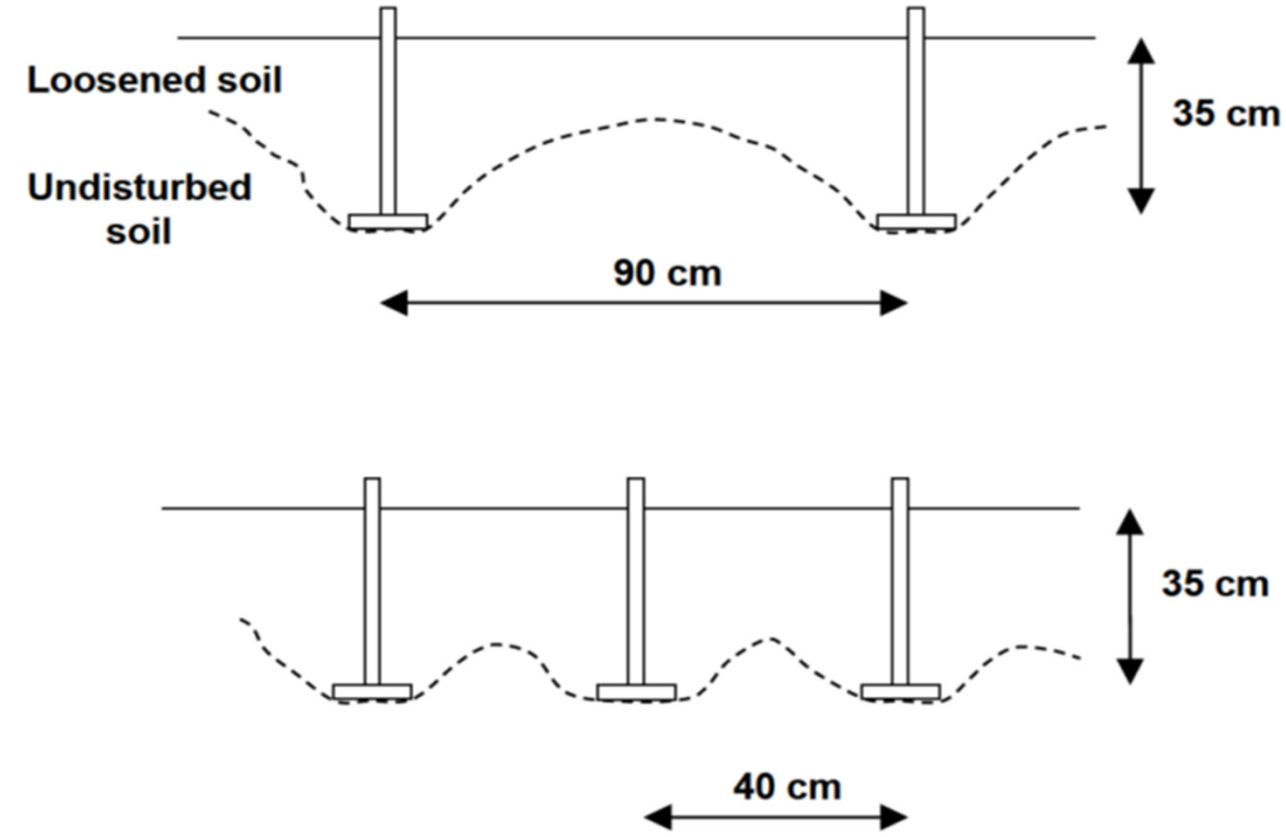

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- Make fissures across the ruts
- Allows water to drain into the adjacent uncompacted soil

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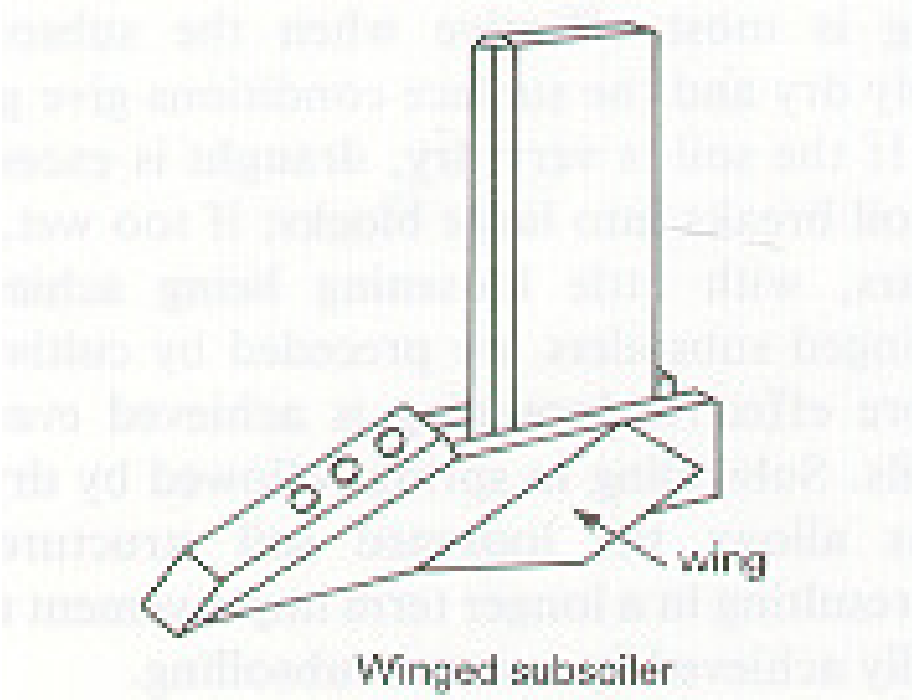
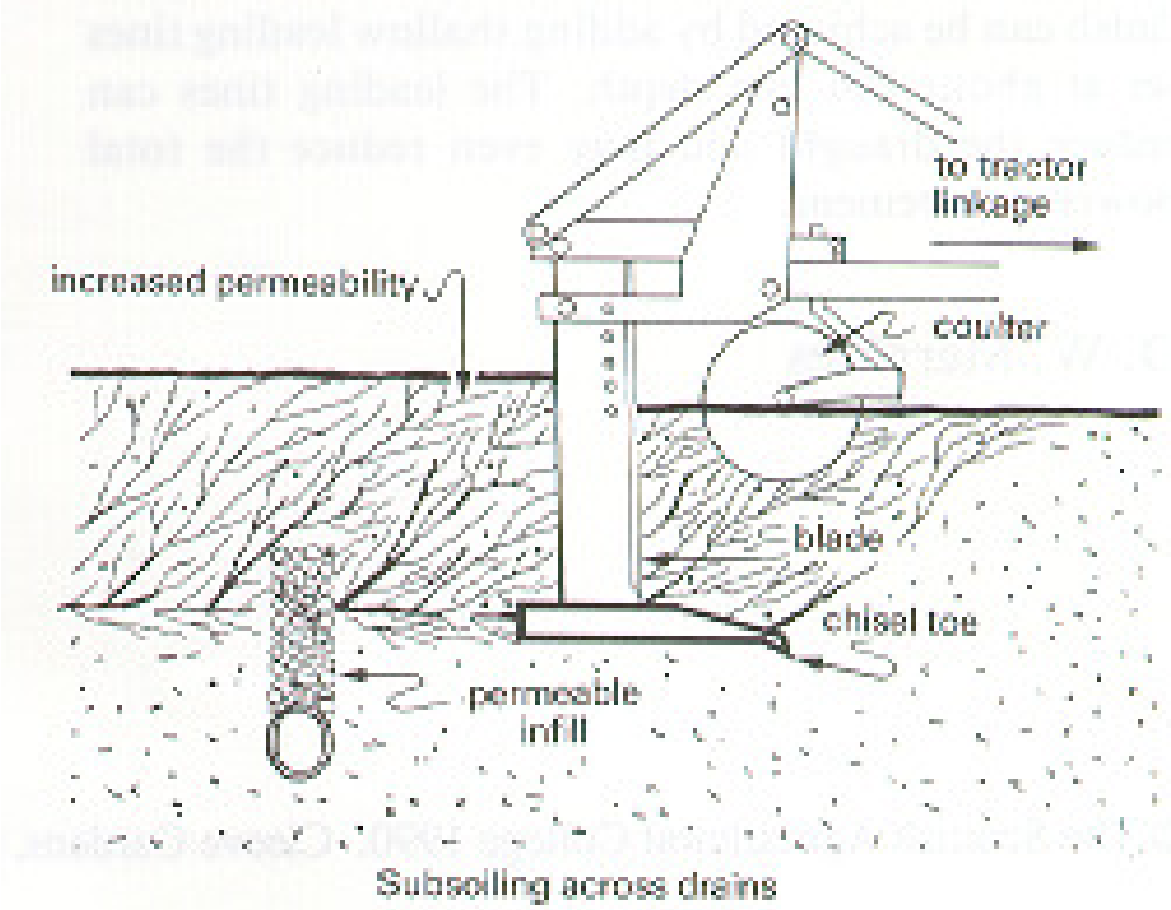
Subsoiler

Subsoiler tine



Winged subsoiler

Subsoilers open up the soil



Subsoil shatter

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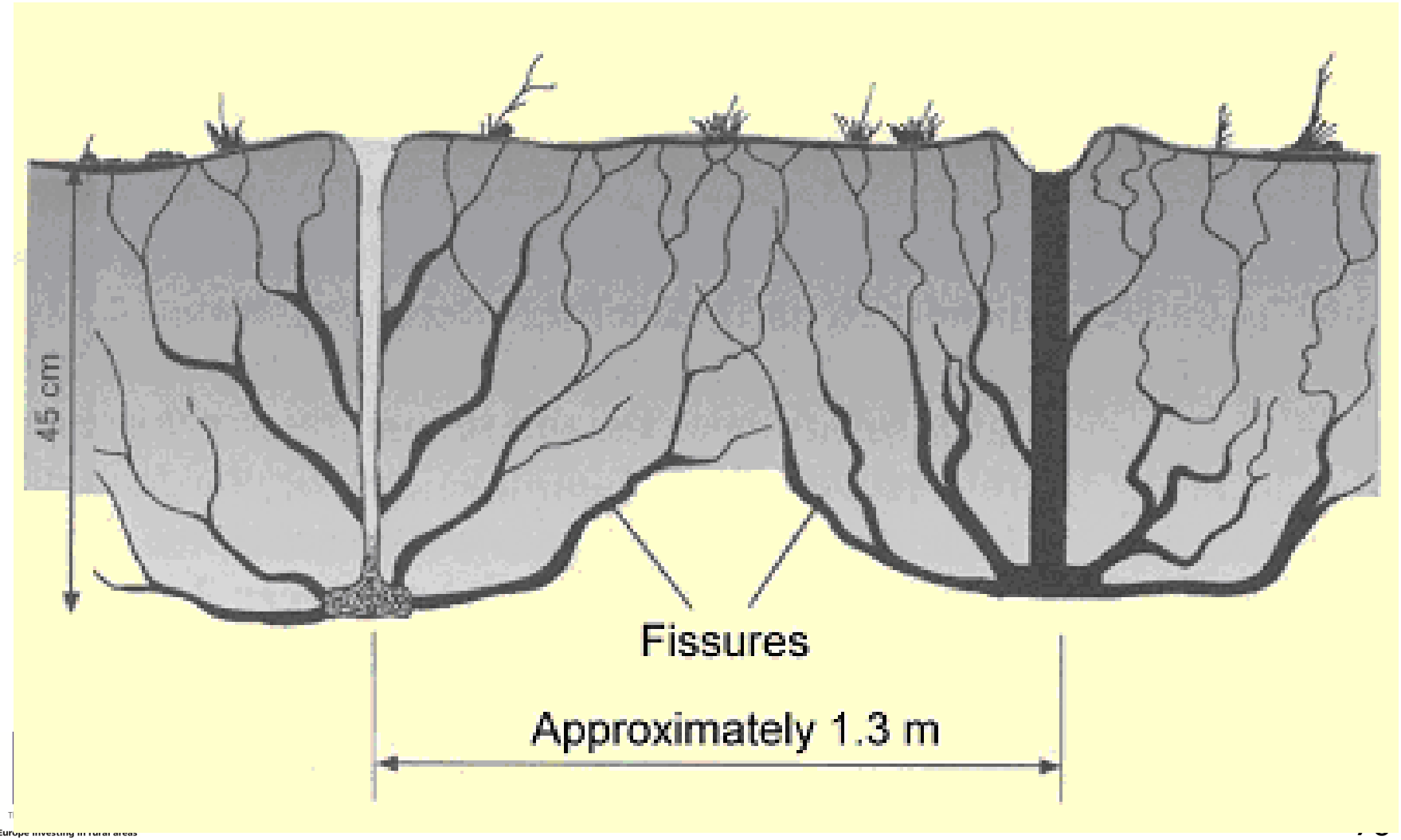
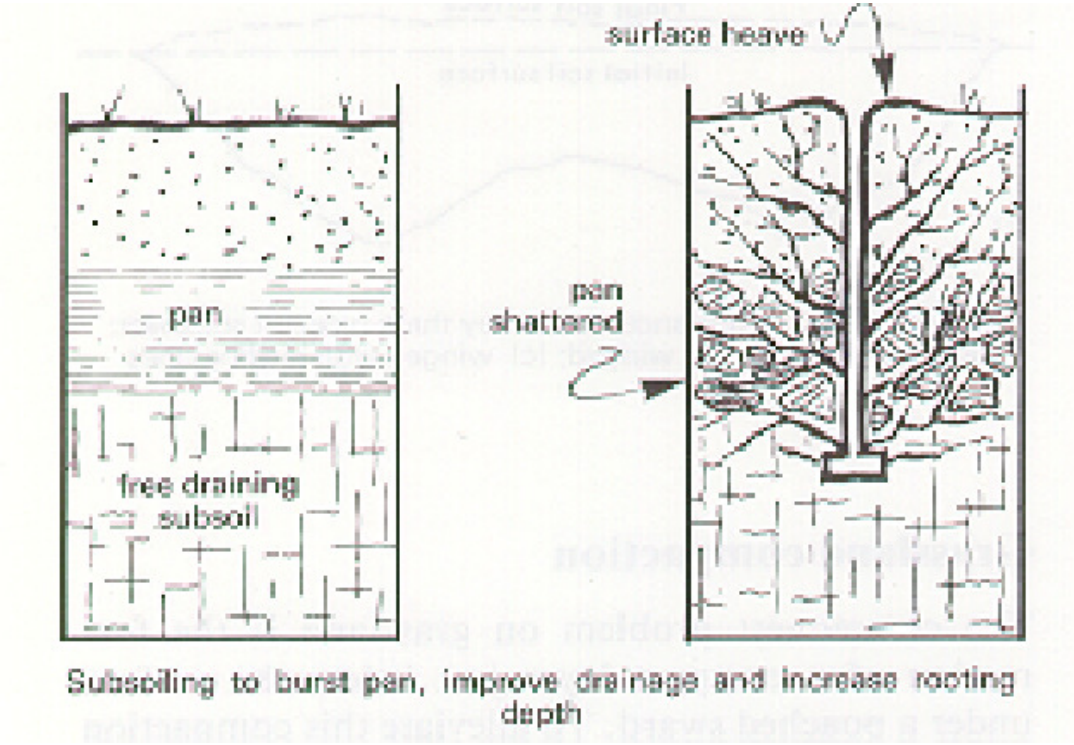


Subsoilers break up pans



Subsoiling to burst pan, improve drainage and increase rooting depth

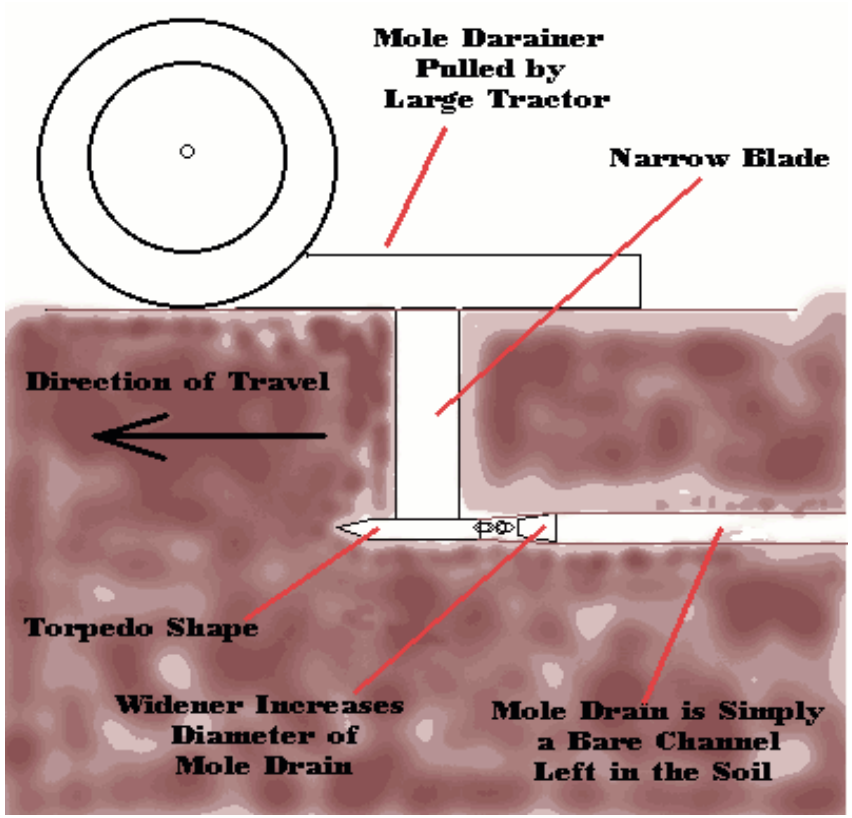
When to subsoil

- 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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