South West NRM
Building Healthy and Productive Ecosystems

South West Soils

Common characteristics and constraints on pastures

12 January 2024

Australian Government
Department of Agriculture, Water and the Environment

Future Drought Fund

GROWER GROUP ALLIANCE
Together we grow

South-West WA Drought Resilience Adoption and Innovation Hub

This project received funding from the Australian Government's Future Drought Fund

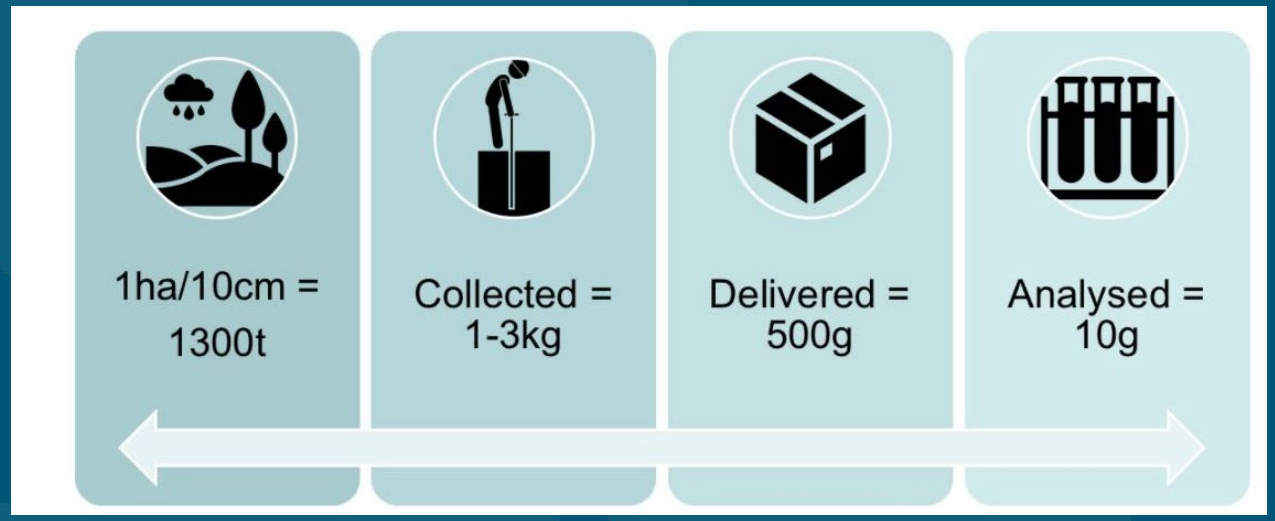
Outline

Representative and standardised soil sampling

Soil Constraints

Soil Health Principles

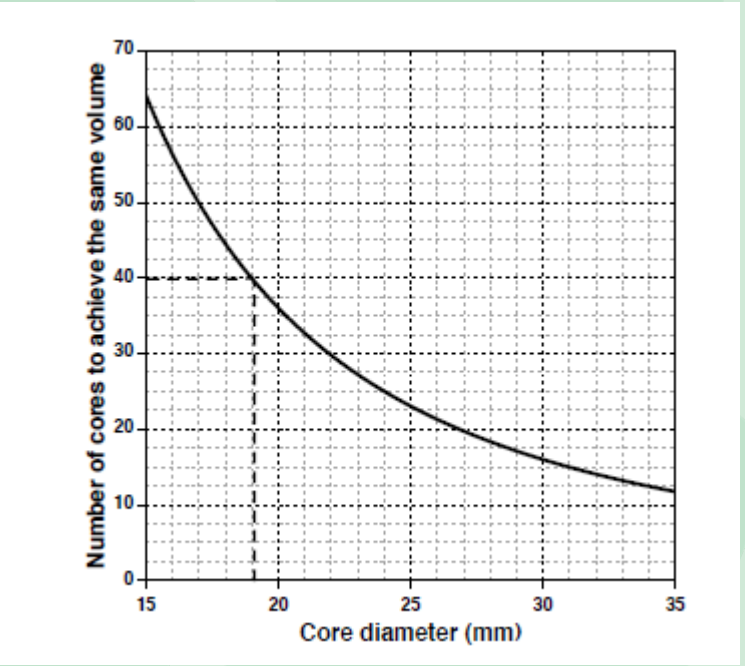
Soil sampling

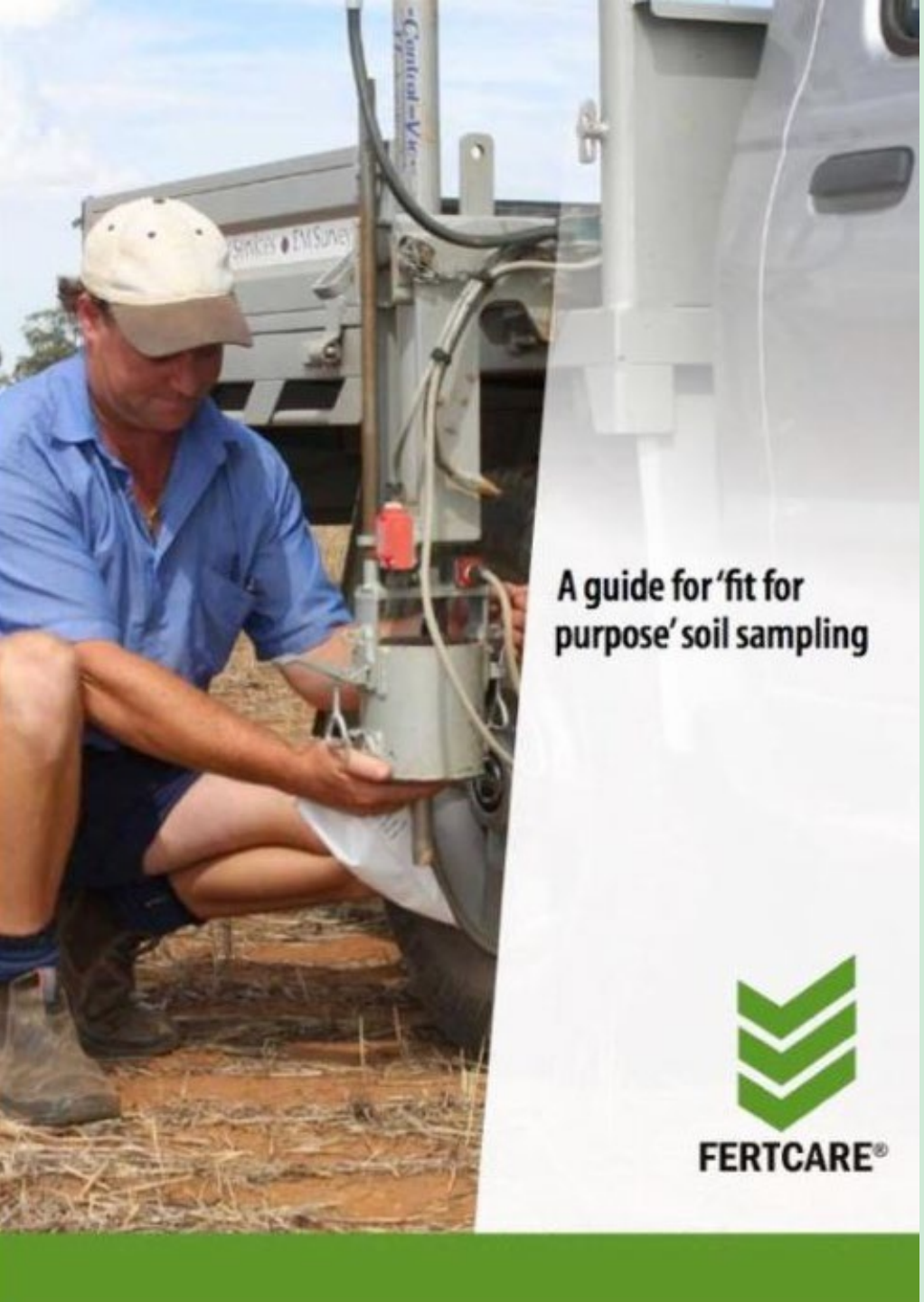


<0.000001% of zone/paddock/unit

Taking a representative soil sample

- 30-40 cores per sample.
- More variability requires more cores.
- Sample dominant soil type or split by soil type
- Avoid high nutrient areas e.g. gates, troughs camps.
- Stay 10-20 m off fencelines.





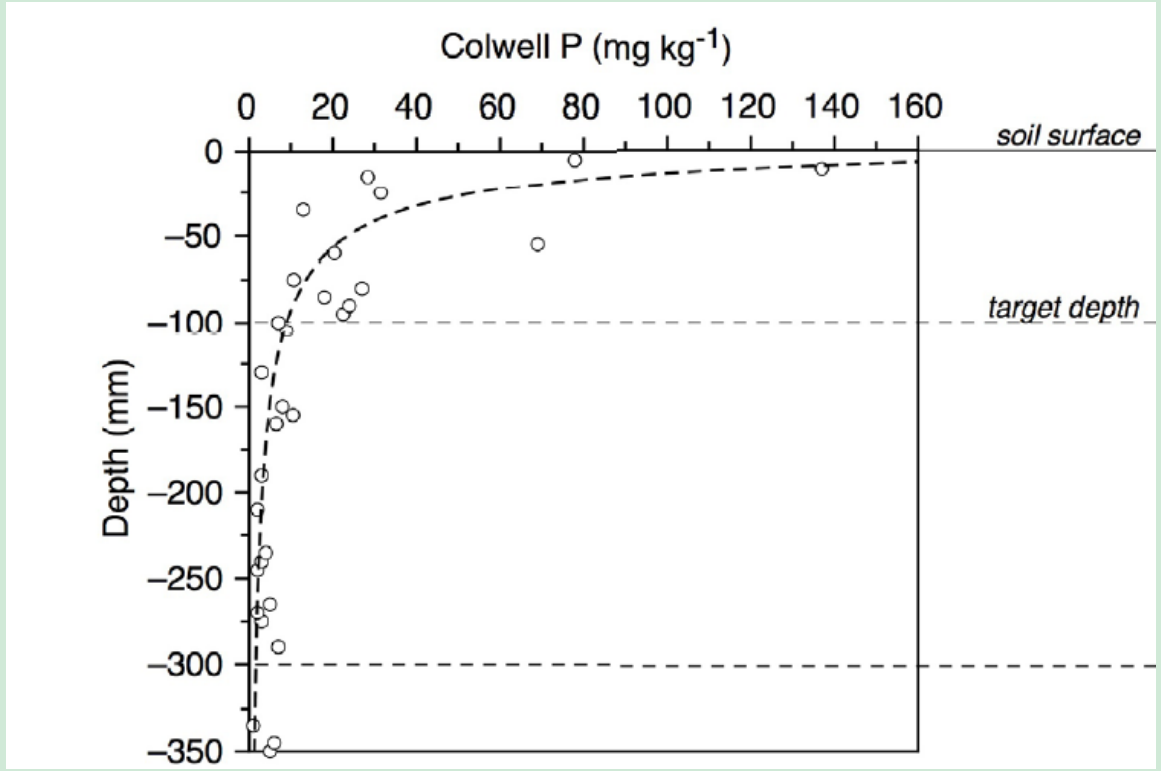
Sampling Pattern

- Choose a method and stick to it
- GPS and repeat next time (power in repeatability)

Pattern	Repeatability for monitoring †	Labour efficiency	Ability to automate	Likelihood of representative sample	Reducing risk of bias
Transect	*****	*****	*****	***	***
Zigzag	*****	****	*****	****	****
Cluster	*****	****	***	**	**
Uniform Grid	**	**	**	*****	*****
Random	*	**	*	*****	****

Repeatability

- Standardise depth
- Don’t scuff the soil surface
- Use the same sampling tool each time
- Sample at same time of year
- Handle the same – e.g. post promptly
- Use the same ASPAC Certified lab



Support with tissue testing

- Most reliable method for micronutrients
- Avoid contamination – use gloves
- Test one species per sample
- Include Moly (and Co, Se – often low)
- Track Cu/Mo for animal health (see below)

Bovitech Veterinary Services
@JessShilling2

This data is from the NZSAP, so isn't Australian specific, but the principles for our grazing systems are the same. This table shows the effects of adding more dietary Cu in the face of increasing Mo.

TABLE 13.1. A guide to Cu and Mo concentrations in pasture, and the consequences for animal health.

	Pasture Cu (mg/kg DM)		
Pasture Mo (mg/kg DM)	Sheep	Cattle	Consequences
0.5	3	3	Simple Cu deficiency
1	5–6	9–10	Cu status adequate
2–3	5–6	9–10	Mo in excess, Cu status not adequate
2–3	9–10	18–19	Mo in excess, Cu status adequate

7:50 AM · Aug 21, 2020

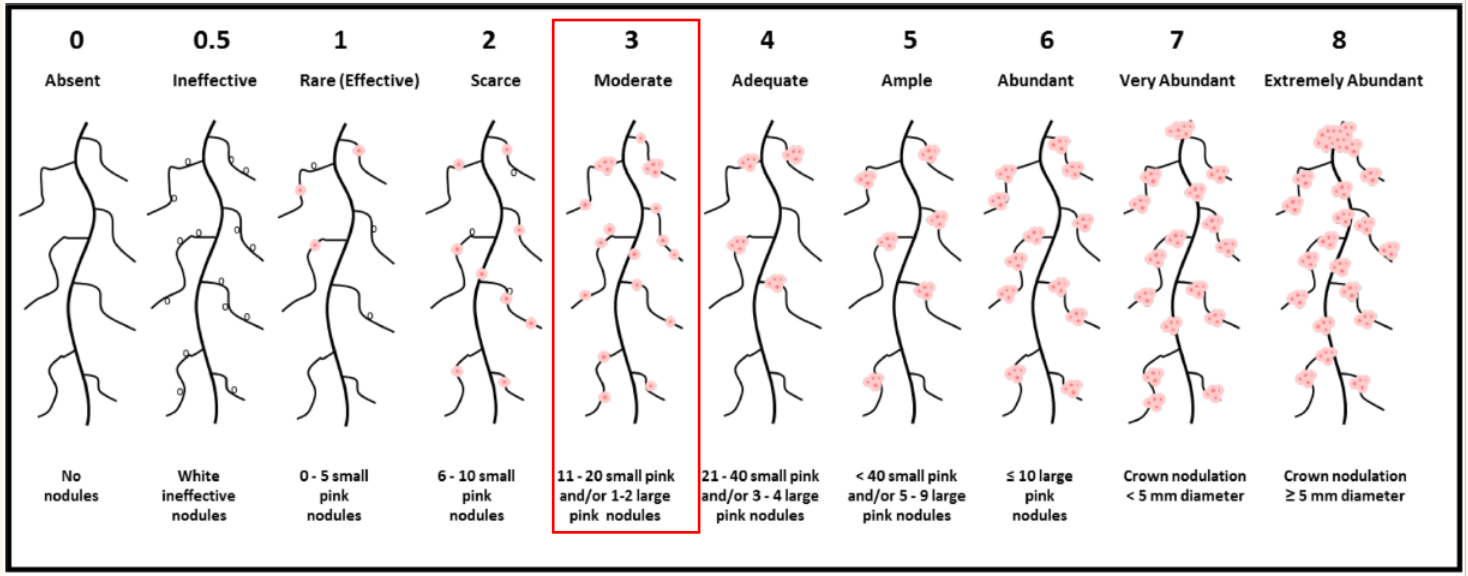
Results from Soil Constraints Project

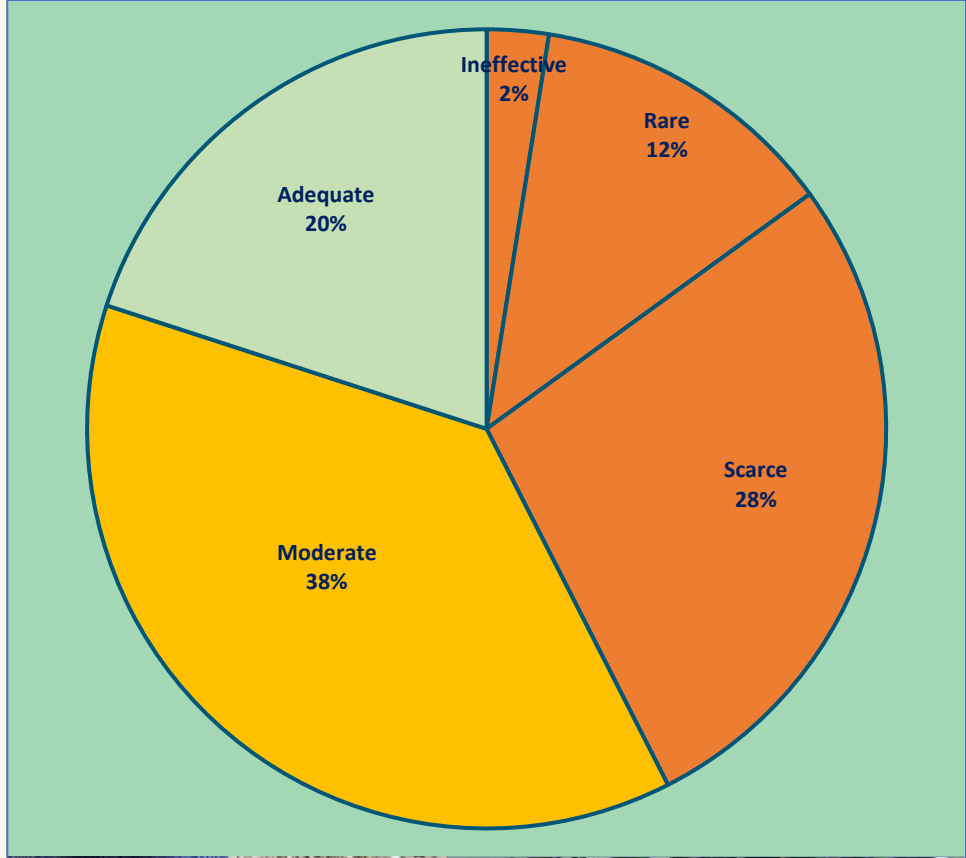
We also looked at:

- Sub clover nodulation
- Sub soil acidity
- Soil compaction
- Arbuscular Mycorrhizal Fungi root colonisation

Nodulation Results

- Legumes can supply 20-30 kg N per tonne of legume DM/ha released over three years, if nodulating adequately.
- Results: Only 20% adequate
- Improved nodulation could double-triple N input
- To view nodules, dig plants up and wash roots carefully in September.

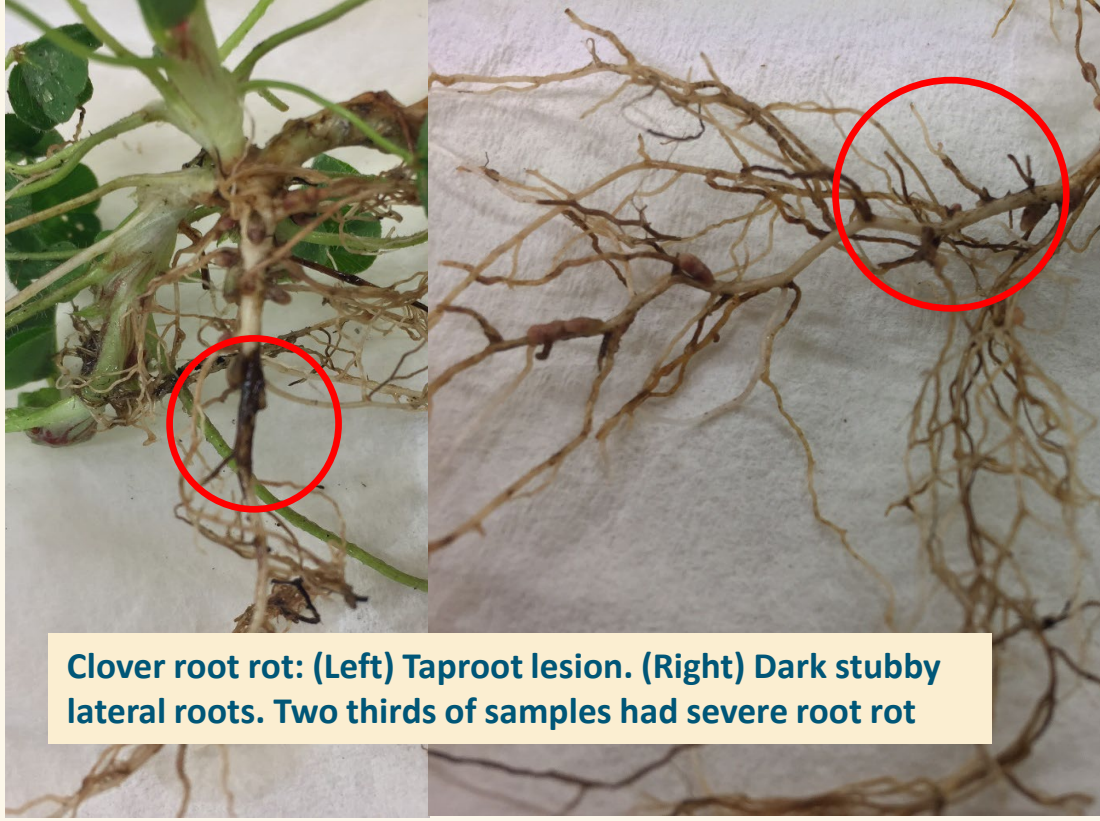




Factors affecting nodulation
(in no order)

- Root rot / nematodes
- Soil acidity (<5) – H^+ toxicity/rhizobia survival
- Low Molybdenum
- Old/crossed rhizobium – update every 5 years
- Poor inoculant management
- Chemicals (Group B, sulfonylureas)
- Poor fertility (P, S, CEC)

Ref: Hackney et al 2019, Inoculating legumes: A practical guide



Clover root rot: (Left) Taproot lesion. (Right) Dark stubby lateral roots. Two thirds of samples had severe root rot

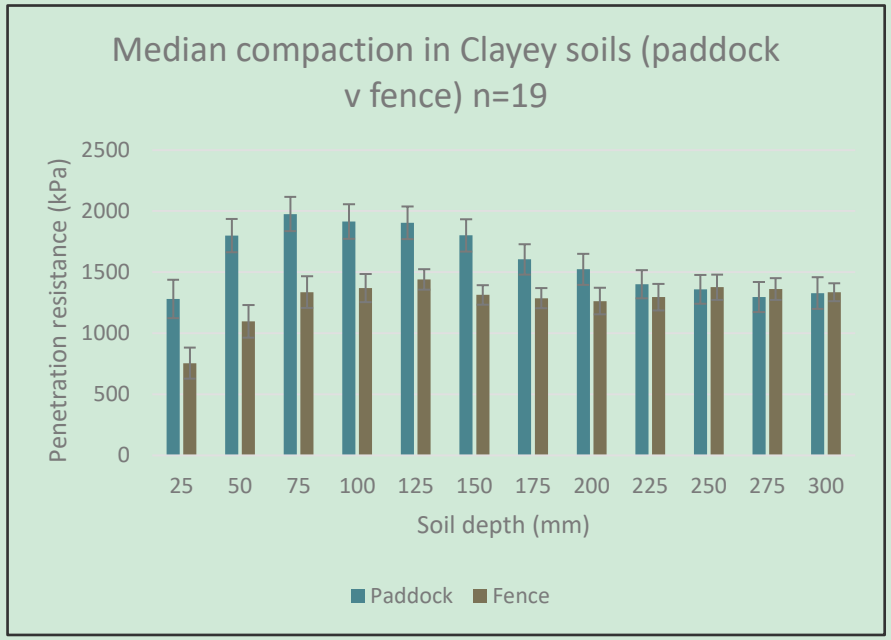
Molybdenum (mg/kg)	<0.1	0.1-0.2	0.2-0.5	0.5-1.5	>1.5
Count	8	6	9	7	7
Percent	22	16	24	19	19

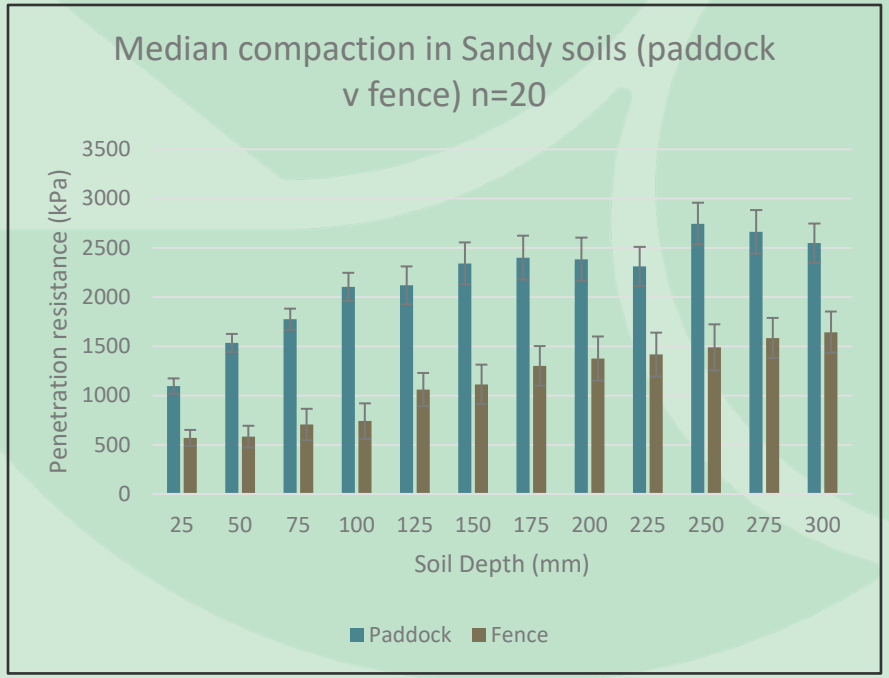
TABLE 2.4 Sensitivity of key rhizobia to pH, where red is sensitive and green is optimal.

Rhizobia	Host legume	pH 4	pH 5	pH 6	pH 7	pH 8
Bradyrhizobium spp.	Cowpea, mungbean, lupin, serradella					
Bradyrhizobium japonicum	Soybean					
Rhizobium leguminosarum bv. *trifolii*	Clovers					
Rhizobium leguminosarum bv. *viciae*	Pea, faba bean, lentil, vetch					
Mesorhizobium ciceri	Chickpea					
Sinorhizobium spp.	Medics					

Soil compaction

- Critical value 2,000 kPa.
- Sampled in late winter / spring with soil and field capacity
- With exceptions, the speed of root growth in pastures slows by 80% at 2,500 kPa and ceases at 3,000 kPa.

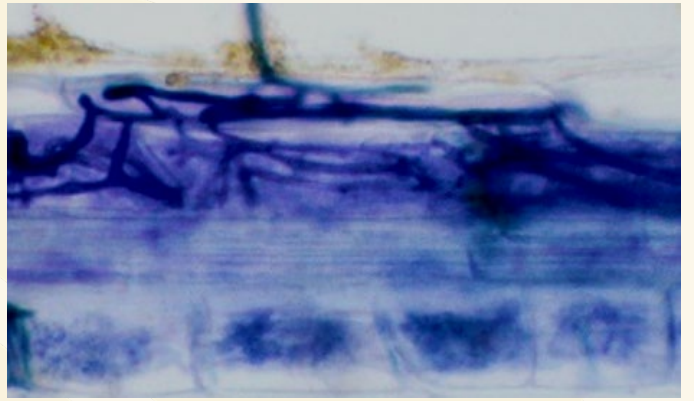




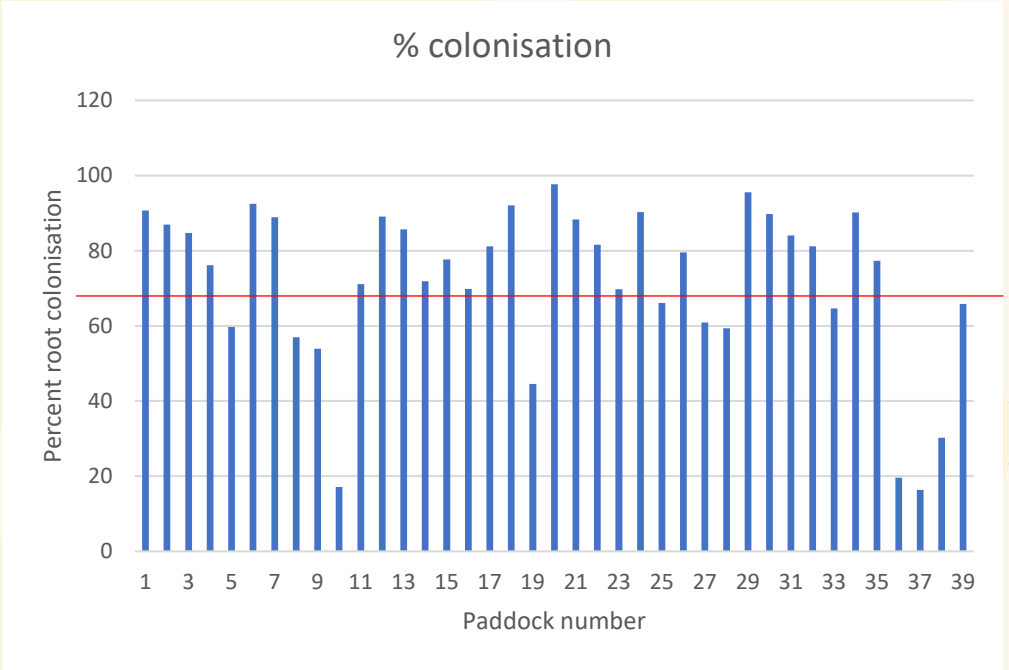
Water repellency

Rating\soil type	Sand	Sandy loam	Loam	Clay loam	Clay	Total
Very severe	0	2	0	0	0	2
Severe	4	9	1	0	0	14
Moderate	0	2	1	2	2	7
Low	0	2	0	6	6	14
Not apparent	0	0	0	1	2	3
Total	4	15	2	9	10	40

Mycorrhizal fungi (AMF) in clover



- Median percentage of root surface colonised was 76%
- May be associated with phosphorus availability:
  - Tended to be lowest where PBI was extremely low (e.g. <35)
  - Tended to be highest in paddocks with lower tissue P (e.g. <0.3 mg/kg)



Soil pH, microbes and nutrients

- Soil pH has a significant influence on microbial activity
- Microbes vital for nutrient mineralisation, soil structure and degradation of pesticides. Can also reduce non-wetting waxes
- At very low soil pH, soil carbon can increase due to lower microbial activity! (less mineralisation)
- Water repellency can also reduce mineralisation due to restricted microbe movement in soil

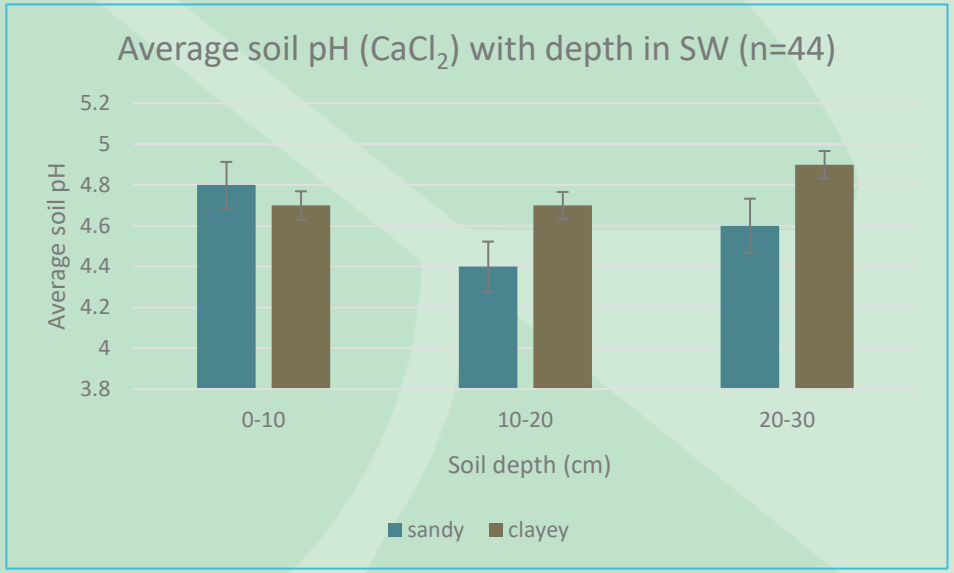
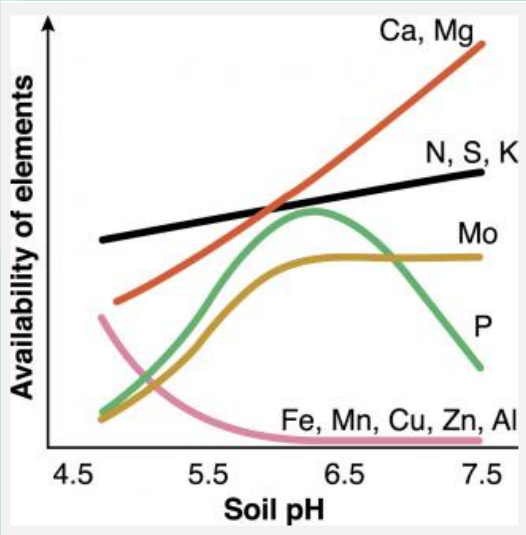


Table 2: Maximum, minimum, and optimum pH values for microbial groups. (adapted from Smith and Doran 1996)

Microorganisms	Range	Optimum
Bacteria	5 - 9	7
Actinomycetes	6.5 - 9.5	8
Fungi	2 - 7	5
Blue green bacteria	6 - 9	> 7
Protozoa	5 - 8	> 7



Aluminium toxicity?

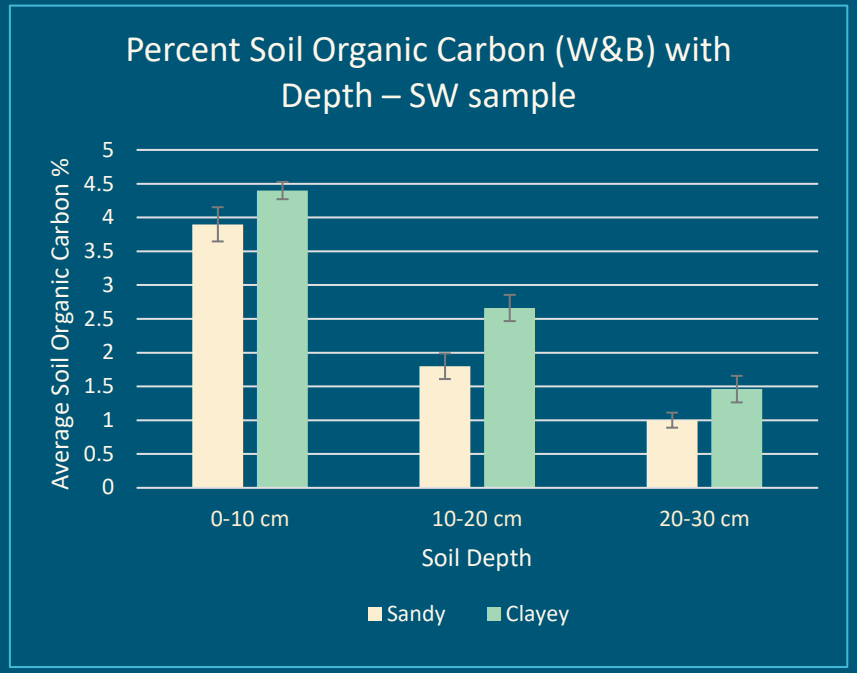
- Aluminium toxicity trims roots
- There was no evidence of root pruning in high aluminium soils
- Soil organic matter can detoxify Al, and is suspected in high-med SOC soils in High Rainfall Zone.
- We suspect our higher SOC mitigates Al toxicity

Wheat seedlings with different levels of Soil Al. Higher Al on left has caused root pruning (Photo: S Carr)

Our bioassay with barley in soils with Al ($CaCl_2$) 4.2 mg/kg and SOC 0.5%. No evidence of root pruning.

Soil Organic Carbon

- Holds nutrients, water, buffers pH
- Main energy source for soil organisms
- Nutrient source when mineralized
- **Declines significantly with depth**
- Results for W&B can differ between labs!!
- Soil carbon credits measure Total Organic Carbon (TOC), not W&B,
- TOC is converted to Tonnes per hectare. This requires a measure of bulk density



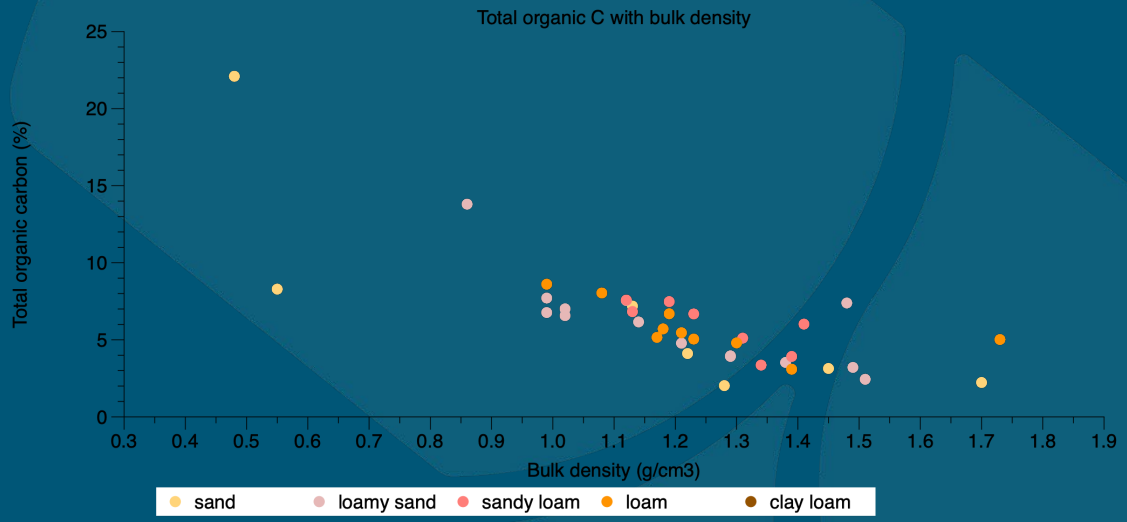
Results for Walkley & Black Soil Organic Carbon from 24 farms in Soil constraints project (CSBP Lab)

Depth	SOC(%) W&B	Total SOC(%)	C content (t/ha)
0-10	6.5	6.0	62.0
10-20	2.9	2.6	34.5
20-30	1.7	1.4	21.0

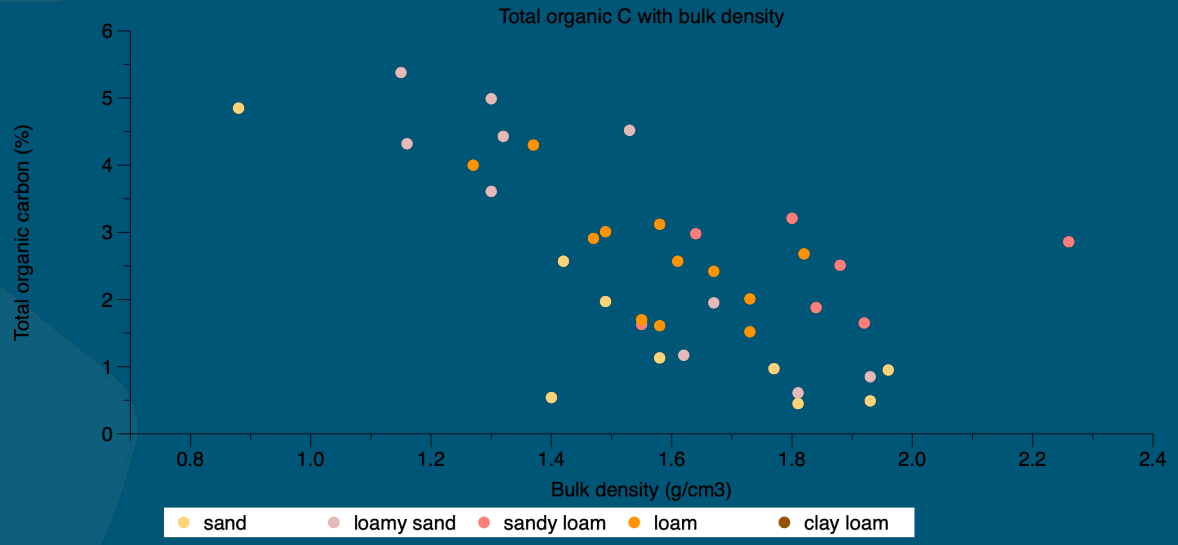
Results from 10 farms in Soil Carbon Benchmarking project (APAL)

Soil Carbon

- Is there a relationship between % Soil Carbon and compaction (measured as bulk density)?



0-10 cm



10-20 cm

Table 1. General relationship of soil bulk density to root growth based on soil texture.		
Soil Texture	Ideal bulk densities for plant growth (g/cm3)	Bulk densities that restrict root growth (g/cm3)
Sandy	< 1.60	> 1.80
Silty	< 1.40	> 1.65
Clayey	< 1.10	> 1.47

http://soilquality.org/indicators/bulk_density.html

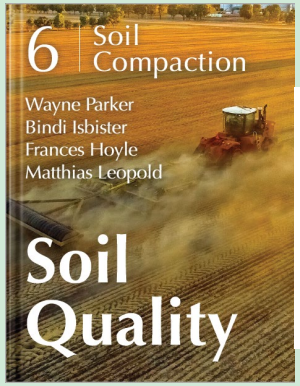
Landcare Farming

Soil Health Principles

- Protect soil surface where most organisms live. The surface is also richest in soil carbon and nutrients.
- Conserve and build soil organic matter. Inputs should outweigh outputs (up to 85% can be lost in mineralisation)
- Roots may provide biggest input, so deal with subsoil constraints (acidity, compaction) and manage grazing pressure.
- Calculate fertiliser applications to replace nutrients to complement (slow) nutrient cycling and avoid overriding N fixation from legume rhizobia, and AMF associations (https://www.agric.wa.gov.au/sites/all/modules/submodules/nutrient-calculator/)
- Select management practices that decrease suitability for pathogens (crop rotation and tillage)
- Base the use of amendments on trials

More info

- Pasture Challenge “Date” - 14 Feb Busselton
- South West NRM - https://southwestnrm.org.au/
- Soil Quality - https://www.soilquality.org.au/
- Soil Quality eBooks
- Soil Health App
- Inoculating Legumes: A practical Guide (GRDC)



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Thank you

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