FARM ADVISORY SERVICE

Scottish Government
Riaghaltas na h-Alba
gov.scot

FARM ADVISORY SERVICE

Kilmore Drainage Meeting
01-02-2018

Scottish Government
Riaghaltas na h-Alba
gov.scot

Managing Soil Drainage and Compaction in Pasture

FARM ADVISORY SERVICE

Key factors for movement of water in the soil

- Soil Texture
- Soil Structure
- Soil Compaction
- Soil drainage – Natural and Installed

Scottish Government
Riaghaltas na h-Alba
gov.scot

FARM ADVISORY SERVICE

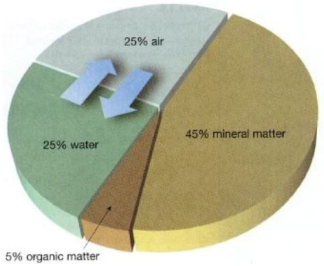
Soil Texture

Scottish Government
Riaghaltas na h-Alba
gov.scot

What is Soil?

FARM ADVISORY SERVICE

Typical soil make-up



Soil Texture

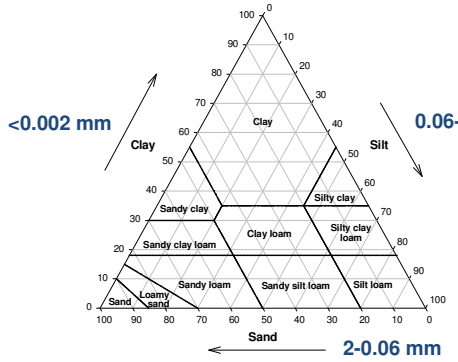
FARM ADVISORY SERVICE

- It describes the physical composition of the soil
  - % of sand, silt and clay
- Refers to the mineral fragments of the soil only
  - water and organic material are not considered
  - only considers particles <2mm
- Texture is a stable soil property - does not change measurably over a long period of years

6

Soil texture classes

FARM ADVISORY SERVICE



7

Soil texture & water

FARM ADVISORY SERVICE

- The sizes of pores in a soil are related to its texture
  - Sands have large pores
  - Clays have small pores
- Large pores allow free drainage
  - Sandy soils drain more easily than clays
- Small pores store water
  - Clay soils have a bigger water holding capacity than sandy soils

8

Water in soil

FARM ADVISORY SERVICE

- **Gravitational water**
  - drains freely from large pores
  - only available to plants for a short time
- **Capillary water**
  - held in small pores
  - available for plants
- **Hygroscopic water**
  - held tightly around small particles
  - not available to plants

Scottish Government Riaghaltas na h-Alba gov.scot

9

Soil Structure

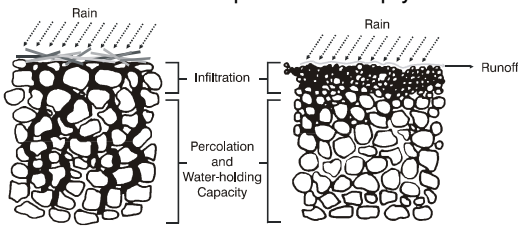
FARM ADVISORY SERVICE

Scottish Government Riaghaltas na h-Alba gov.scot

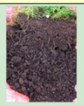
Soil structure: the importance of macropores

FARM ADVISORY SERVICE

- Macropores and cracks : allow water infiltration and drainage, keep the soil aerated reducing nitrous loss and increase water uptake and crop yield.



SMI Soil Management Initiative

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.

Benefits of Good Soil Structure

FARM ADVISORY SERVICE

- **Good structure improves aeration & reduces waterlogging**
  - easier for roots to access nutrients
  - leaching of nutrients less likely
- **Good structure reduces compaction**
  - more extensive root system
  - better water & nutrient uptake
- **Good structure reduces droughtiness**
  - improves nutrient uptake

Scottish Government Riaghaltas na h-Alba gov.scot

13

Structure-forming processes

FARM ADVISORY SERVICE

- **Activity of roots and soil organisms especially earthworms**
  - mixing, cementing, transforming
  - needs organic matter
- **Wetting & drying**
  - swelling & shrinkage
- **Freezing & thawing**

- ***Organic matter is key to structure formation and maintenance***

Scottish Government Riaghaltas na h-Alba gov.scot

14

Benefits of soil organic matter

FARM ADVISORY SERVICE

- Develops and maintains soil structure
- Supplies mineral nutrients
- Increases water holding capacity
- Retains nutrients that might be leached out
- Increases availability of micronutrients to plants
- Substrate for soil organisms
- Darkens colour - increases rate of warming

Scottish Government Riaghaltas na h-Alba gov.scot

15

Soil Compaction

FARM ADVISORY SERVICE

Scottish Government Riaghaltas na h-Alba gov.scot

Main causes of compaction

FARM ADVISORY SERVICE

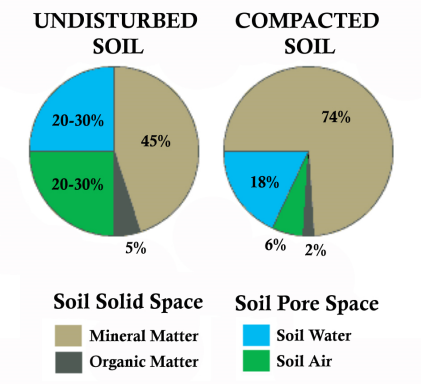
- **Working / Cultivating / Grazing in wet conditions**
- **Over-cultivation**
- **Continuous cultivation**
- **Heavy machinery**
- **Over-grazing**

Scottish Government Riaghaltas na h-Alba gov.scot

17

Effects of Compaction

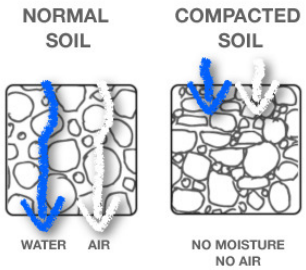
FARM ADVISORY SERVICE



Scottish Government Riaghaltas na h-Alba gov.scot

Compaction Reduces infiltration and Increases surface run-off

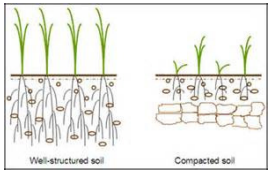
FARM ADVISORY SERVICE

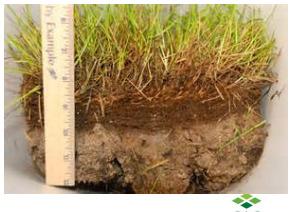


Scottish Government Riaghaltas na h-Alba gov.scot

Rooting in compacted soils

FARM ADVISORY SERVICE





Scottish Government Riaghaltas na h-Alba gov.scot

Soil structure is affected by management

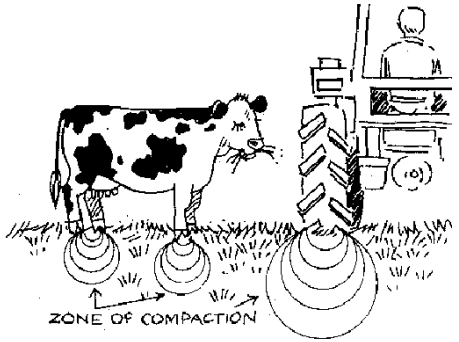
- Compaction
- Poaching
- Waterlogging

Image: Farmers Weekly

FARM ADVISORY SERVICE

Scottish Government Riaghaltas na h-Alba gov.scot

Zone of Compaction

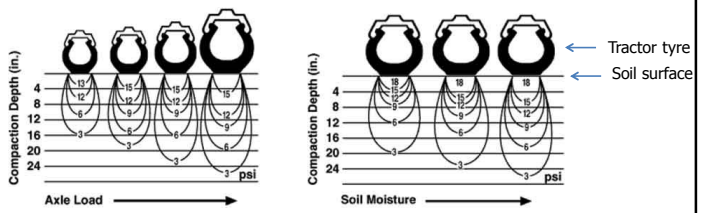


FARM ADVISORY SERVICE

SAC

Scottish Government Riaghaltas na h-Alba gov.scot

Compaction and soil moisture



Wheel traffic compaction. The depth of compaction increases with increasing equipment weight (axle load) or increasing moisture condition. (Adapted from Soehne, 1958. Journ. of Agr. Eng.)

Source: University of Minnesota Extension Publication WW-03115; Available on-line at: http://www.extension.umn.edu/distribution/cropsystems/components/3115s01.html#section1

FARM ADVISORY SERVICE

SAC

Scottish Government Riaghaltas na h-Alba gov.scot

Tyres and Compaction

Spot the difference: Trailer with 11 tonne payload running on
500/60R22.5 (left)
385/65R22.5 (right)

FARM ADVISORY SERVICE

SAC

Scottish Government Riaghaltas na h-Alba gov.scot

Tyres and Compaction (2)

Extreme problems

Land Drainage

Main Drainage Problems

- **Surface water**
- **Ground water**
- **Springs**

Problem type and occurrence

FARM ADVISORY SERVICE

- During the late 1970,s the various drainage problems were broken down into the following types,

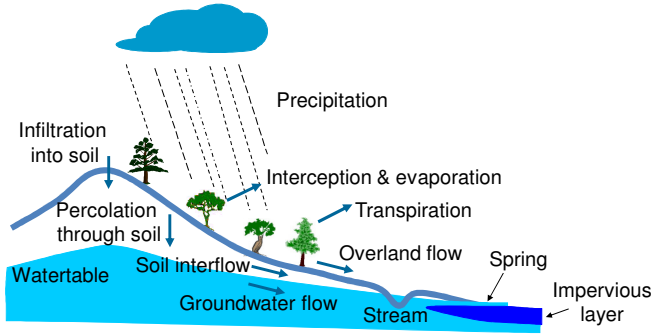
Drainage Problem	Scotland as a Whole % of problems
Water Table	25
Impermeable Subsoil	20
Springs	12
Failure of Old Drains	39
Other	4

Scottish Government Riaghaltas na h-Alba gov.scot

29

Water Pathways

FARM ADVISORY SERVICE



Scottish Government Riaghaltas na h-Alba gov.scot

30

Waterlogging

FARM ADVISORY SERVICE

- Reduces crop yield
  - low nutrients, toxins, oxygen deficiency etc
- Affects soil management, e.g.
  - cultivation machinery choice
  - cultivation timing
  - cultivation energy input (number of passes required)
- Reduces access to the field
- Reduces optimum timing for harvest without causing compaction damage

Scottish Government Riaghaltas na h-Alba gov.scot

31

How do you know when a soil has poor drainage?

FARM ADVISORY SERVICE

- Water lies on the surface
- Water can be seen in a soil pit
- Roots are brown and shallow
- Dull grey colours (rusty or multi-coloured)
- Mottled colours in subsoil
- “Sour” smell
- Unrotted manure or crop residues

Scottish Government Riaghaltas na h-Alba gov.scot

32

Benefits of Good Drainage

FARM ADVISORY SERVICE

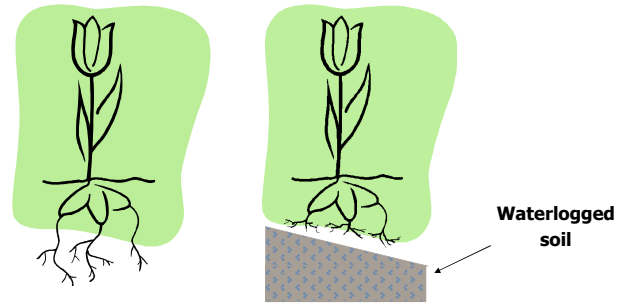
- Improved root growth
- Better crop and grass yields
- Better animal health – reduces risk of some parasites and diseases
- Less surface run-off (diffuse pollution)
- Less soil damage
- Longer utilisation of fields

Scottish Government Riaghaltas na h-Alba gov.scot

33

Effect of drains on root growth

FARM ADVISORY SERVICE



Scottish Government Riaghaltas na h-Alba gov.scot

34

Where do you start?

FARM ADVISORY SERVICE

Investigate the existing drainage scheme

- Clean ditches
- Exclude livestock where possible
- Clear pipe outfalls and culverts
- Repair burst pipes

Scottish Government Riaghaltas na h-Alba gov.scot

35

Drainage system components

FARM ADVISORY SERVICE

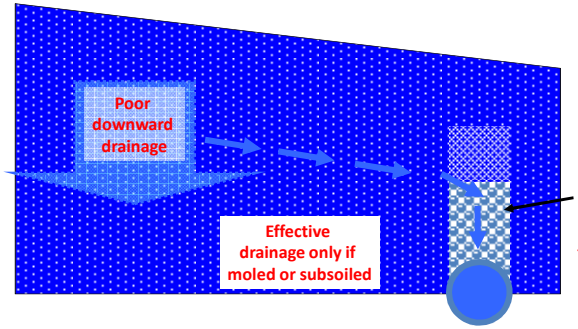
- **Outfall**
  - **where water leaves the drained area and enters a ditch, burn or river**
- **Leader pipes**
  - **larger pipe or ditch which collects water from many field drains and conducts it to the outfall**
- **Field drains**
  - **ditches**
  - **laterals - plastic or clay pipes**

Scottish Government Riaghaltas na h-Alba gov.scot

36

Drainage of impermeable soils - surface water problem

FARM ADVISORY SERVICE



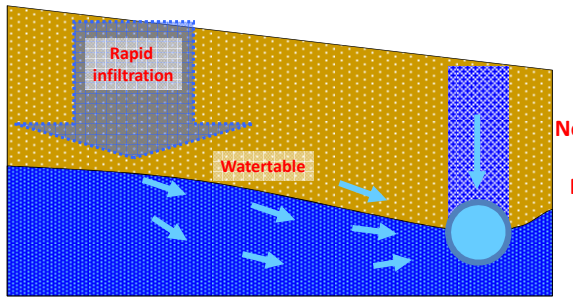
Must have gravel backfill to connect to drains

Scottish Government Riaghaltas na h-Alba gov.scot

37

Drainage of permeable soils - ground water problem

FARM ADVISORY SERVICE



Scottish Government Riaghaltas na h-Alba gov.scot

38

How do you Improve Drainage ?

FARM ADVISORY SERVICE

- Investigate the site
- Identify the problems
- Prepare a plan
- Budget the plan
- Prioritise the solutions
- Carry out the work
- Record the work carried out

Scottish Government Riaghaltas na h-Alba gov.scot

39

New Drainage

FARM ADVISORY SERVICE

- Drainage is expensive – prioritise areas to be drained
- Collaborate with neighbours where possible to maximise benefits
- Ditches lowest cost but take up land
- Pipes with gravel most expensive but take up least land

Scottish Government Riaghaltas na h-Alba gov.scot

40

Drainage Design

- Design for required outcome – allow for expansion at a later date
- Design from the outfall back
- Install ditches on boundaries where possible
- Minimise requirement for culverts – potential for blockage in the future.
- Install correctly sized pipes where required – use gravel if necessary
- If there are problems with ochre or running sand – install a bigger diameter pipe if practical

41

Drainage Maintenance

- Mark outfalls clearly.
- Clear outfalls on a regular basis (annual / bi annual).
- Clear ditches on a regular basis Clay soils every 3 to 5 years,

  Peat soils every 2 to 3 years sandy soils every 1 to 2 years.
- Keep trees, shrubs and bushes on the banks cut back every 3

  to 5 years **(Especially important on flood banks).**

Drainage Maintenance (2)

- Check and clear culverts on an annually in late summer / early autumn in preparation for winter rainfall.
- Check flood banks every summer and after flood event for damage.
- Every 3 to 5 years check and repair culvert banks and crossing surface.
- Where flap valves are installed check on an annual basis that they are free to open and close before winter rains.
- Annually mark unusual wet areas on a plan and compare with drainage plans to identify areas that may need existing systems repaired or new drains installed.

Benefits of Good Drainage

- Less surface run-off
- Improved root growth
- Greater soil biology
- Better crop and grass yields
- Better animal health – reduces risk of some parasites and diseases
- Less soil damage
- Longer utilisation of fields

44

Any Questions?

Soil Compaction

Dealing with compaction

- Avoid compacting the soil in the first place (Prevention)
- Change management systems to protect soil
- Make the soil more resistant to compaction
- Protect the soil against raindrop impact - protects soil structure
- Eradicate the compaction (Cure)

47

Remediation of poaching, shallow compaction

www.sumo1.com

Shallow Compaction

FARM ADVISORY SERVICE

Pasture Harrow

Pasture Harrow with Grass Seeder

Grassland Surface Spikers

FARM ADVISORY SERVICE

Grassland spiker

Effect of surface spiking

Roller spiker with grass seeder and frame for extra weight

Spiker with water tank for extra weight

Grassland Sward lifters

FARM ADVISORY SERVICE

Pre-cutting Disc and Closer leg spacing

Roller for depth control and break back legs to reduce bringing stones to the surface

Spiked roller to help aereate surface

Roller to level surface following treatment

Sub Soilers

FARM ADVISORY SERVICE

Subsoiling

FARM ADVISORY SERVICE

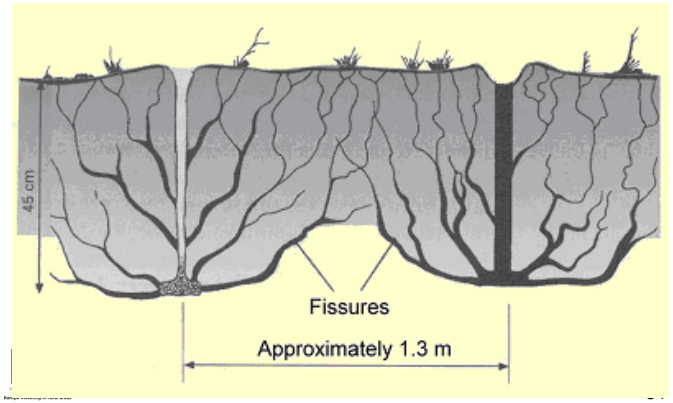
- Some soils benefit from subsoiling
- Subsoiling aims to loosen the soil and allow water to flow more freely through it
- Can be effective in soils of low clay content or stony soils where mole drains would not work

Scottish Government Riaghaltas na h-Alba gov.scot

53

Subsoil shatter

FARM ADVISORY SERVICE



Remediation of subsoil compaction and pans

FARM ADVISORY SERVICE

- Make fissures through the layer with minimal soil break up and mixing.
- This creates paths for drainage and root movement while keeping the support capacity of the compacted layer

http://vro.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/gloss_ac

When to subsoil

FARM ADVISORY SERVICE

- Only when necessary - check the subsoil for compaction
- When the subsoil is brittle i.e. not too dry or too wet
- Late summer subsoiling is generally best in terms of land access and soil suitability
- Spring subsoiling gives the longest benefit if done in the correct conditions

Scottish Government Riaghaltas na h-Alba gov.scot

56

Any Questions?

FARM ADVISORY SERVICE

Scottish Government
Riaghaltas na h-Alba
gov.scot