Department of Primary Industries and Regional Development

GOVERNMENT OF WESTERN AUSTRALIA

Protect
Grow
Innovate

Soil reengineering redefines yield potential

Gaus Azam I Grains Industry Day I 6 December 2022

How we determine water-limited yield potential?

Yield potential calculation!

An example

Half a dozen models

Modified French & Shultz 1984

Yield potential (kg/ha) = (stored water, mm + growing season rainfall, mm – evaporation, mm)* WUE, kg/mm

13 for canola

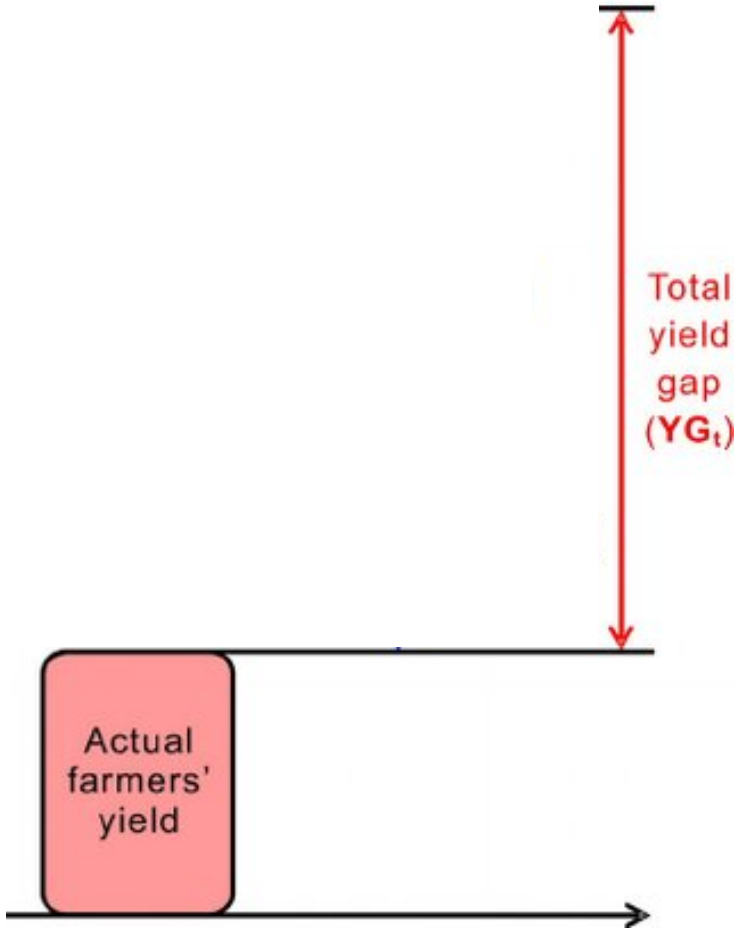
Yield potential (kg/ha) = (100*30%, mm + 180*100%, mm - 110, mm)* 20, kg/mm for cereals

Yield potential (kg/ha) =100, mm* 20, kg/mm

Yield potential = 2,000 (kg/ha) or 2 (t/ha)

Why large gap between actual yield and potential yield?

- Multiple soil constraints and many other factors



Lui et al. 2016: https://www.sciencedirect.com/science/article/abs/pii/S0048969715306471?via%3Dihub

Soil reengineering can eliminate the yield gap!

HOW?

Soils in Western Australia – multiple constraints in same paddock

- Poor old soil and low fertility (millions year old and mined to the end)
- Acidity, compaction, non-wetting, sodicity and elemental toxicity (e.g. Al, B, Na)
- Too much rain at wrong time (water logging & poor aeration)
- Not enough rain (drought)

Soil profile reengineering to make soils unconstrained

- ➢ Fix acidity, compaction, non-wetting, sodicity and elemental toxicity
- ➢ Make soil rich in nutrients (adding OM and nutrients)
- ✓ Absorb all rainfall (no run off) and keeps water within access (no deep drainage)
- ✓ Grow plants with deeper root system that can use water (and nutrients) throughout the season to finish the crop

Re-engineering profile trials across the grainbelt of WA

3 x deep sand

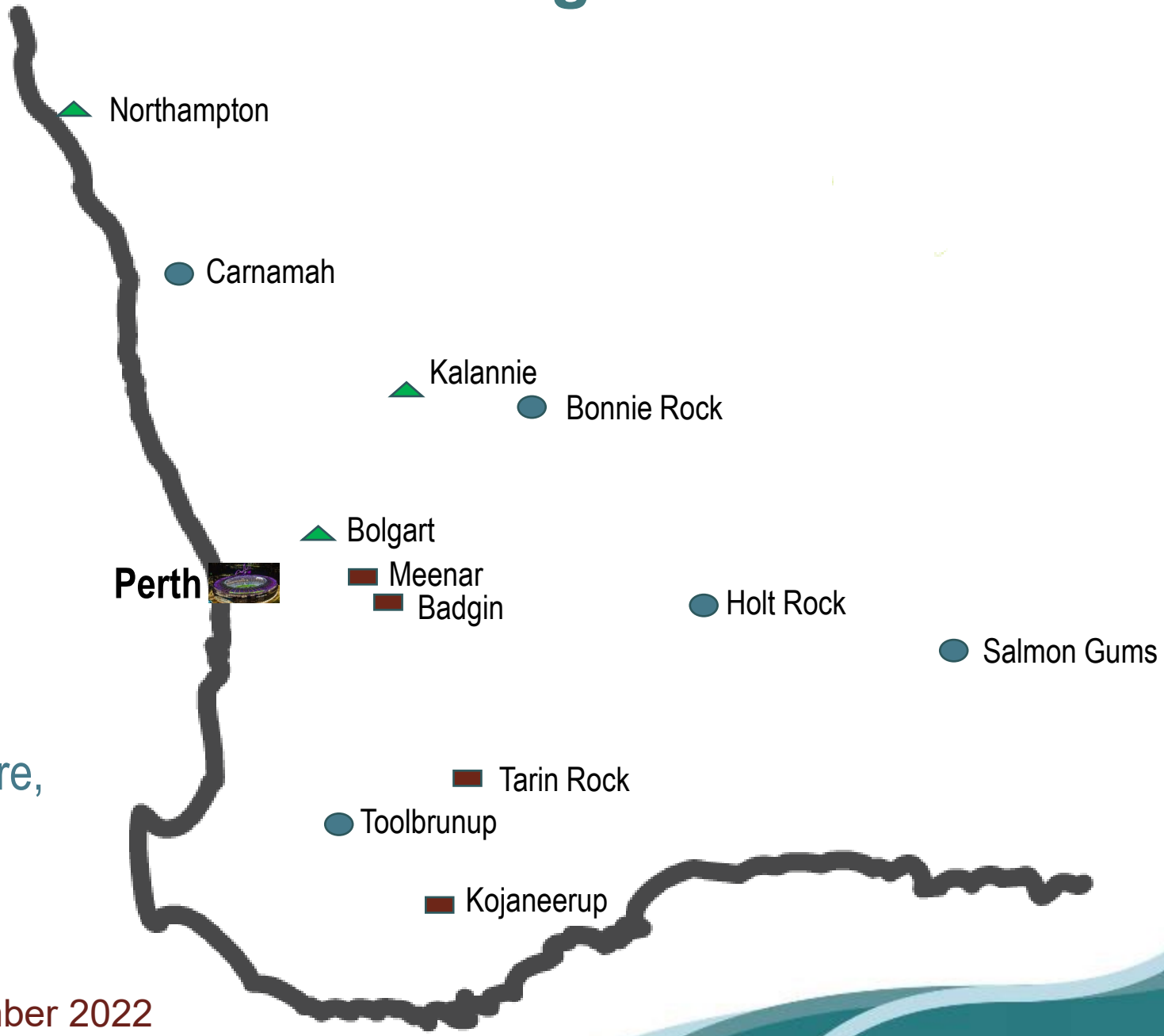
Non-wetting, compaction, acidity (Al), water holding capacity, structure, OM, and nutrients

4 x duplex soil

As above PLUS sodicity, infiltration, naturally dense

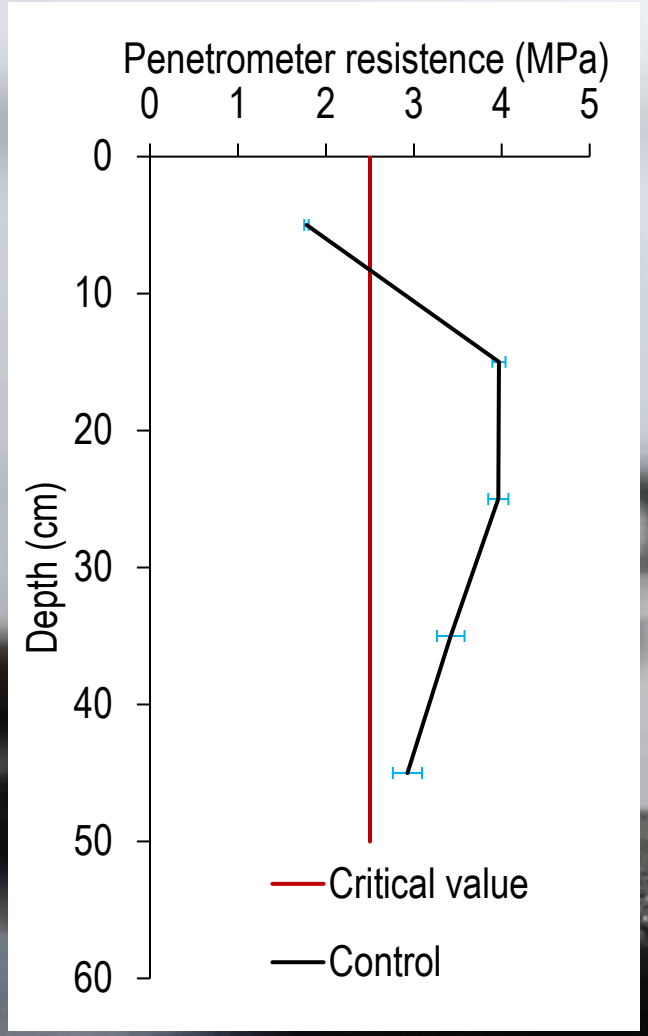
5 x heavy soil

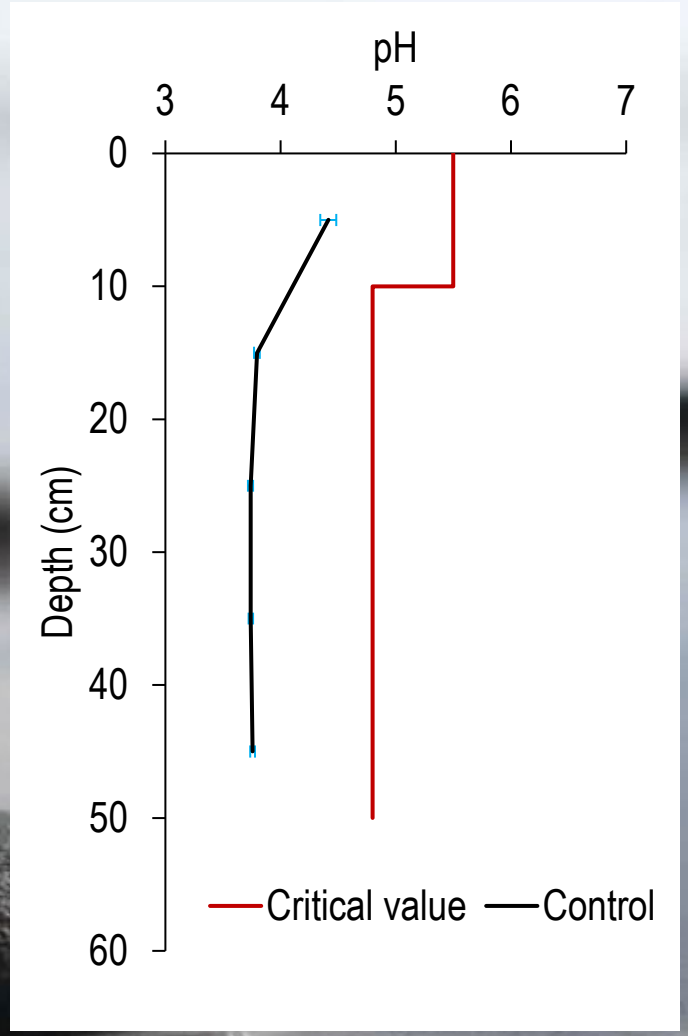
Sodicity, alkalinity, infiltration, structure, tightly bound water, boron, OM, and nutrients



Kalannie graveyard trial – the stepping stone

Two major constraints = compaction and acidity

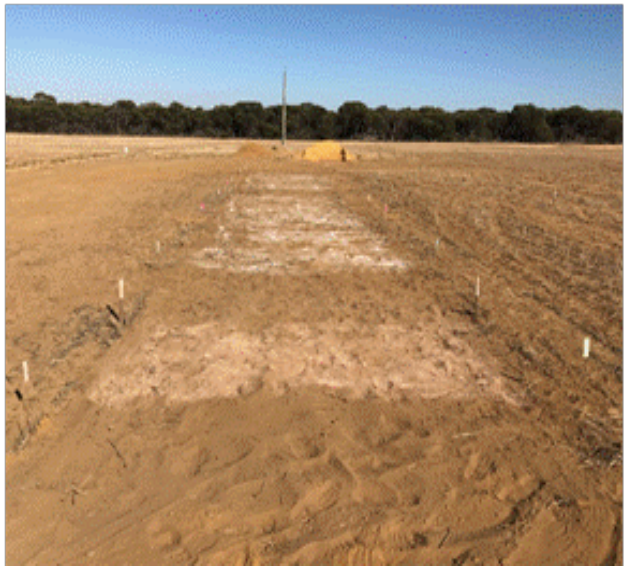




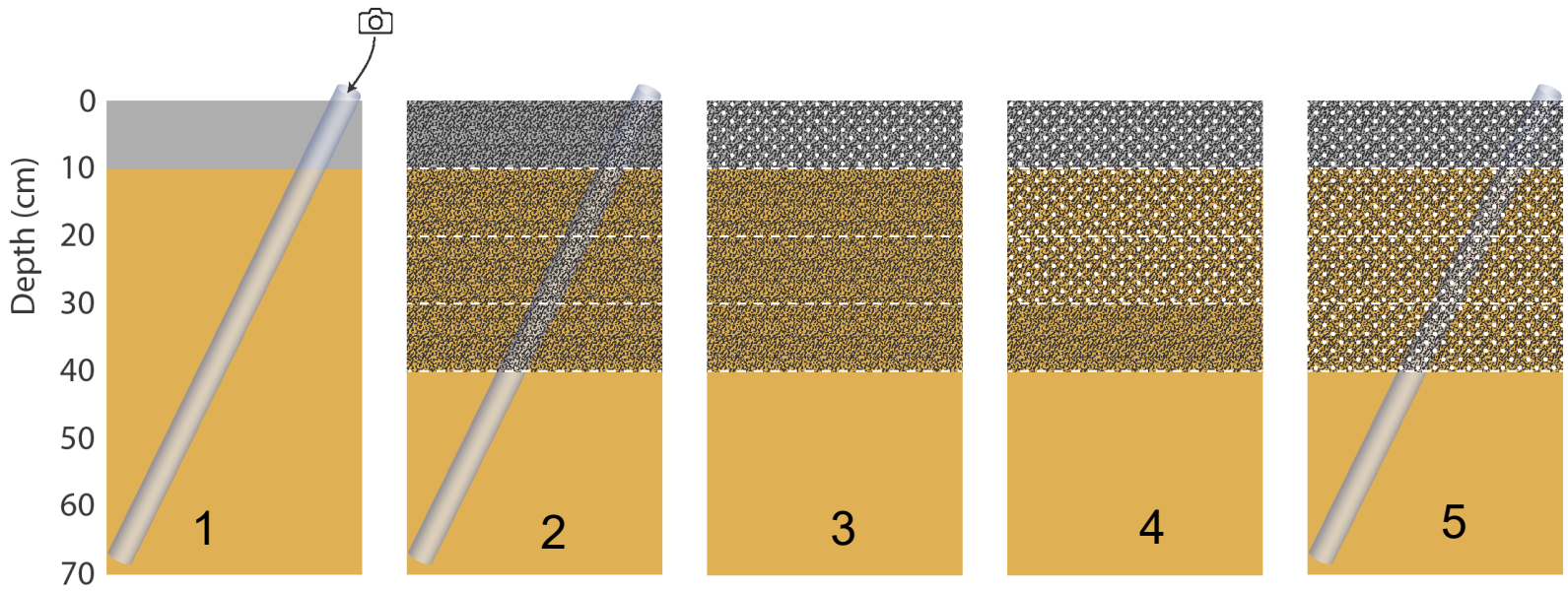
Kalannie graveyard trial – how we did it?





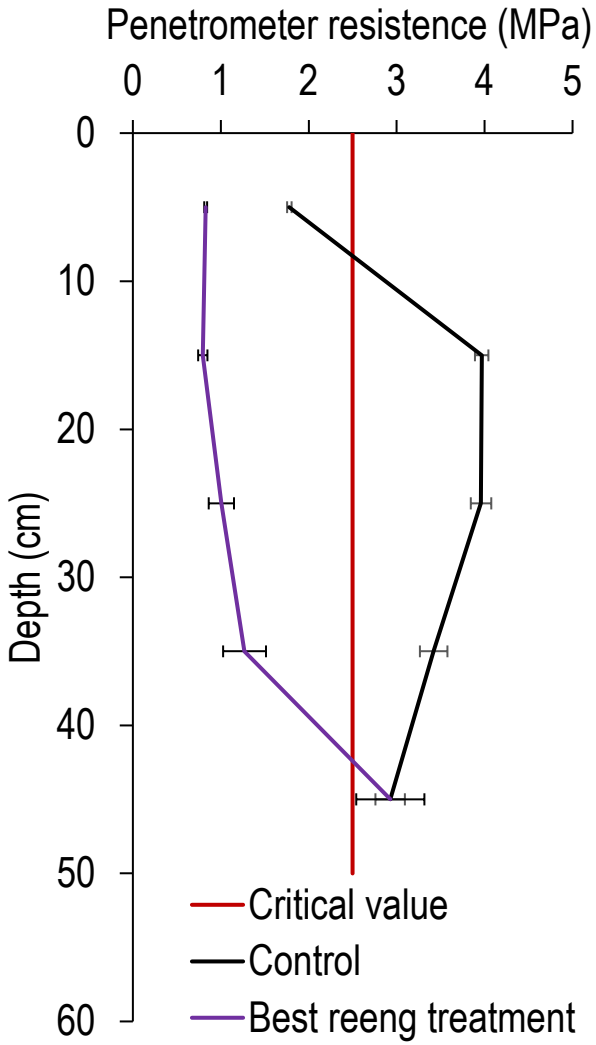


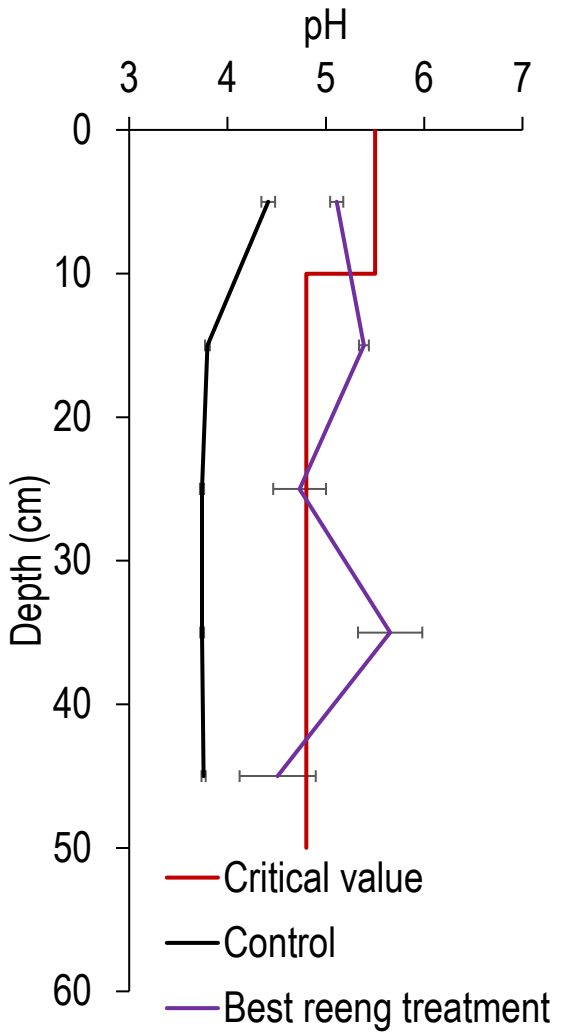
Kalannie graveyard trial – treatments



Kalannie graveyard trial

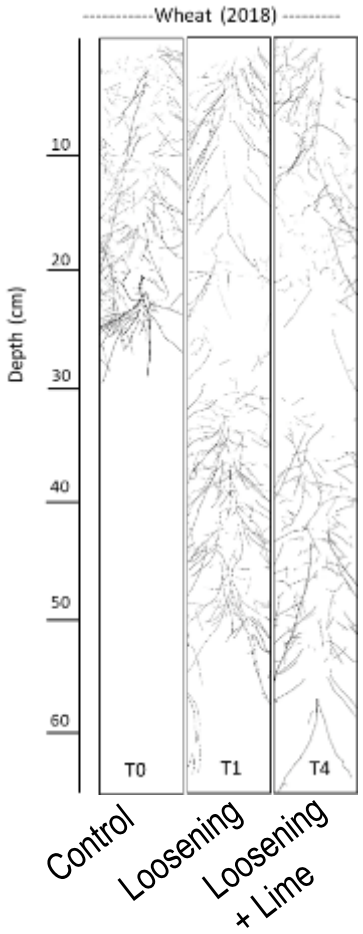
Soil problems solved in weeks



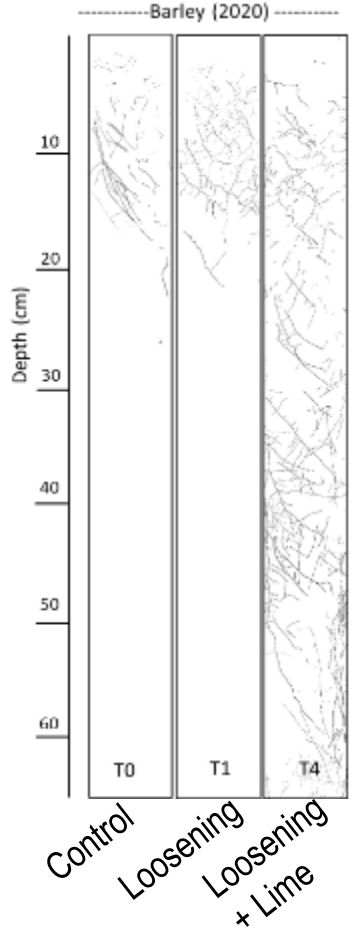


Kalannie graveyard trial – root says it all!

Deeper roots - deeper buckets

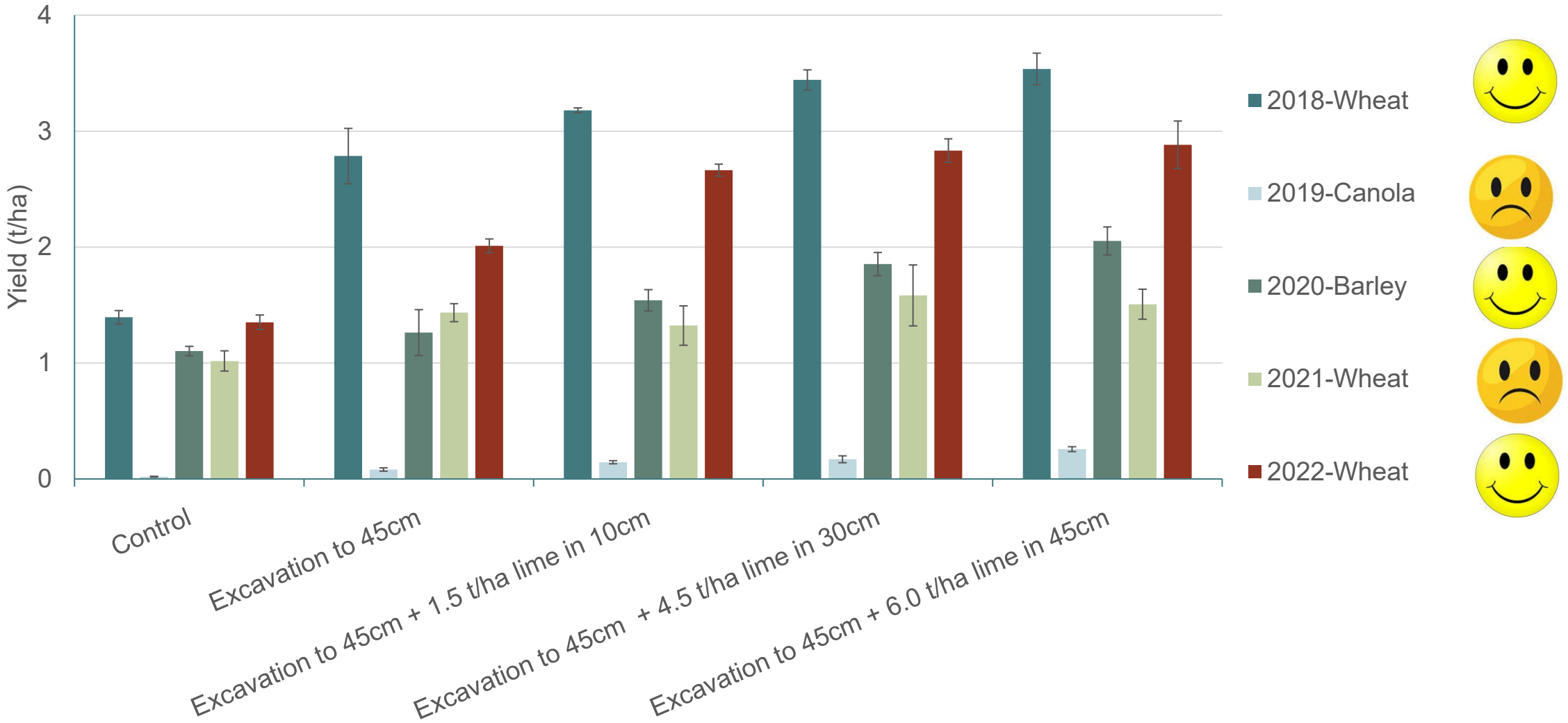


A tolerant **wheat** grew 60–65 cm deep root system in 2018 in both T1 and T4

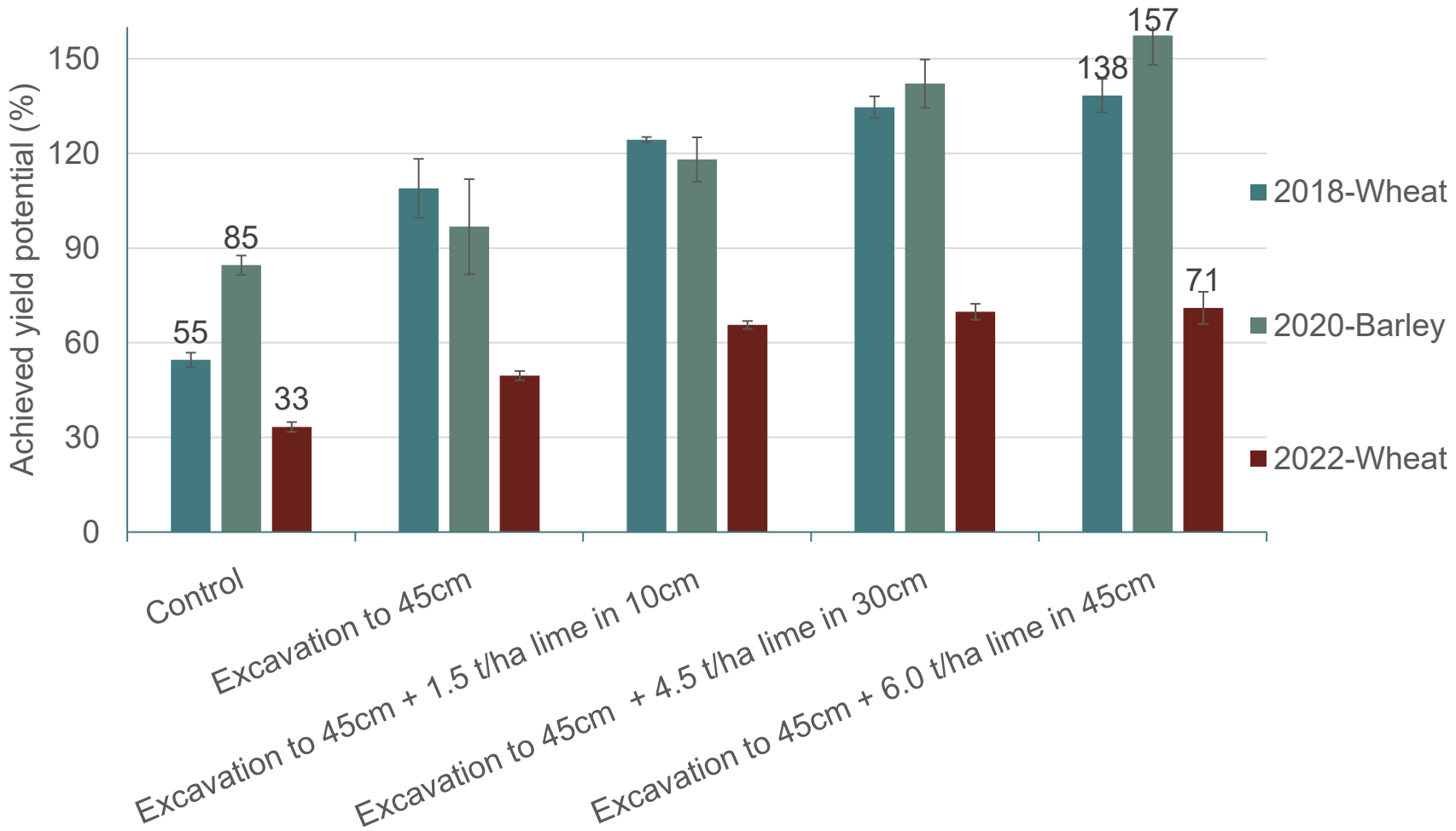


A sensitive **barley** grew 60–65 cm deep root system in 2020 only in T4

Grain yield in Kalannie graveyard trial over 5 years



Achieved yield potential in Kalannie over 5 years



Ypot (t/ha)
2.5
1.4
4.4

Soil reengineering redefines water-limited potential!

How about for other soil type?

Class of 2021-2022

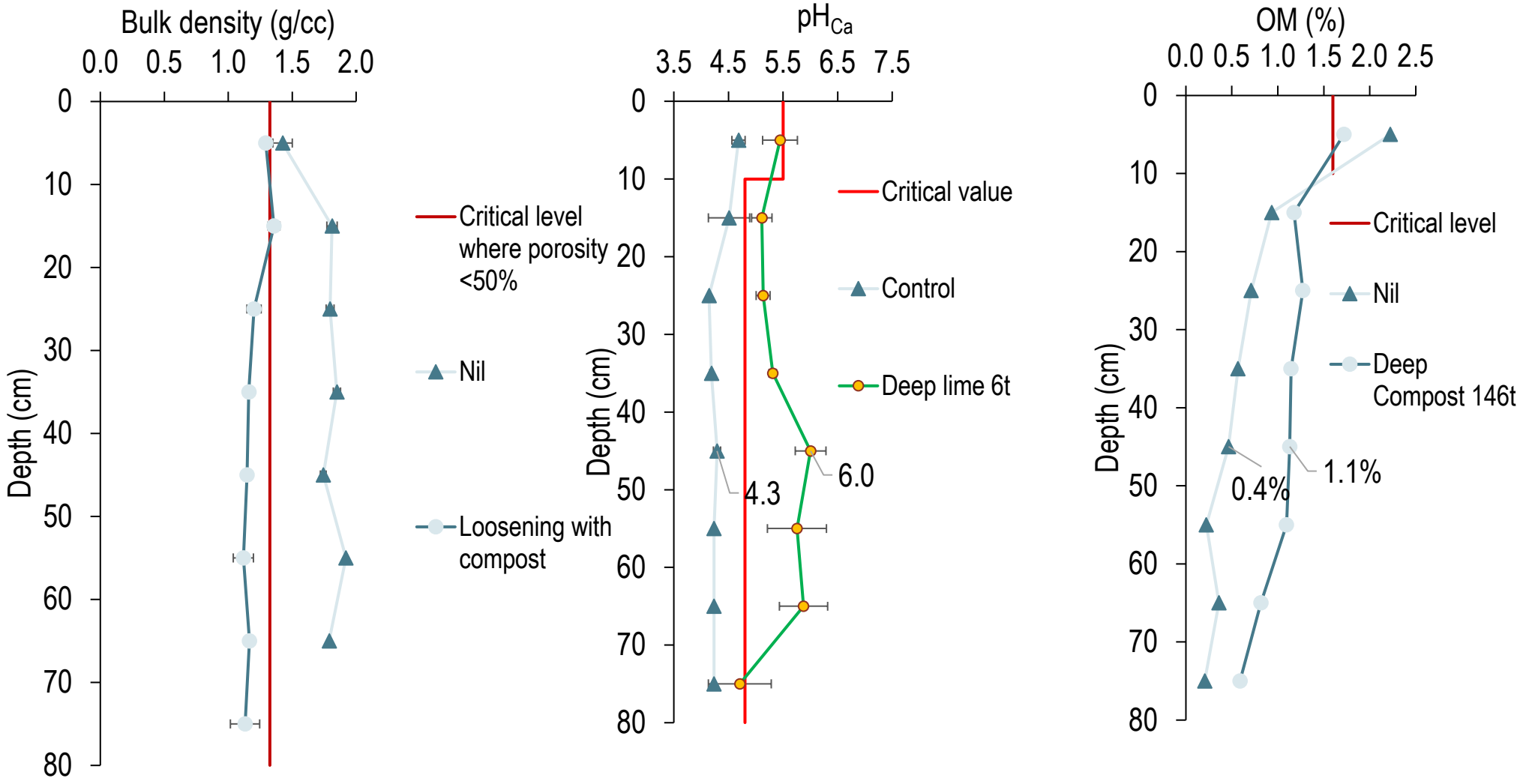
11 x 80 cm deep soil profile reengineering

The set up

Four reengineering pathways in 2021

Reengineering Treatments	
1. Decompaction; deacidification	
2. Decompaction; deacidification; improved soil wettability, water holding capacity, aggregate stability	
3. Decompaction; deacidification; improved soil wettability, water holding capacity, aggregate stability; higher organic matter	
4. Decompaction; deacidification; improved soil wettability, water holding capacity, aggregate stability; matching inorganic nutrients (only 13-16% of what was in compost)	

Soil became unconstrained quickly: An example from Meenar duplex soil



Results for deep sand!

Bolgart deep sand – multiple constraints removed in one pass

Soil constraints

- Prone to wind erosion
- Non-wetting topsoil (MED ~3)
- Subsoil moderately acidic (pH 4.5)
- Compaction (Pen. Res. >3.5 MPa)
- Low water holding capacity (~7%)
- Low fertility (~0.6% OM)

➢ We improved soil water bucket by 30 mm at a point of time

Depth (cm)	Control profile
	Plant available water (mm/100mm)
0-10	7
10-20	7
20-30	7
30-40	7
40-50	7
50-60	7
60-70	7
70-80	7
Total	56

Bolgart Deep sand – poor crop in 2021 (establishment year)

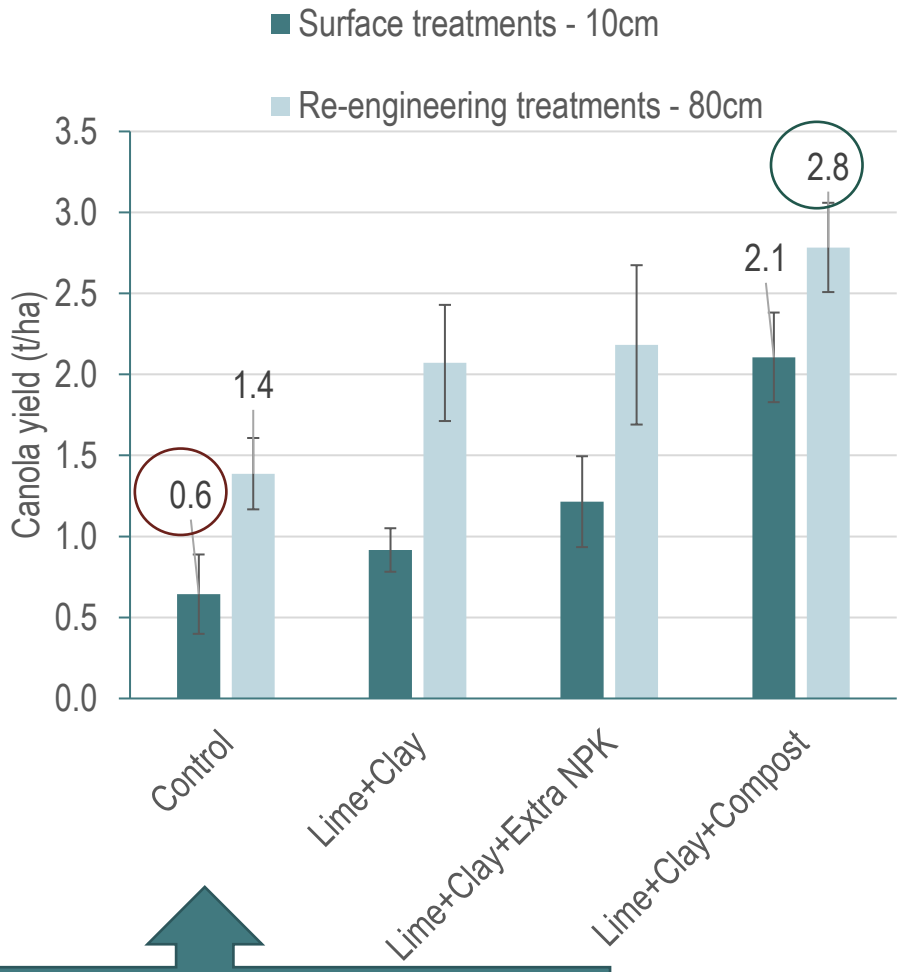
Not attractive in in the first year!

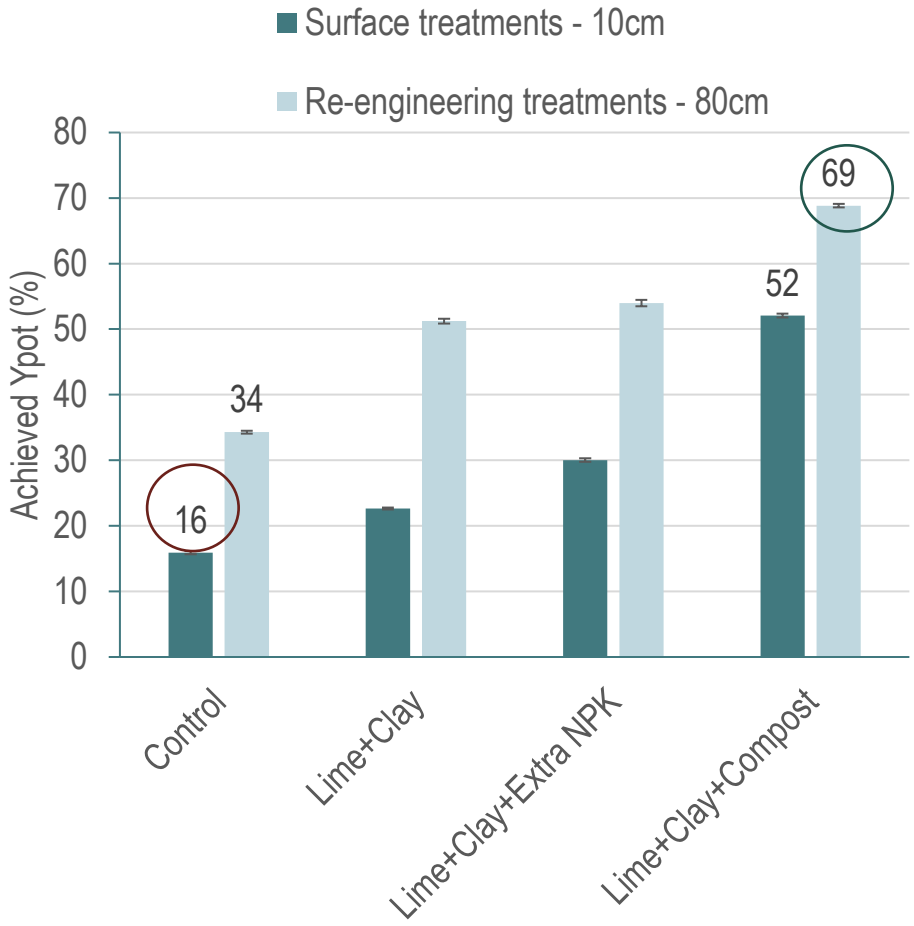
Bolgart deep sand – much better canola establishment and growth in 2022

Bolgart deep sand – much better yield in 2022

4022P RR Canola

Fertiliser
500kg of gypsum
100kg/ha AgflowMn/MoP 70/30
100kg/ha urea
80kg/ha urea
30L/ha FlexiN





Re-engineering control = lime incorporated to 80 cm depth

Results for duplex soil!

Canola plants lived longer and happier in 2021

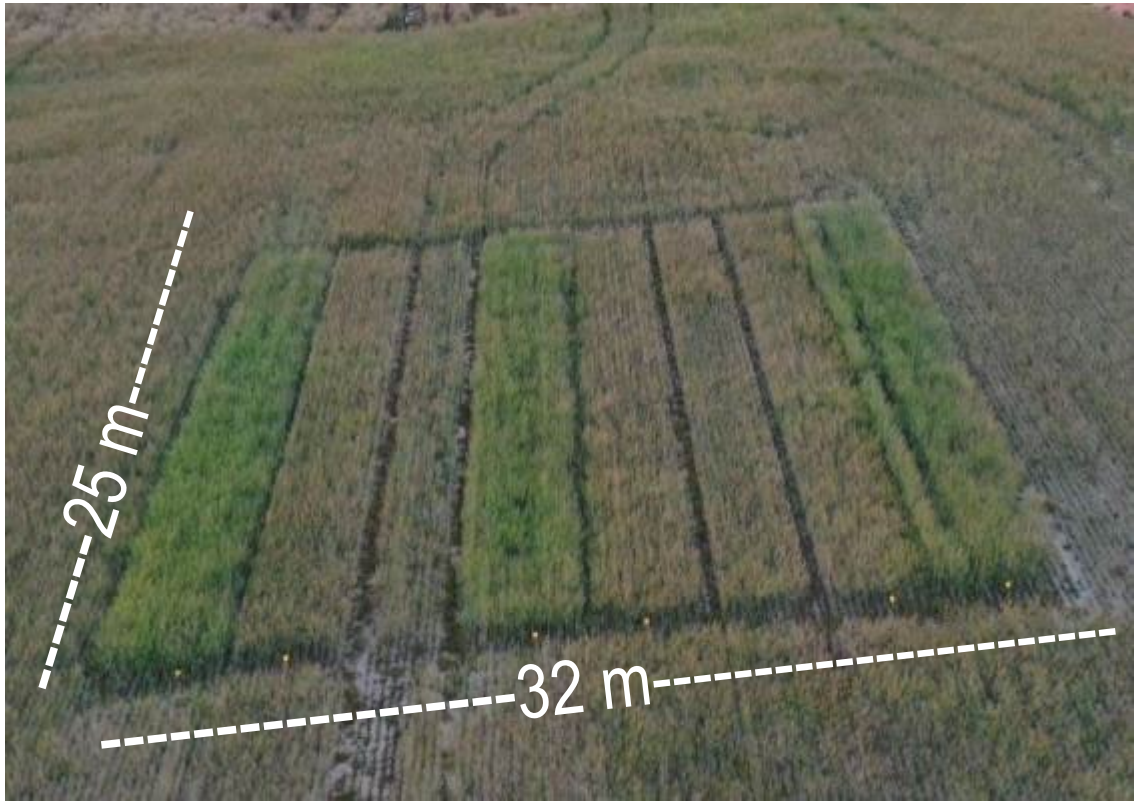
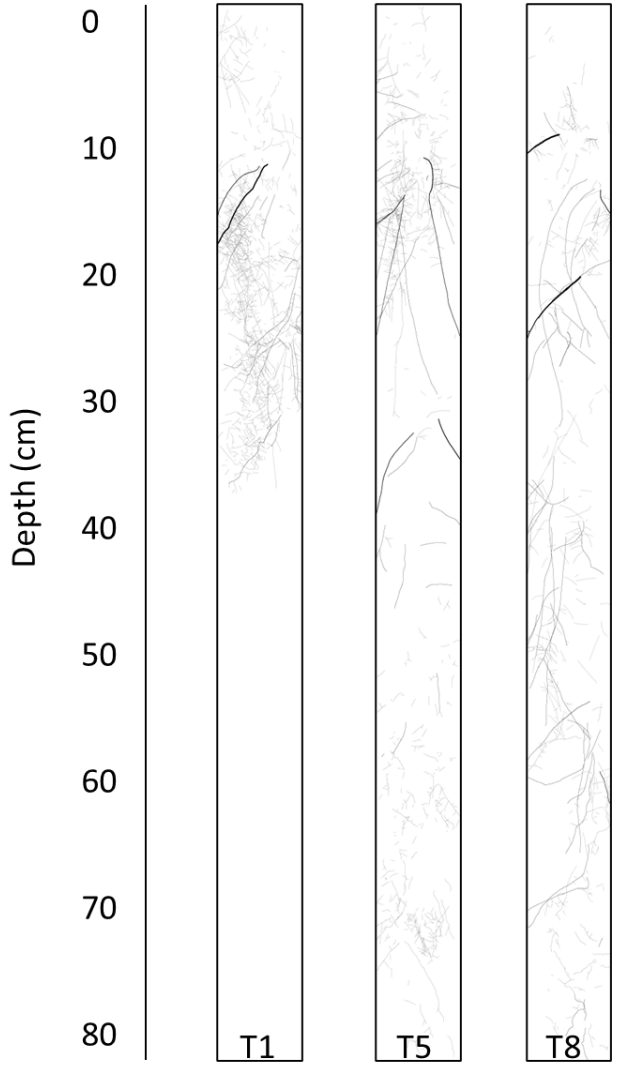
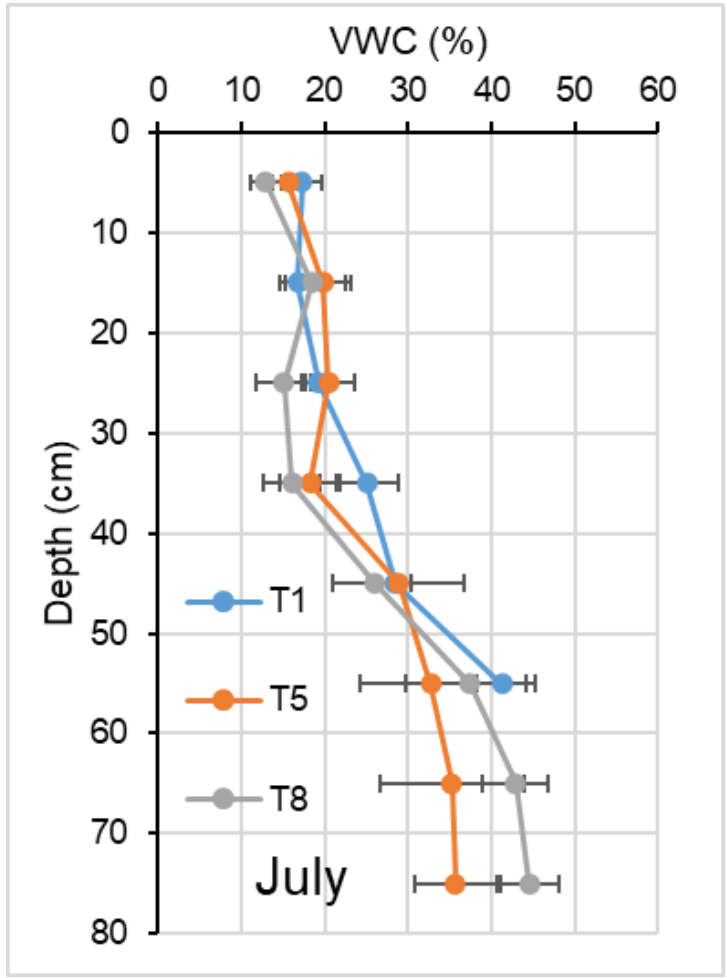


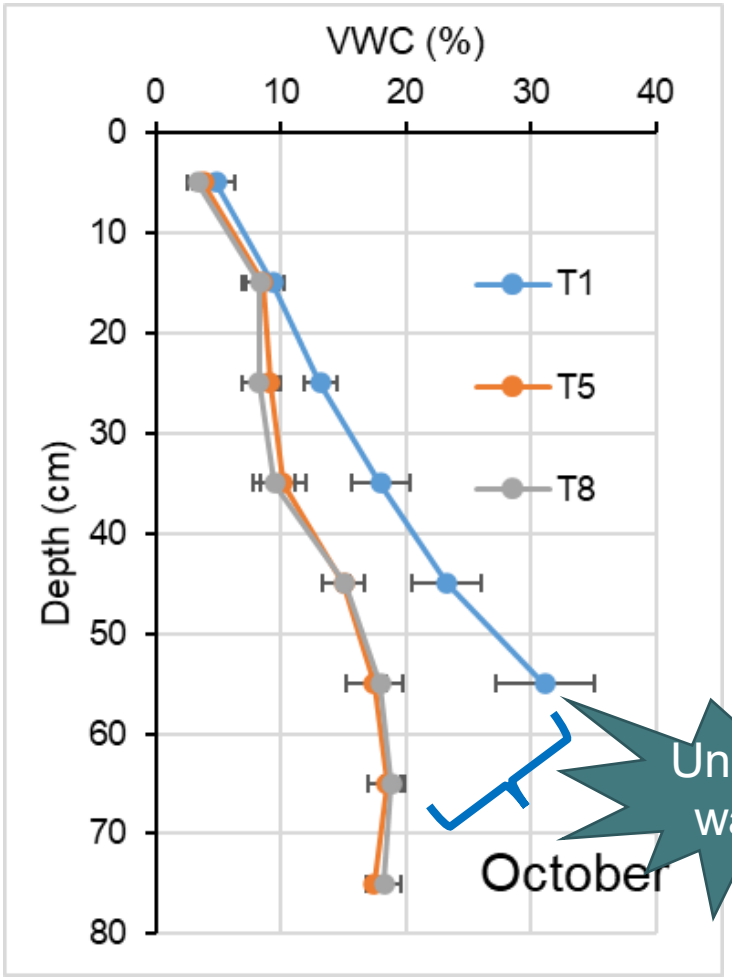
Photo: Ty Fulwood



T1 = Nil
T5 = lime and decompaction
T8 = everything and compost

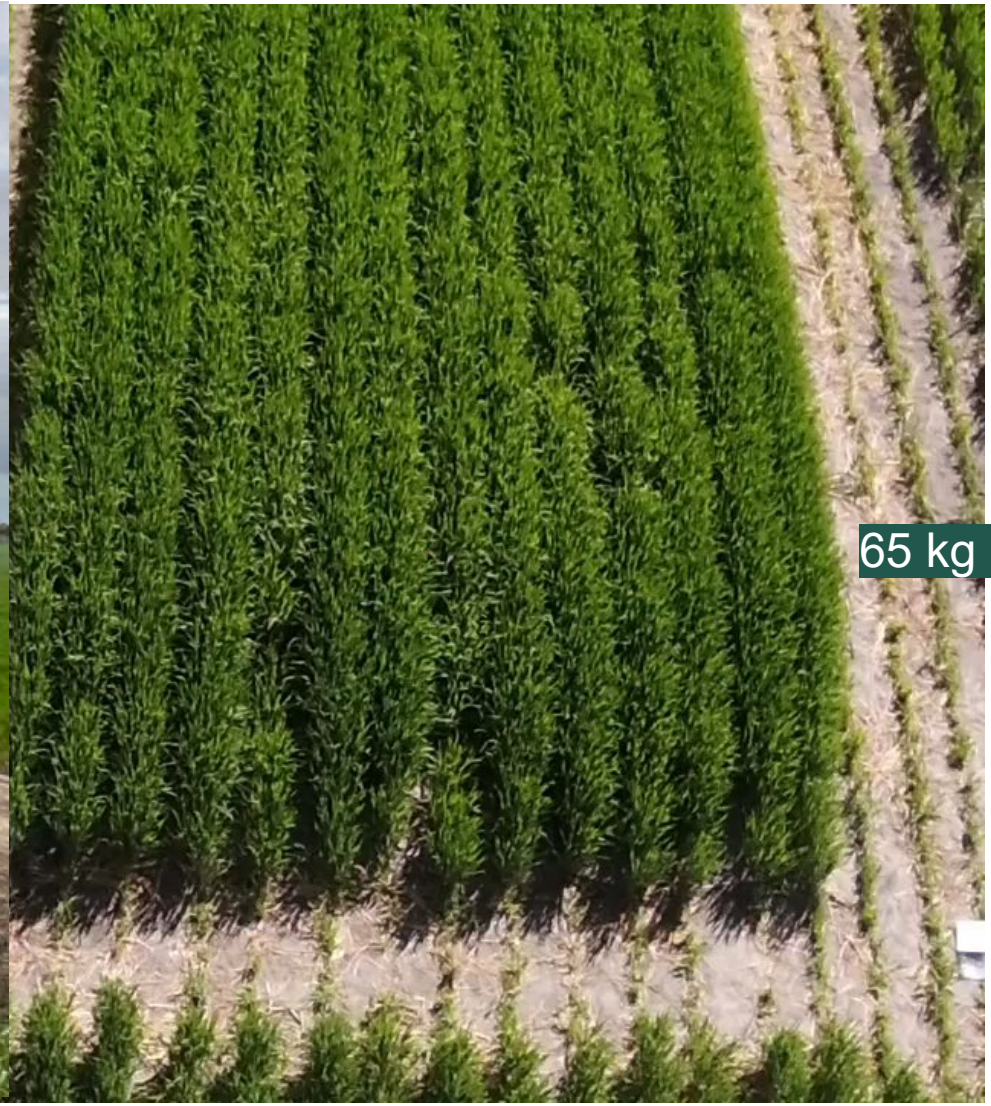
Water uptake by canola plants in 2021



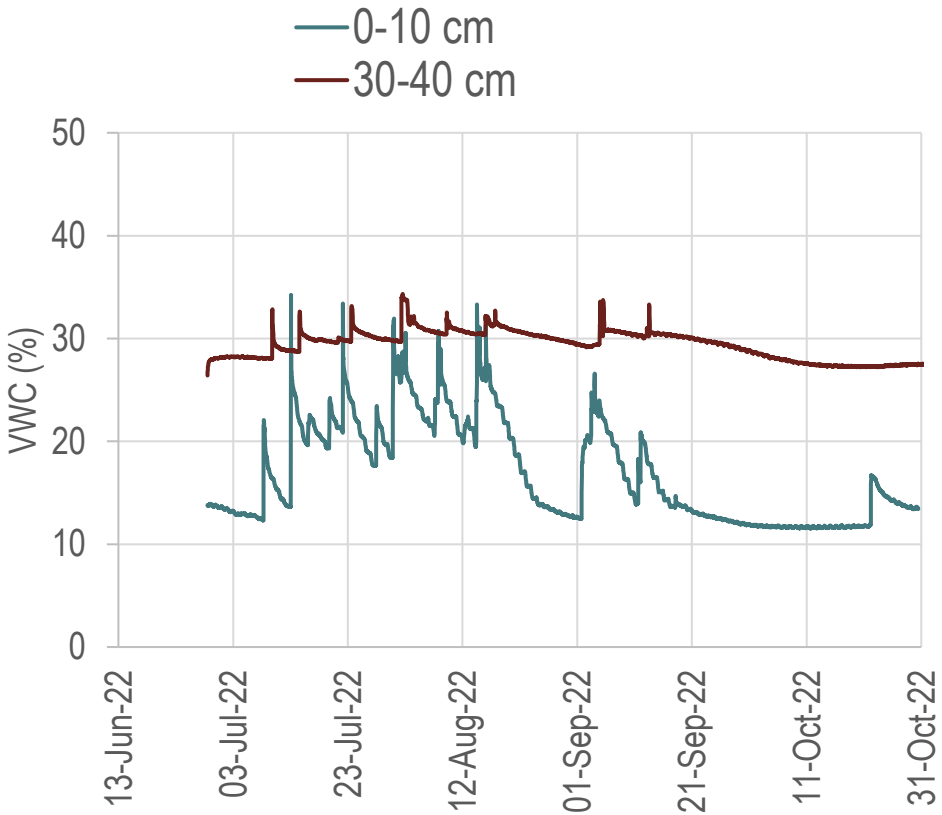


T1 = Nil
T5 = lime and decompaction
T8 = everything and compost

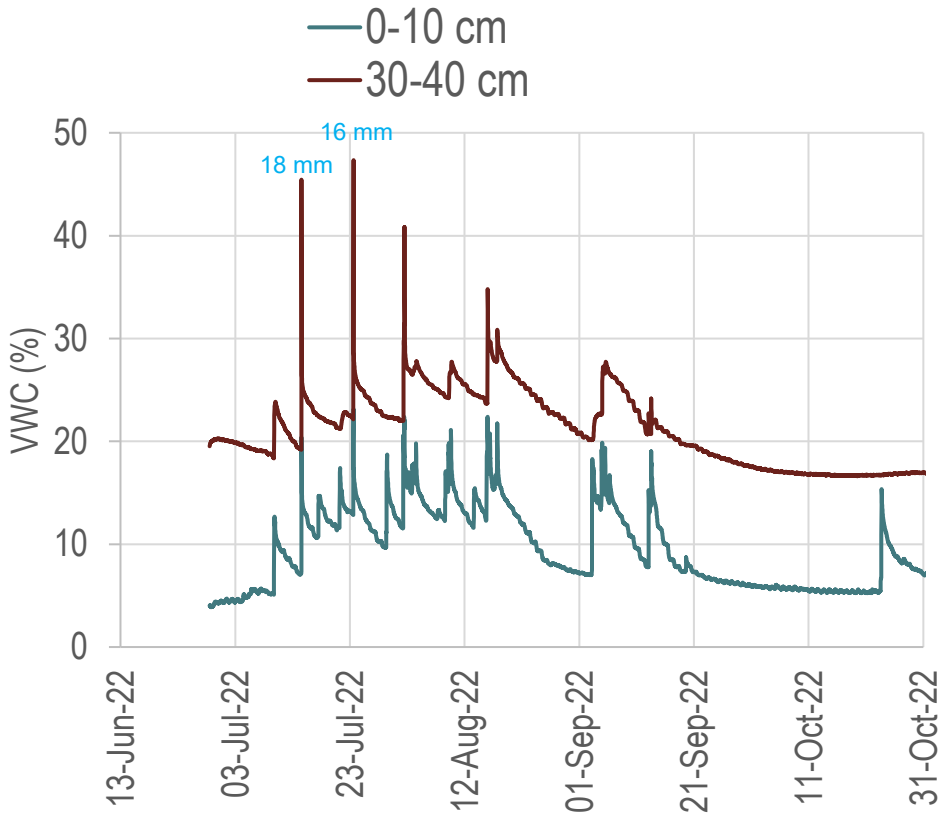
Maximus barley grew to the maximum in 2022



Water uptake by barley plants in 2022



Control plot



Re-engineered plot

Maximus barley grew to the maximum in 2022

Looks like Canadian barley

Lodging of compost treatment plots

125 t/ha compost

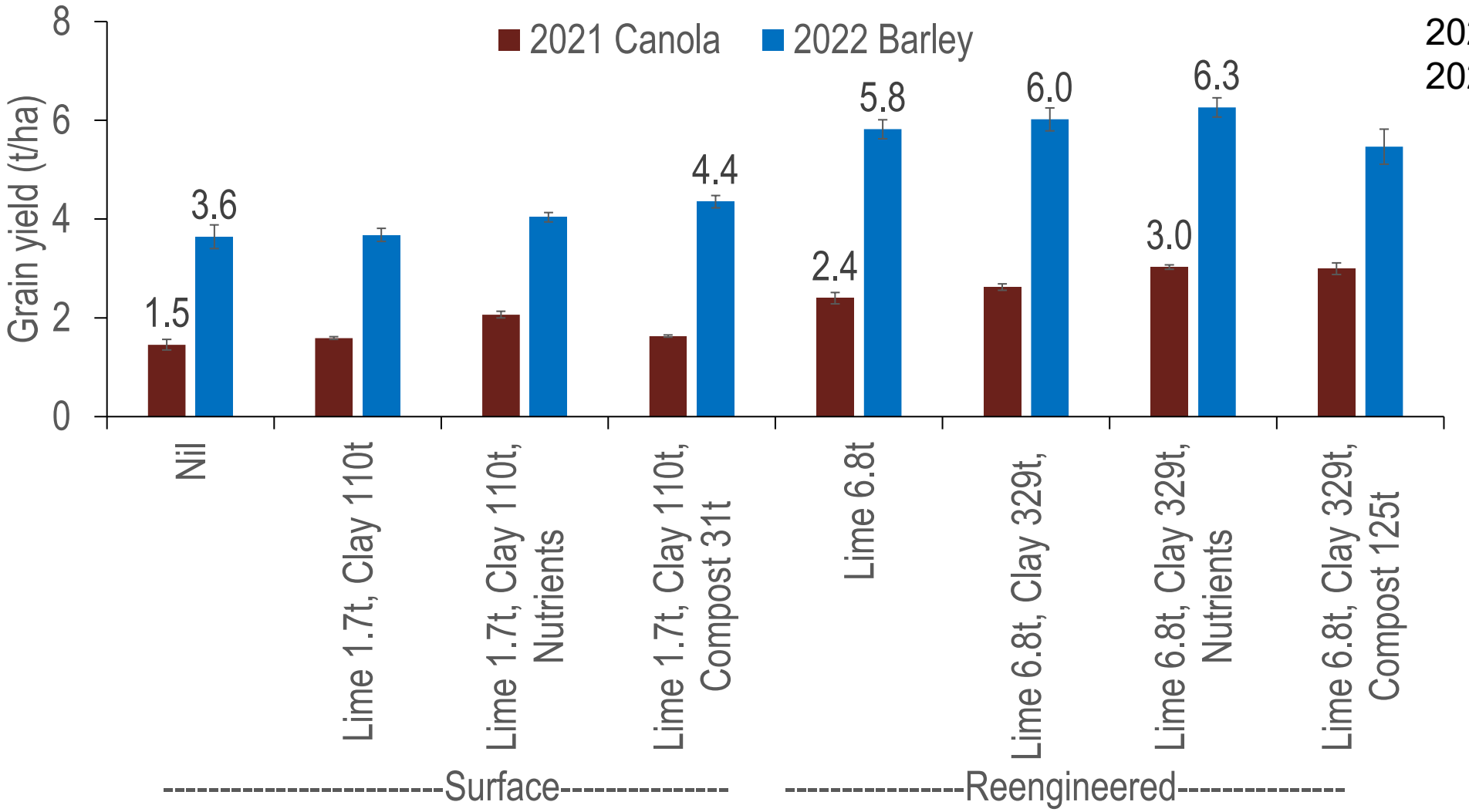
Table: Inorganic N mg/kg (July 2022)

Depth	Control	Lime	Lime + NPK in 2021	Lime + Clay + OM in 2021
0-10	17	20	26	30
10-20	5	10	10	14
20-30	4	4	4	10
30-40	6	3	3	8
40-50	6	3	3	13
50-60	6	2	2	15
60-70	6	2	2	18
70-80	6	3	2	15

70 kg/ha N

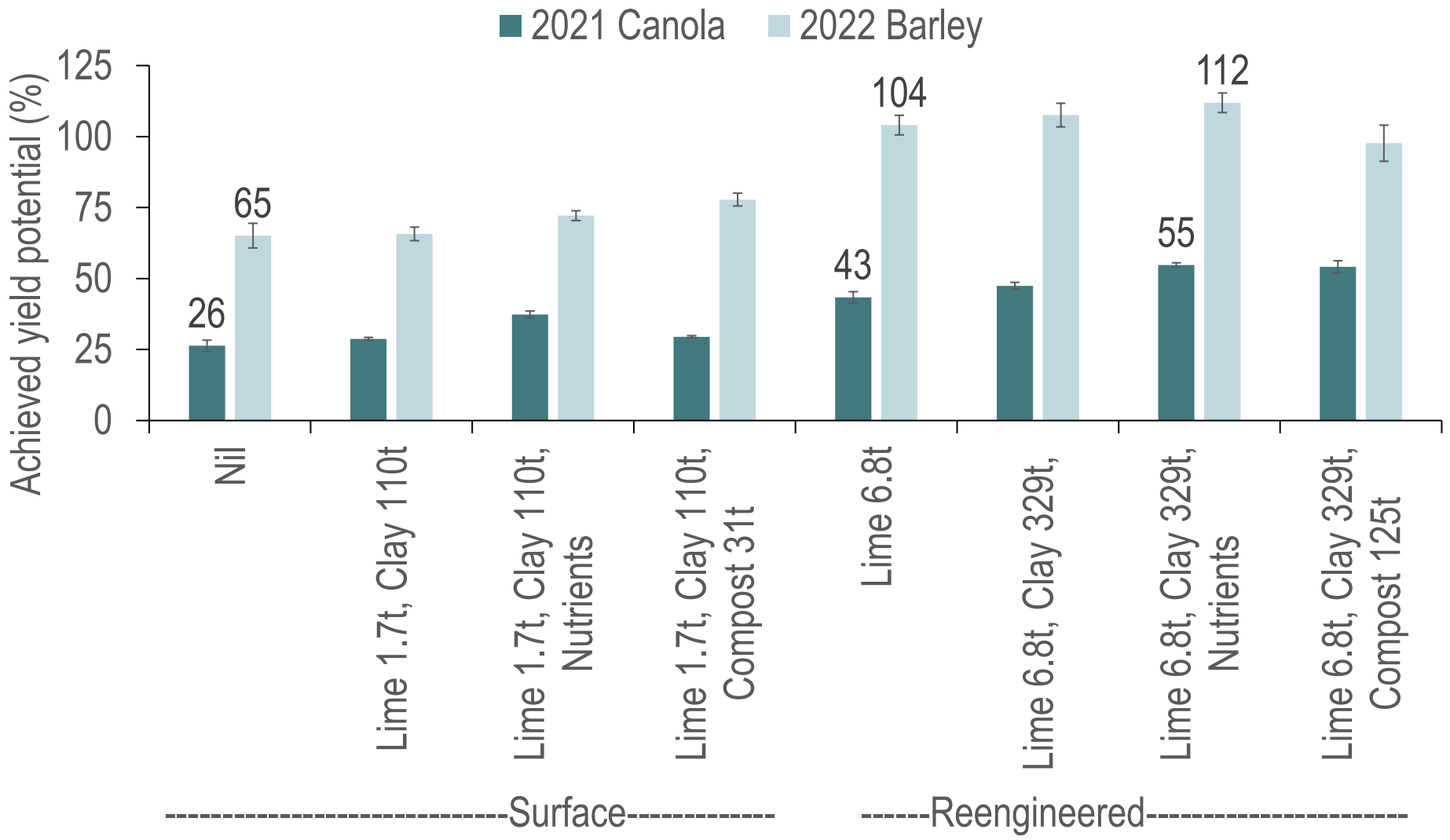
185 kg/ha N

Grain yield at Meenar reengineering trial for last 2 years



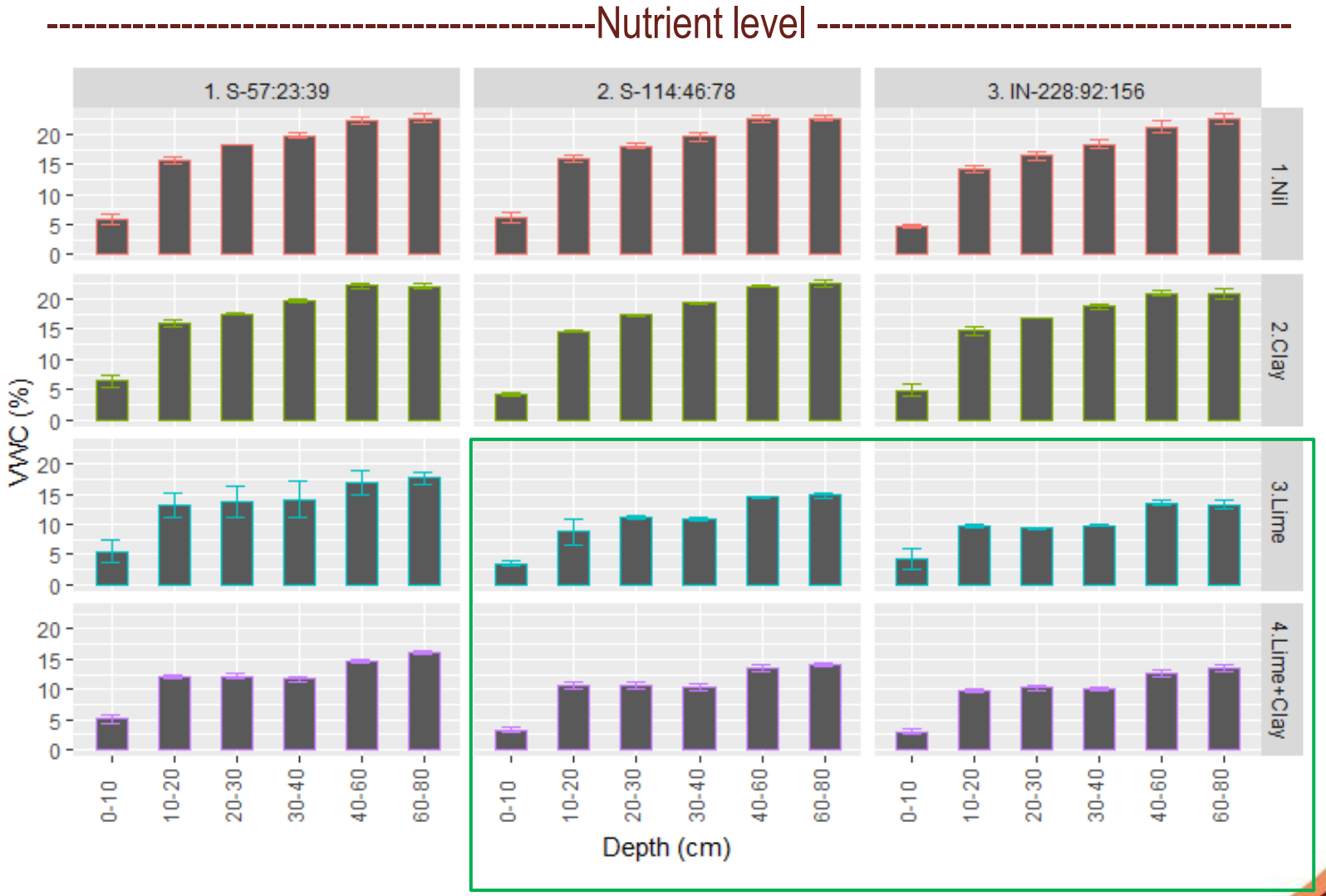
Extra grain:
2021 Canola: 1.5 t/ha
2022 Barley: 2.7 t/ha

Achieved yield potential at Meenar Re-engineering trial for last 2 years



Did we miss out some yield with 65 kg/ha N?

Soil moisture after 8 weeks of seeding

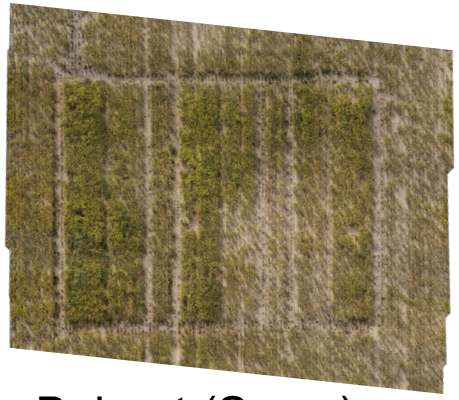


Reengineering heavy soil treatments in 2022

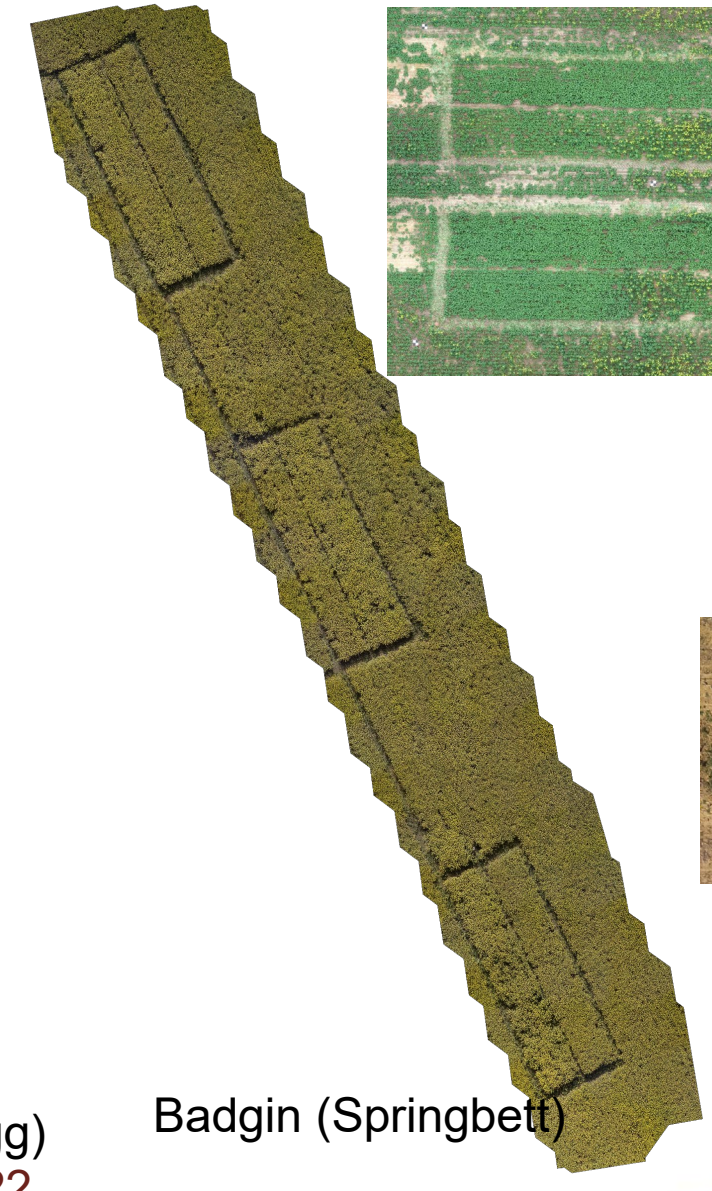
Reengineering Treatments	Description
1. Decompaction	**Loosen**, all soil layers in original position; expected soil resistance 1 MPa (throughout)
2. Decompaction, improving structure, aggregate stability	Loosen & **gypsum** incorporated; all soil layers in original position; expected soil resistance 1 MPa (throughout)
3. Decompaction, improving structure, aggregate stability, enriching OM	Loosen, gypsum and **compost** incorporated; all soil layers in original position; expected soil resistance 1 MPa (throughout); increasing OM by around 0.50% (throughout)
4. Decompaction, improving structure, aggregate stability, enriching OM	Loosen, gypsum and **biochar** incorporated; all soil layers in original position; expected soil resistance 1 MPa (throughout); increasing OM by around 0.50% (throughout)
5. Decompaction, improving structure, aggregate stability, enriching OM	Loosen, gypsum and **chaff-cuts** incorporated; all soil layers in original position; expected soil resistance 1 MPa (throughout); increasing OM by around 0.50% (throughout)
6. Decompaction, improving structure, aggregate stability, enriching OM	Loosen, gypsum and **inorganic nutrients** incorporated; all soil layers in original position; expected soil resistance 1 MPa (throughout); increasing NPK (13% of what is in compost)
7. Decompaction, improving structure, aggregate stability, decrease pH (&B), decrease wilting point	Loosen, gypsum and **Wodjil sand** incorporated; all soil layers in original position; expected soil resistance 1 MPa (throughout); decrease pH in subsoil by 1 unit

Season 2022 for other re-engineering experiments

Meenar (Fulwood)



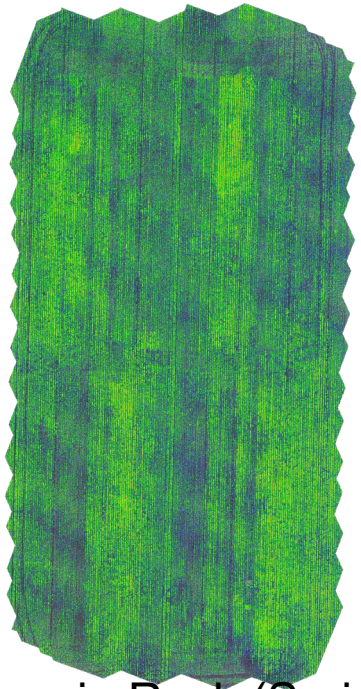
Bolgart (Syme)



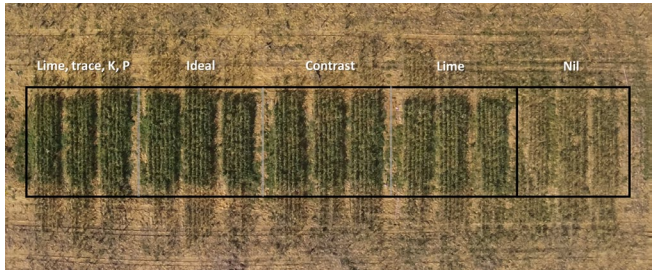
Badgin (Springbett)

Tarin Rock (Pearce)

Holt Rock (Smudge)



Bonnie Rock (Sprigg)



Northampton (KLK)

Take home message

- Reengineering can make a soil an ‘ideal soil’ by changing wettability, pH, compaction, water capacity, infiltration etc almost immediately.
- Soil Reengineering increased grained yield by 2-4 times. Grain yield increased by up to 2.7 t/ha.
- Soil Re-engineering exceeded estimated water-limited yield potential depending on season, level of amelioration, type of soil and crop. Therefore, after soil re-engineering, water-limited yield potential needs to be redefined.

Thanks for your support……


Brad Wilson


Sam Guest


Bob Nixon

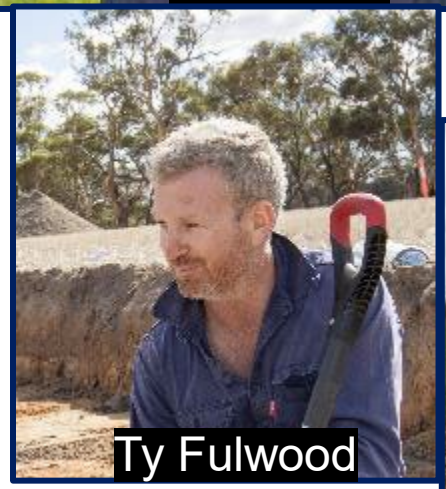

Josh Goad


Hayden Sprigg


Cam Mudge


Mark Pearce


Trevor Syme


Ty Fulwood


Scott Bowman


Tim Springbett


Stuart Witham

Thanks for working smart and hard

Thank you

dpird.wa.gov.au

Important disclaimer

The Chief Executive Officer of the Department of Primary Industries and Regional Development and the State of Western Australia accept no liability whatsoever by reason of negligence or otherwise arising from the use or release of this information or any part of it.