Soil structure, management and effect on nutrient availability and crop production

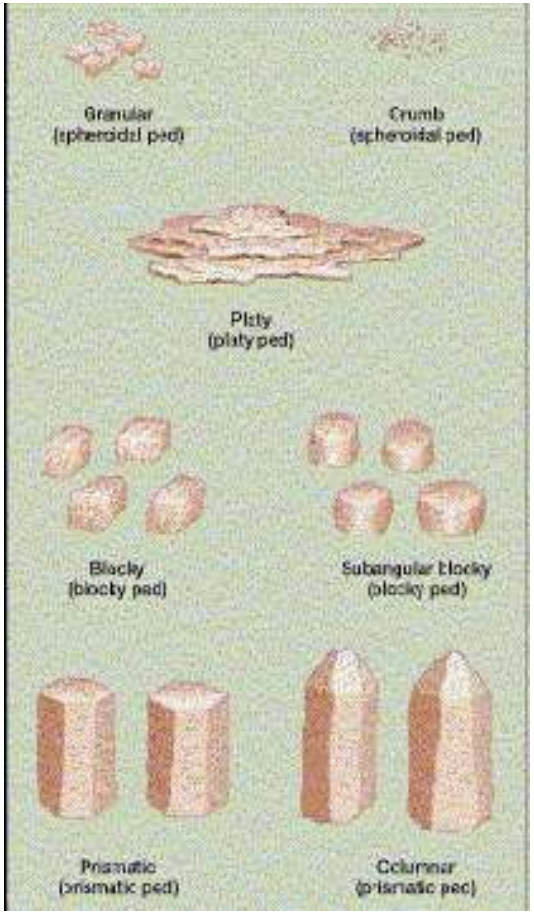
Julia Cooper

Organic Producer Conference, Facing Current and Future Challenges
17 January 2011

Outline

- Define soil structure
- How do we measure it
- Relate structure to soil conditions affecting productivity
- How these conditions affect crop productivity
- Improving soil structure & productivity
- Research needs

What is soil structure?



http://www.ksre.ksu.edu/fieldday/kids/soil_pit/soil_structure.htm

Simple spade test

- soil structure and consistence
- soil porosity
- soil colour
- soil mottles
- earthworms

http://www.consumer.org.nz/reports/soil-quality/check-your-soil-condition

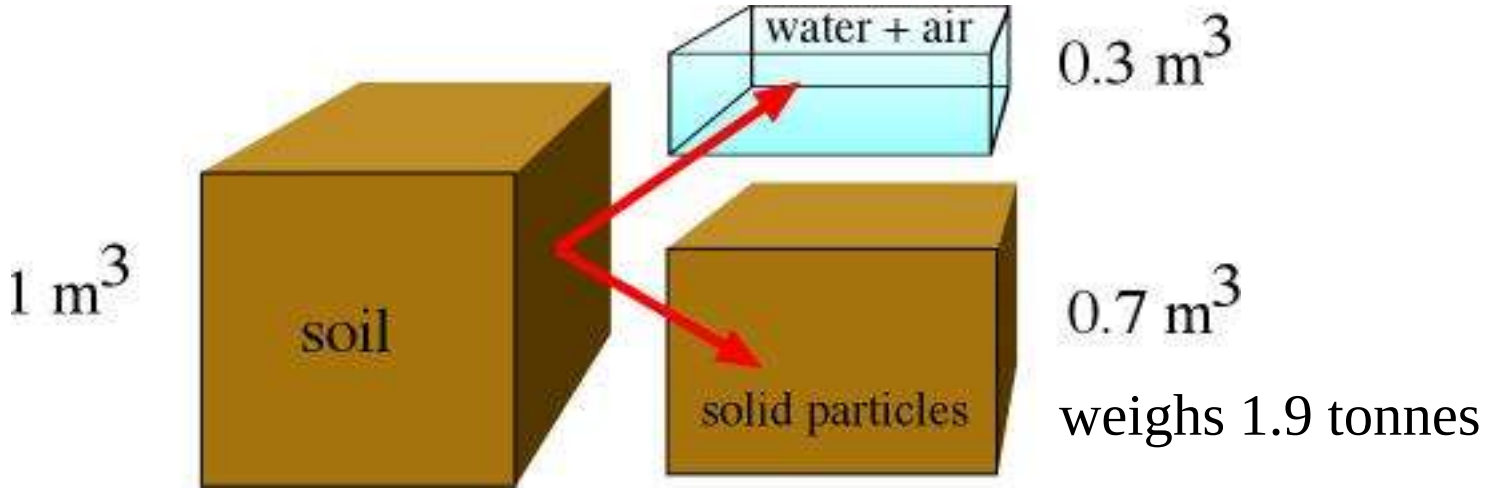
Can we measure soil structure?

- Bulk density=BD=mass dry soil/total volume=M_s/V_b in g/cm^3

e.g. soil below BD = 1.9 Mg/m^3

- Porosity = volume pores/volume soil

e.g. soil below porosity = 30%

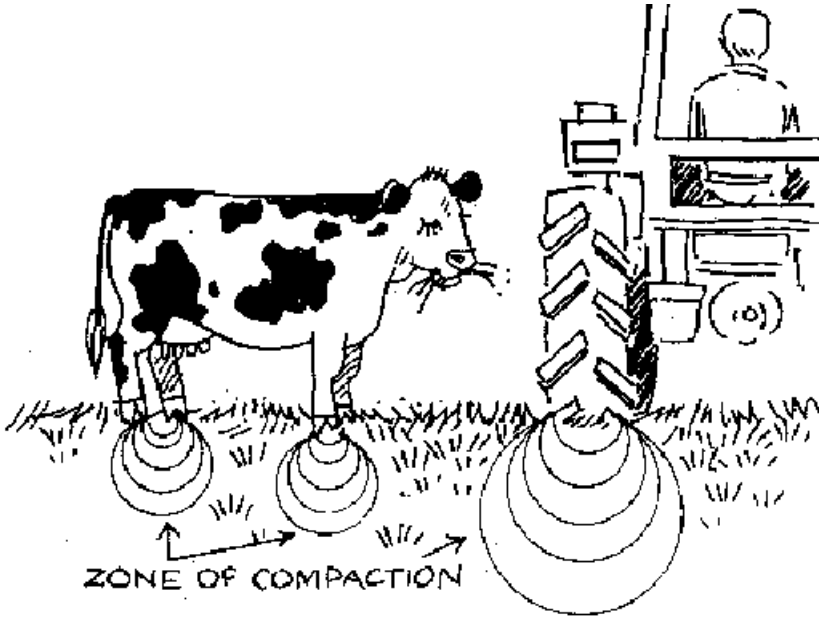


Can we measure soil structure?

- Aggregate stability
- E.g. water stable aggregates

Measuring soil structure in the field – soil strength using a penetrometer

These measures are indices of…



COMPACTION!!

http://www.dpi.nsw.gov.au/agriculture/resources/soils/structure/compaction

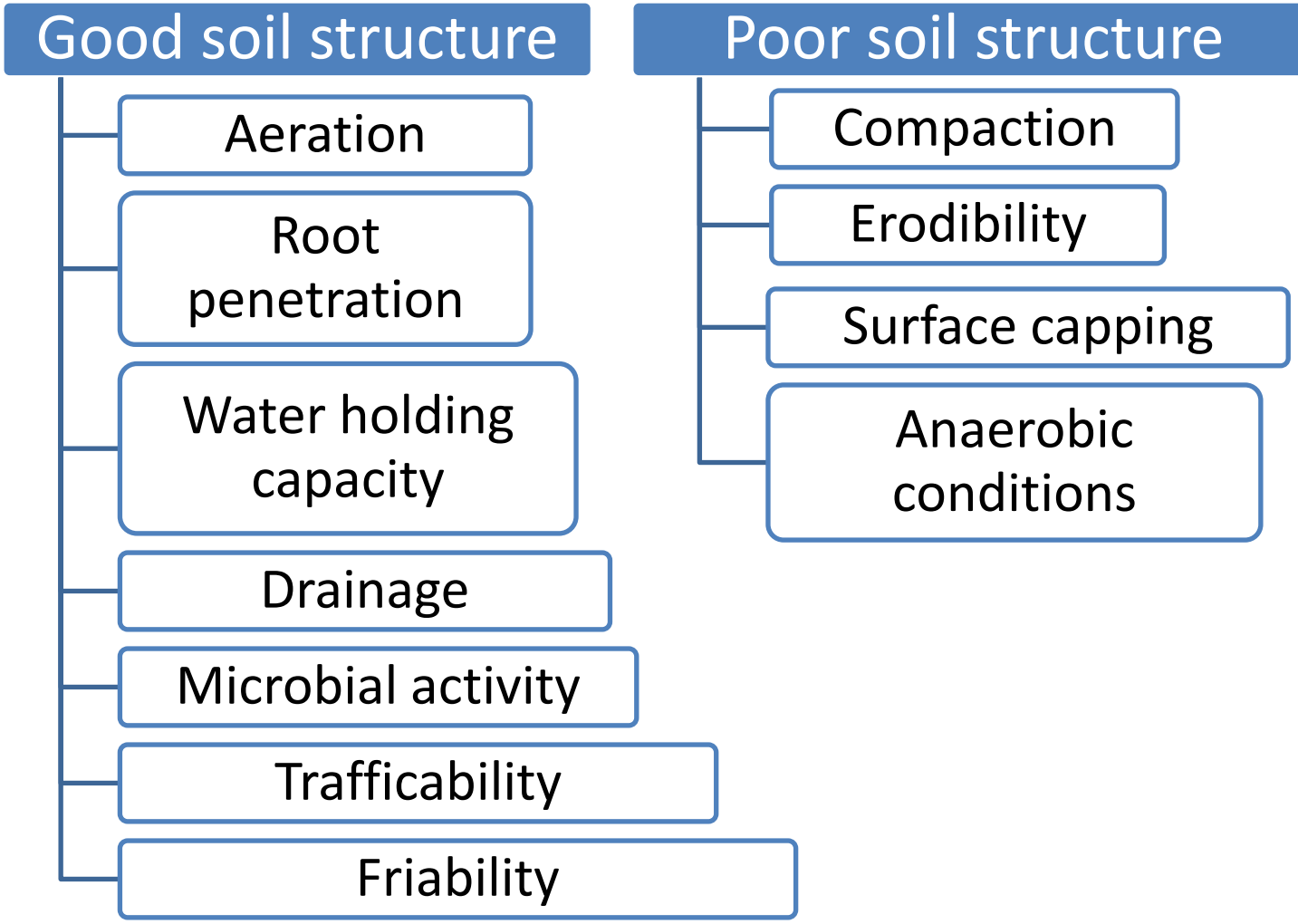
Aggregate stability is an index of….

EROSION RISK!!

Poor aggregate stability can also lead to…

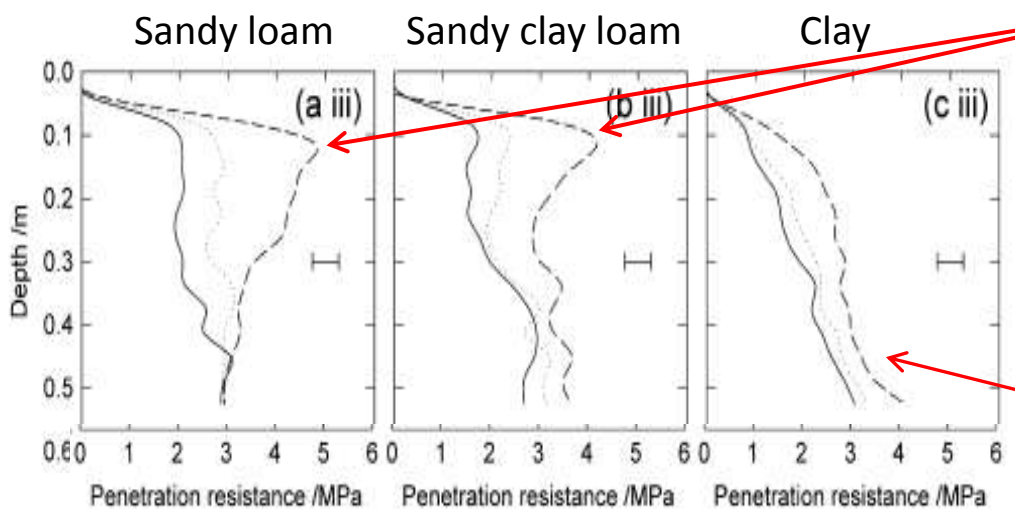
SURFACE CAPPING!!

Directly and indirectly, soil structure impacts on soil fertility and crop productivity



Compaction – soil textural differences

Silsoe, Bedfordshire, wheat experiments



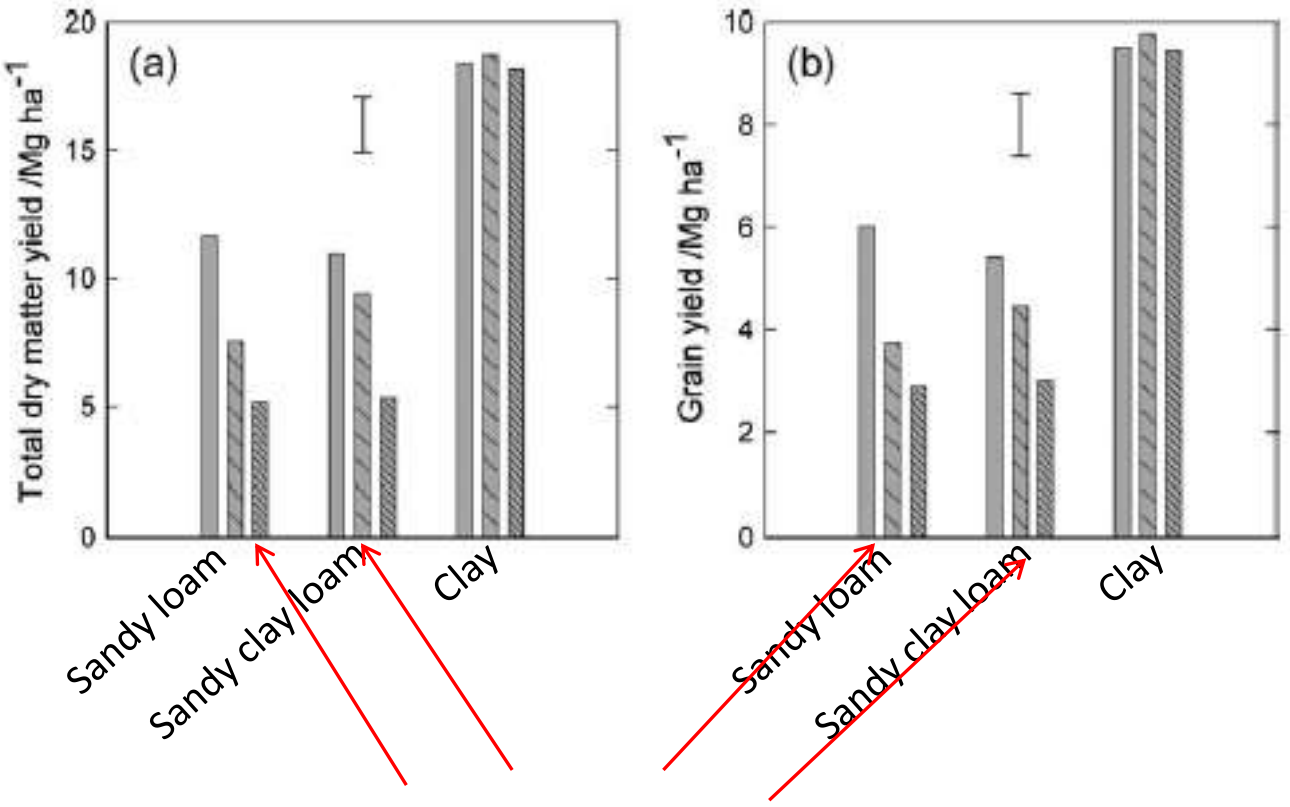
High penetration resistance = compaction in May 2005

Clay less affected by compaction

Gregory et al. 2007

What about effects on yields?

Silsoe, Bedfordshire, wheat experiments

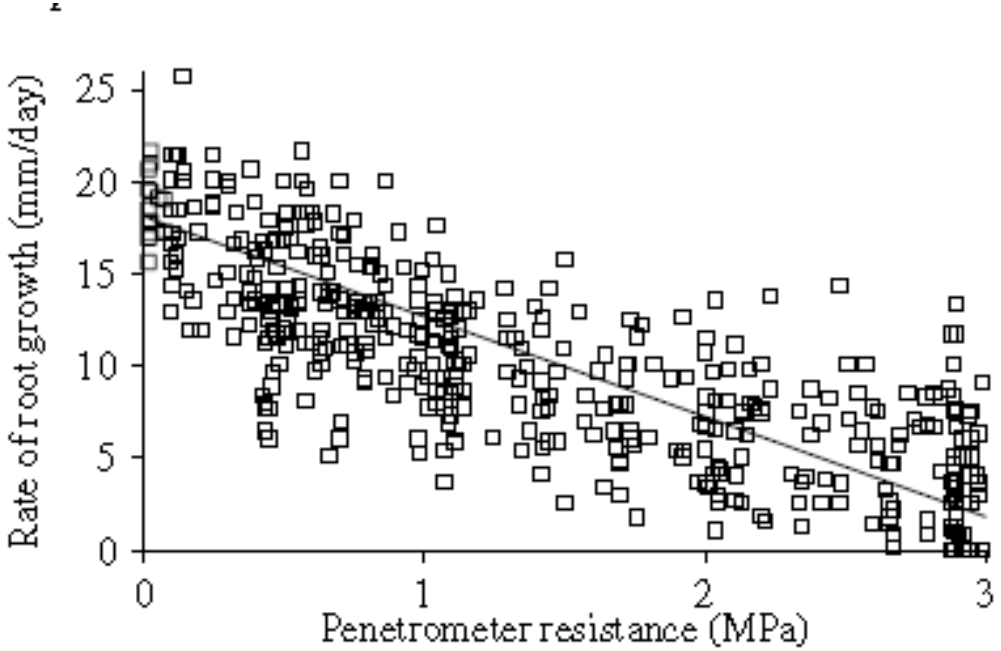


Higher compaction, decreased yields

Loveland & Webb, 1997, MAFF Project Code SP0306

Compaction - effects on potato growth

- Compaction – delays emergence, reduces mainstem length, reduce rate of leaf appearance, leaf length, rooting depth



Stalham et al. 2007

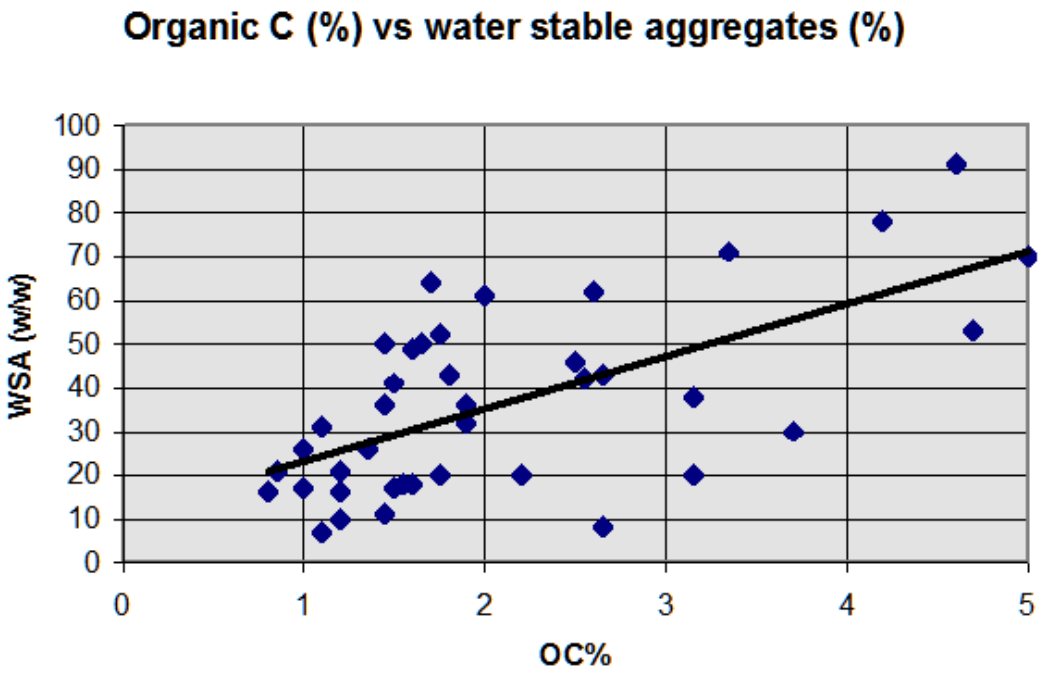
Soil structure affects on crop productivity

- Soil erosion = loss of valuable, fertile soil, impacts water quality and crop yields
- Surface capping – slows and inhibits crop emergence
- Anaerobic conditions – GHG emissions
- Knock-on effects – microbial activity

Managing for good soil structure

Organic matter additions

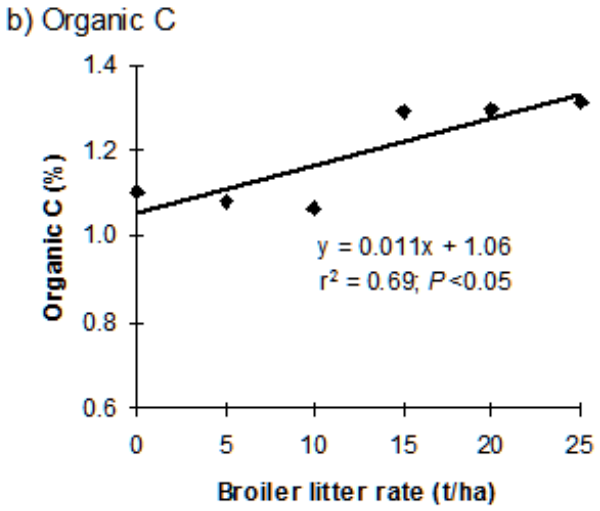
Effect of organic C on water stable aggregates

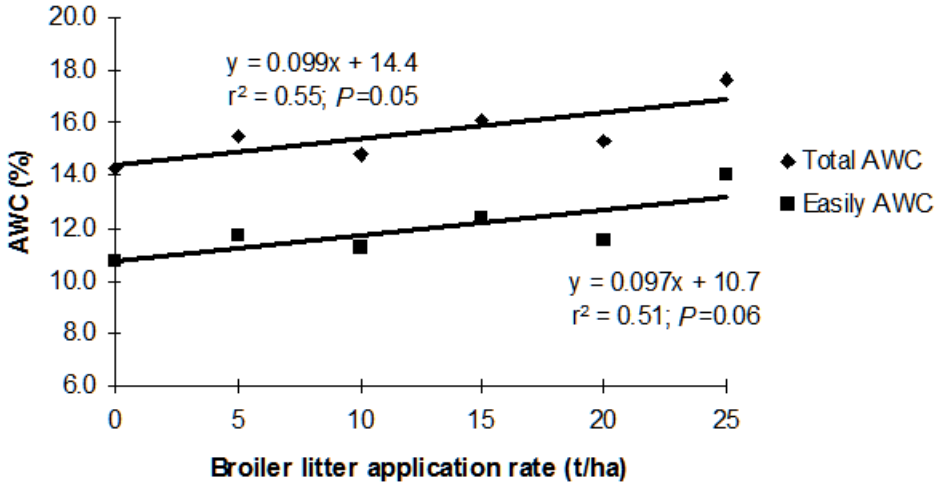


Loveland & Webb, 1997, MAFF Project Code SP0306

Improving soil structure with broiler manure

Results from ADAS Gleadthorpe (loamy sand soil)
Receiving 5, 10, 15, 20 or 25 t/ha/y broiler litter for 9 years





ADAS, 2002, Defra project code SP0501

Managing for good soil structure

- Does it need to be the “right kind” of organic matter?
- Fresh soil organic matter improves aggregate stability
- “microbial gum” single most important factor in aggregation (Chesters et al. 1957)
- Root exudates are key

Managing for good soil structure

Crop rotation

Crop rotation	Year							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Conventional	Winter wheat	Winter wheat	Winter barley	Vegetables/ Potatoes	Winter wheat	Winter barley	Grass/ clover	Grass/ clover
Organic	Winter wheat	Vegetables/ Potatoes	Spring beans	Vegetables/ Potatoes	Spring barley	Grass/ clover	Grass/ clover	Grass/ clover

Managing for good soil structure

Reduced tillage

Horsch cultivator at Nafferton Farm

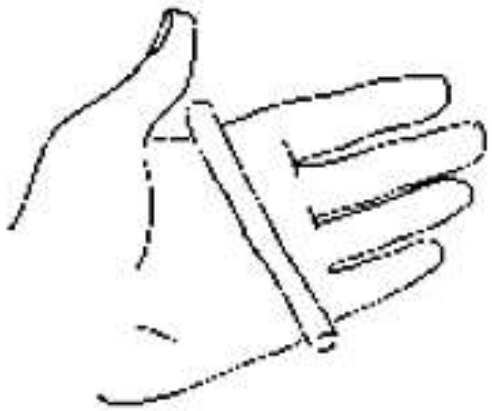
Managing for good soil structure

Addressing pasture compaction at Nafferton

Managing for good soil structure

Don’t till when it is too wet!

- Rapidly squeeze a small lump of soil into a ball and try to roll it into a rod about 3 mm in diameter.
- If you can make a rod easily, the soil is too wet and will compact if it is worked or has animals or machinery on it.



Managing for good soil structure

Livestock management on pastures

- Don’t overstock, especially when the ground is wet
- Move feeders frequently to avoid poaching

Future Research Questions

- Biochar effects on structure – are claims valid?
- Adapting minimum till to organic systems
- Are there others?

Acknowledgements

- Funding for NEFG is largely provided by the European Commission, Directorate General for Research, within the 7th Framework Programme of RTD, Cooperation Theme 2 - Biotechnology, Agriculture & Food.
- Nigel Critchley & Paul Newell-Price, ADAS.

Newcastle University

NEFG