Magnitude and longevity of yield response to deep tillage on sandy soils of southern Australia.

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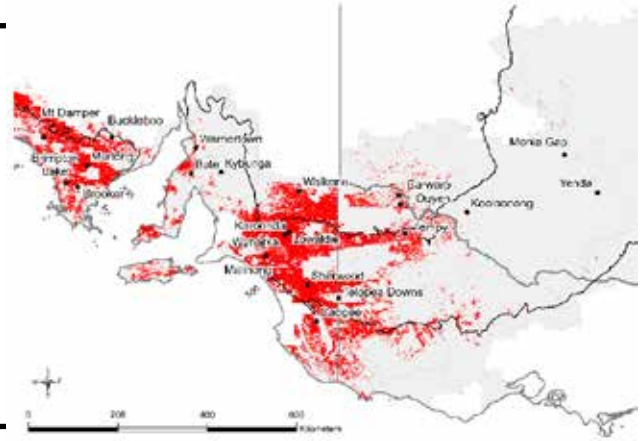
Southern cropping region of south-eastern Australia

More than five million ha of cropping land classified as a deep sand.

Farming in this area is challenging due to:

- Low to medium rainfall (250-450 mm annual)
- Seasonal drought
- Dune-swale systems
- Variable soils which change over short distances



The Sandys soil 1 project:

Increase crop productivity by improving the diagnosis and management of constraints.

Optimism for sandy soils

There's growing optimism around techniques that reshape the soil profile.

"The sand was always deemed the worse soil on the farm, and then all of a sudden, it became better than the red ground in some ways. There is an element of excitement in trying to fix these soils and then manage them."

(Participant from impact and adoption survey)

Survey of growers and consultants:

- 25% of respondents had used deep ripping in the past five years.
- 56% plan to adopt it in the next five.

Project framework

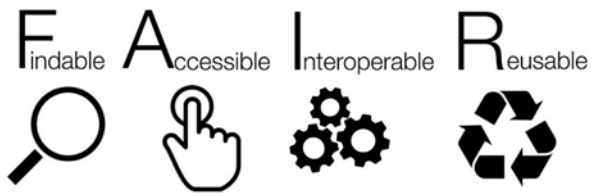
1. Know your constraint

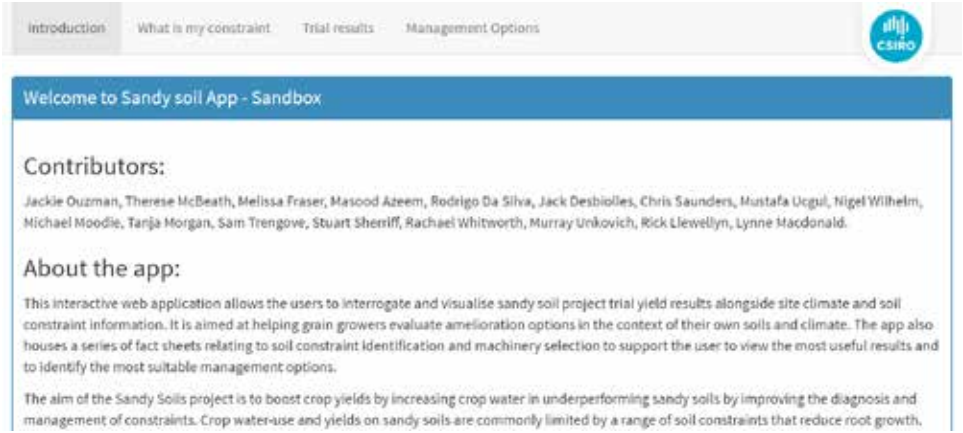
2. Implement the treatment with the tool that ameliorates the constraint

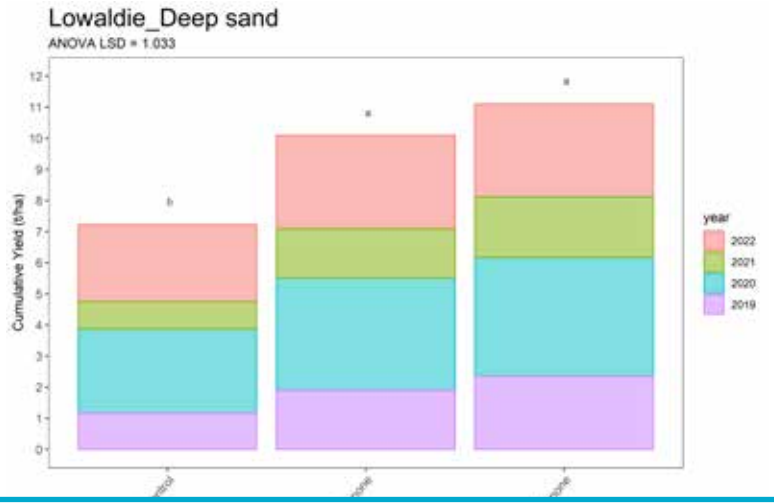
3. Post-amelioration management

Sharing data and project outputs

Sharing project data is now expected practice.

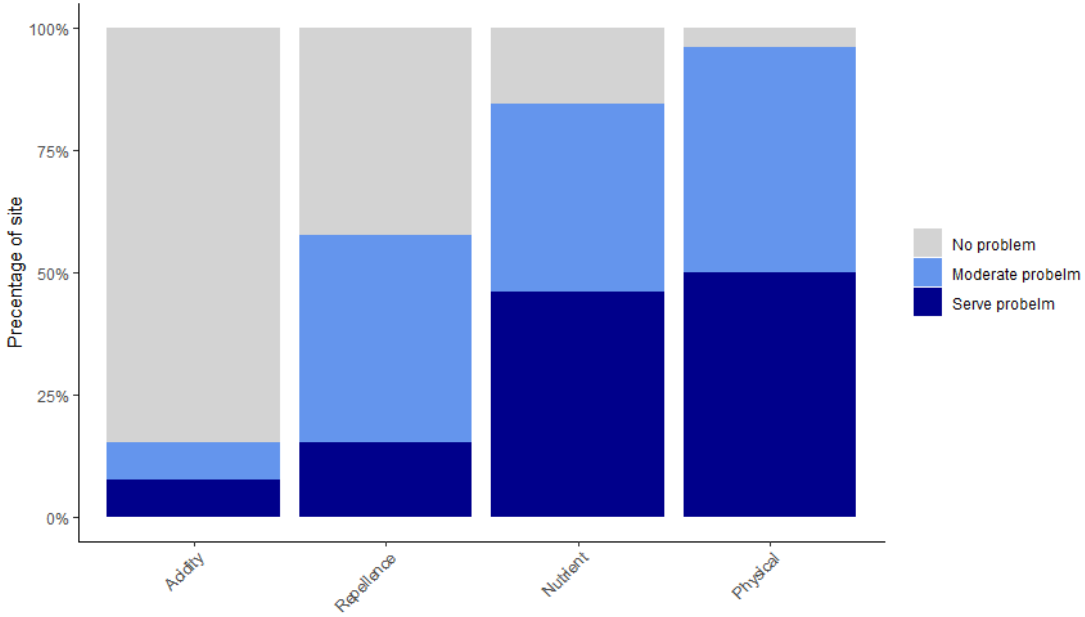






App https://shiny.csiro.au/soil-sandbox/ **Data Access Portal** https://data.csiro.au/

Soil constraints



Physical constraint (assessed as high soil strength) was the most common constraint.

Acidity was less common with only 15% of sites rating this as moderate or severe.

Many sites had multiple soil constraints.

Percentage of trial sites with multiple constraints - ranked as moderate or severe		
2 Constraints	3 Constraints	4 Constraints
42%	50%	4%

Tillage Options

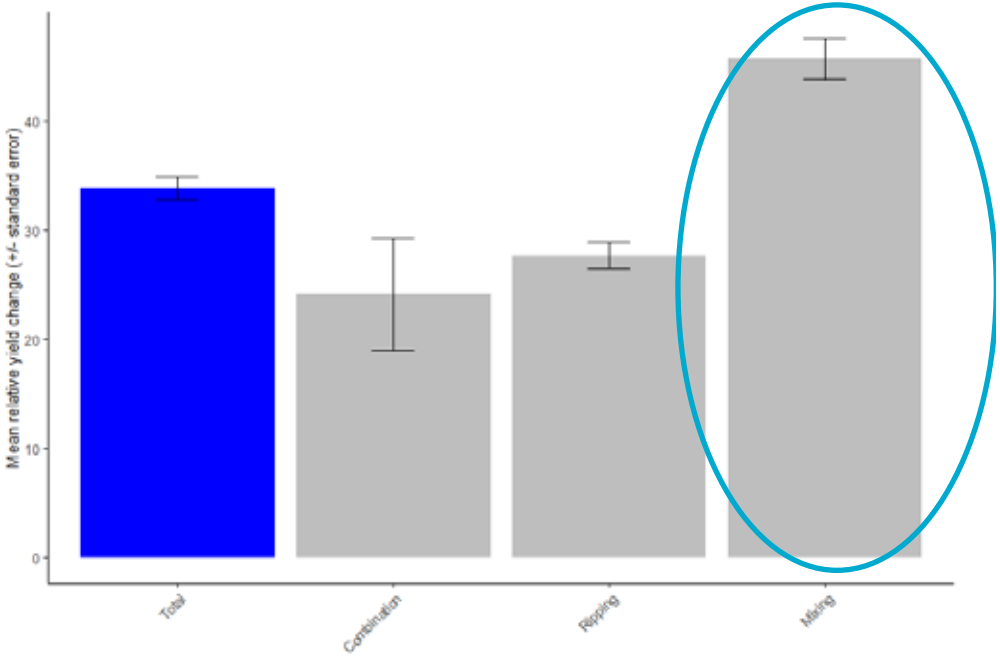
Experiments at 26 sites and included 98 different treatments.

		Without amendments	With amendments
Mixing	35%	8%	27%
Ripping	61%	29%	32%
Combination	4%	3%	1%

Constraint	Seeder Strategies		Amelioration Options			
	Furrow inputs	Paddock practices and Seeder upgrades	Amendments	Strategic deep tillage options		
				Ripping	Mixing	Inversion
Water repellence	✓	✓	Clay	×/✓	✓	✓
Acidity	×	×	Lime Alkaline clay	With inclusion plates (IP)	✓	✓
Compaction and hard setting	×	×	Gypsum Organic amendment	✓	✓	✓
Low nutrient fertility	×	✓	Fertiliser package Organic amendment Clay	IP	✓	×

Aligned with equipment available and the best tool to ameliorate the constraints.
Variation existed; in equipment used, tillage depth, and amendment type.

Relative yield change



Site	Total	Mean	SD	Mean	MRAW	95%-CI	Weight
Waikerie	112	-2.53	45.9783		-2.53	[-11.04; 5.99]	4.0%
Malinong	18	0.81	15.7884		0.81	[-6.49; 8.10]	4.0%
Sherwood	24	5.19	36.0338		5.19	[-9.22; 19.61]	3.8%
Wynarka	48	8.22	11.4249		8.22	[4.99; 11.45]	4.1%
Buckleboo	36	8.98	16.3575		8.98	[3.64; 14.33]	4.1%
Bute boundary	144	9.57	13.4045		9.57	[7.38; 11.76]	4.1%
Monia Gap	30	10.37	18.9387		10.37	[3.59; 17.15]	4.1%
Yenda	128	15.22	28.6273		15.22	[10.26; 20.18]	4.1%
Ouyen ripping	240	16.04	27.1454		16.04	[12.61; 19.47]	4.1%
Warnertown	24	16.07	19.9623		16.07	[8.08; 24.05]	4.0%
Carwarp	200	20.65	44.9714		20.65	[14.42; 26.89]	4.1%
Kybunga	48	21.22	15.0231		21.22	[16.97; 25.47]	4.1%
Karoonda	125	33.42	54.1005		33.42	[23.94; 42.91]	4.0%
Tempy	32	36.09	24.2717		36.09	[27.68; 44.50]	4.0%
Telopea Downs	4	38.57	55.8482		38.57	[-16.16; 93.30]	1.9%
Ouyen spading	159	39.62	33.7191		39.62	[34.38; 44.86]	4.1%
Kooloonong	8	40.91	38.5188		40.91	[14.22; 67.60]	3.3%
Lowaldie	30	51.61	40.5502		51.61	[37.10; 66.12]	3.8%
Brimpton Lake	124	55.47	48.6122		55.47	[46.91; 64.03]	4.0%
Cadgee	116	57.68	56.7364		57.68	[47.35; 68.00]	4.0%
Lowaldie deep sand	30	57.78	47.9249		57.78	[40.63; 74.93]	3.7%
Bute	144	67.54	47.8690		67.54	[59.72; 75.36]	4.0%
Younghusband	86	67.60	39.8448		67.60	[59.18; 76.02]	4.0%
Mt Damper	21	76.61	50.8701		76.61	[54.85; 98.37]	3.5%
Murlong	110	76.94	46.0829		76.94	[68.33; 85.56]	4.0%
Brooker	13	102.91	57.3028		102.91	[71.76; 134.06]	3.0%
Random effects model	**2054**				**34.72**	**[23.57; 45.87]**	**100.0%**
Prediction interval						**[-20.83; 90.28]**	

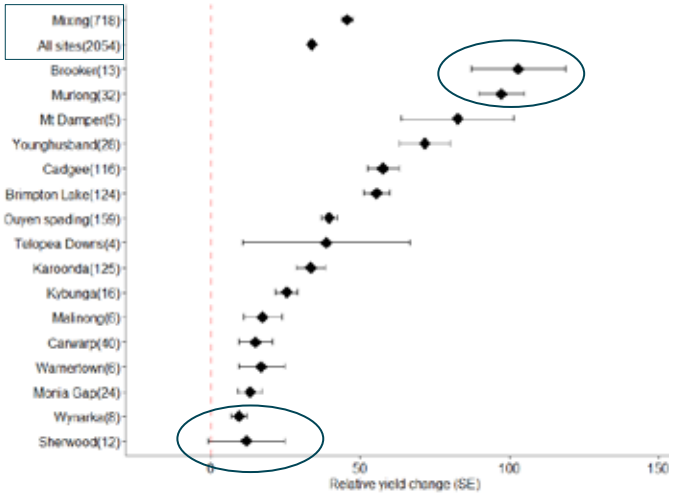
Heterogeneity: $I^2 = 97.4\%$, $p < 0.0001$

-20 0 20 40 60 80 100 120

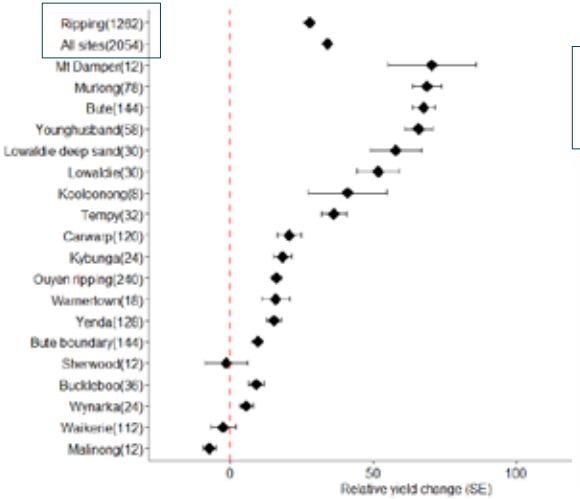
Relative Yield Change=((Treatment Yield−Control Yield) / Control yield) × 100%

Variation of yield response

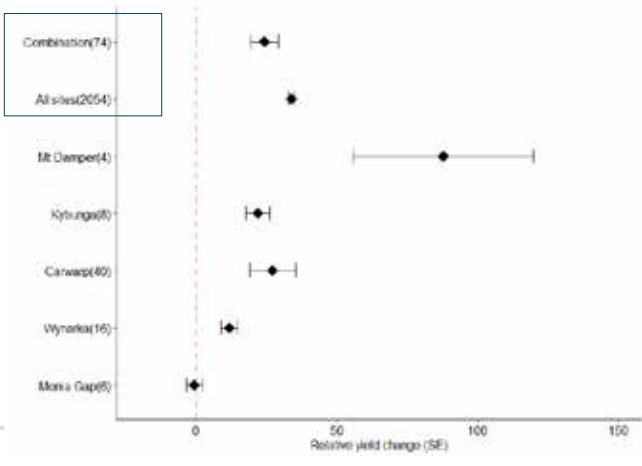
Mixing



Ripping



Combination



Understanding this variability will help us better understand the drivers of the yield response.

Sources of variation

Within paddock soil variation

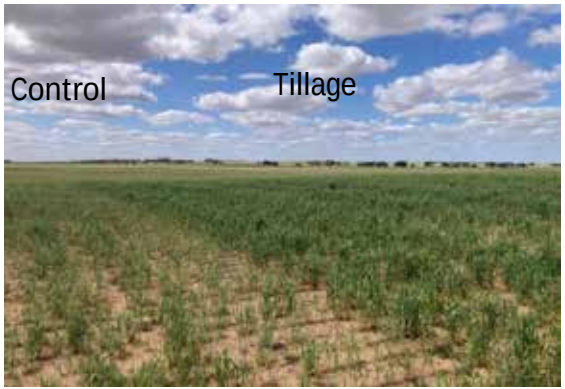
- Type of soil constraint
- Number of soil constraint
- Severity of constraint
- Depth of sand
- Soil variability

Implementation of tillage

- Depth of tillage
- Age of machine
- Soil condition at time of tillage
- Speed of tillage
- Overall effectiveness of tillage method

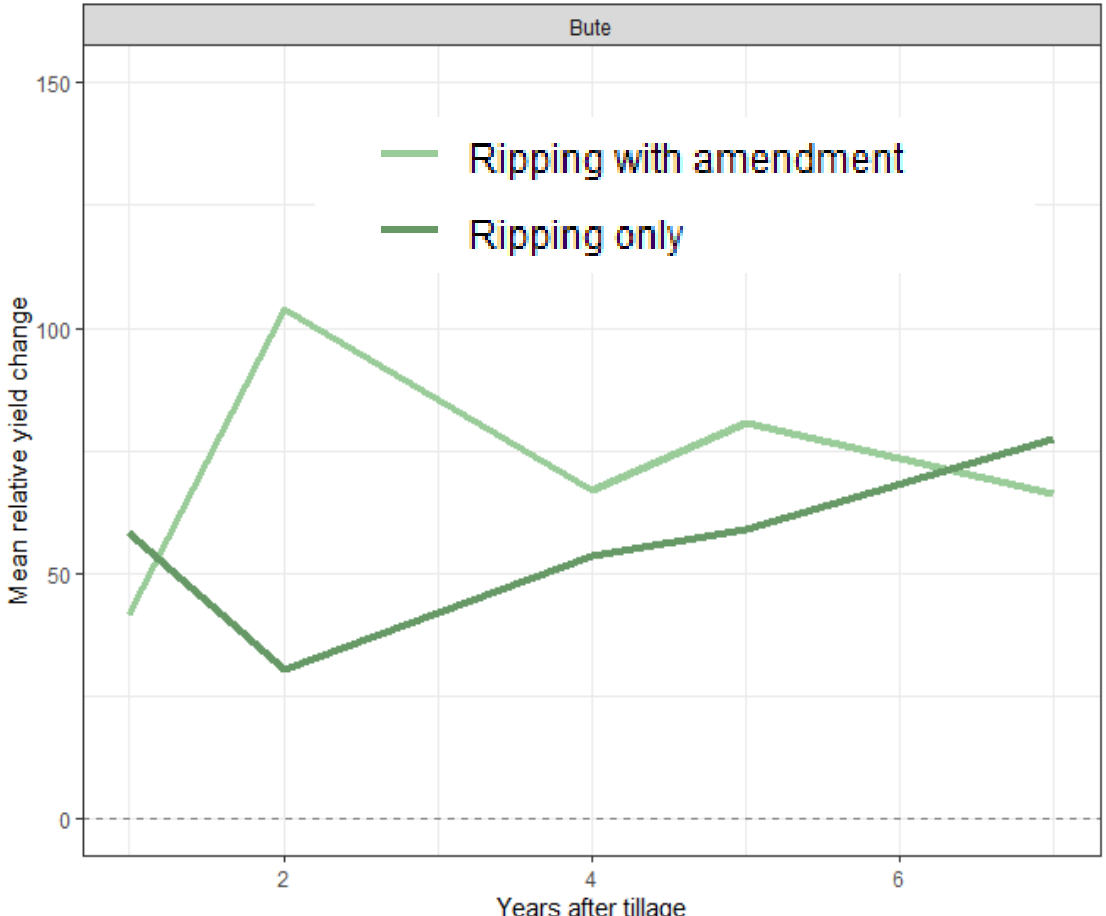
Other variation

- Climate and season
- Crop type
- Amendment type and amount applied
- Nutrient management



Lowaldie site. Image Bill Davoren.

Relative yield change over time



Longevity at Bute

Soil constraints at Bute:

Physical	= Severe issue
Nutrient	= Severe issue
Repellency	= Moderate issue
Acidity	= No issue

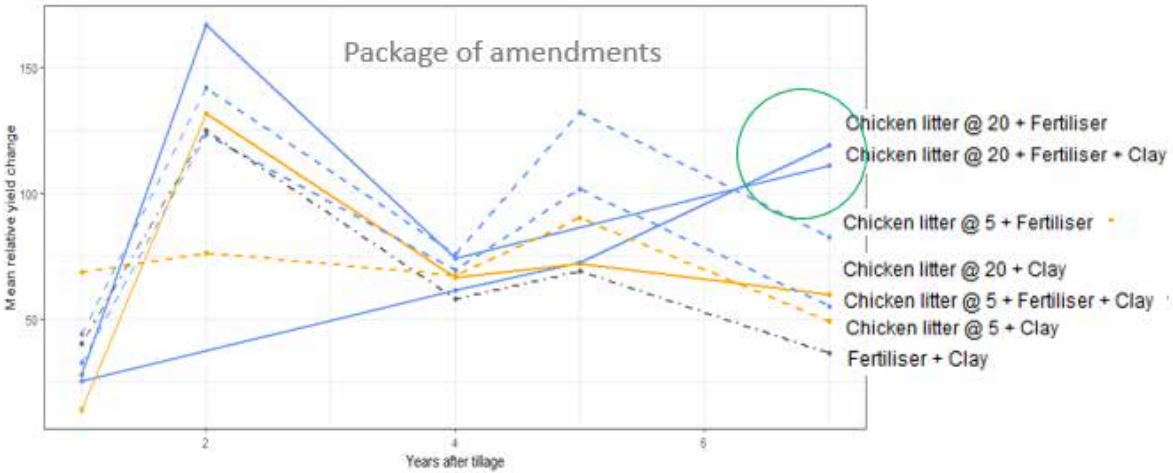
Tillage method ripping to 50 cm:

No amendments

Amendments

- Chicken litter at 5 and 20 t/ha applied at tillage
- Clay 100 t/ha applied at tillage
- Fertiliser amendments applied annually at surface

- Other treatments were a package and included mix of amendments applied at tillage and annually



Longevity at Karoonda

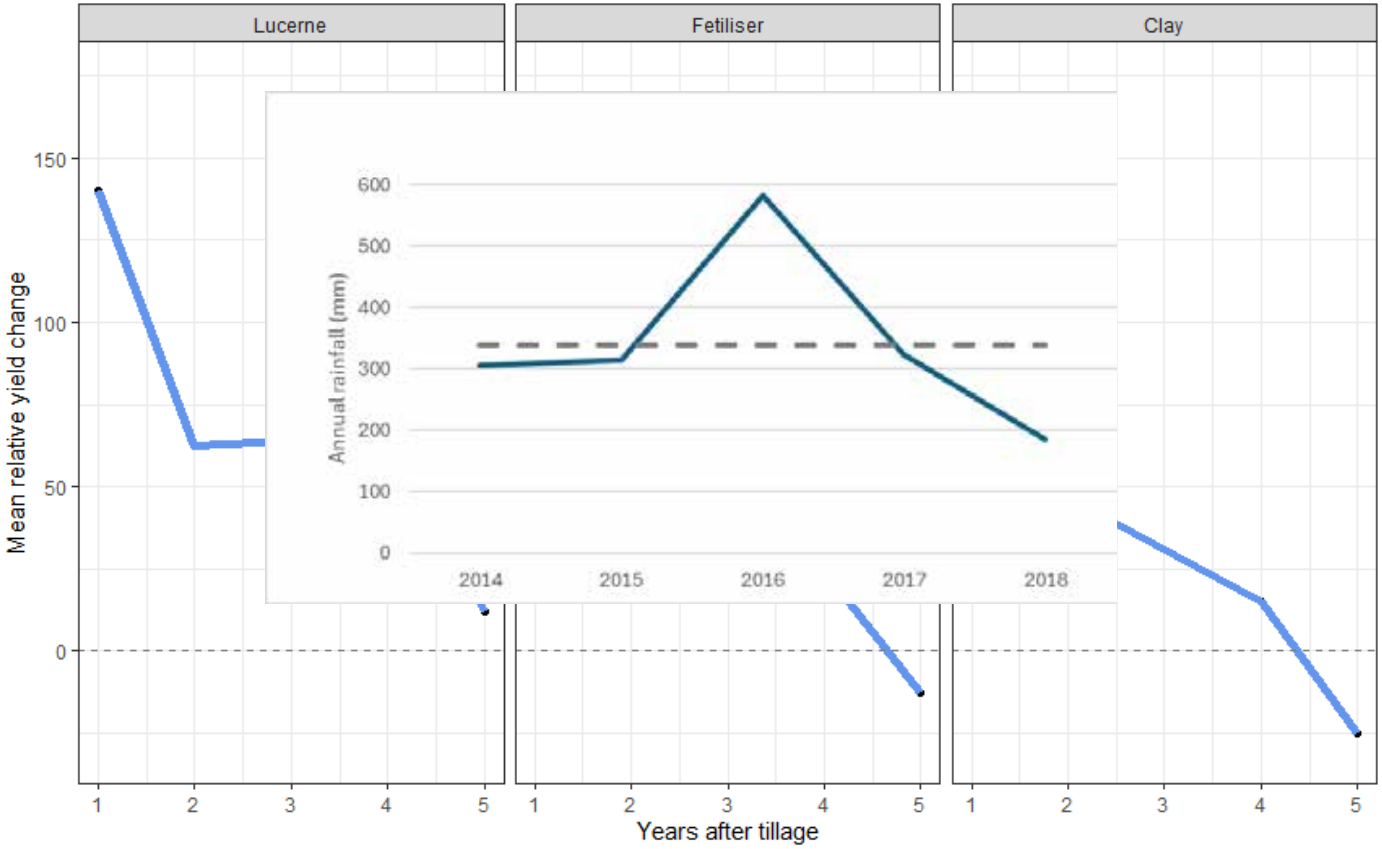
Soil constraints at Karoonda:

Physical	= Severe issue
Nutrient	= Moderate issue
Repellency	= Moderate issue
Acidity	= No issue

Tillage method spading to 30 cm:

- **No amendments**
- **Clay** 450 t/ha
- **Fertiliser** NuPk
- **Lucerne** 10 t/ha

- Other treatments were a package and included mix of amendments



Conclusions

- Yield response to tillage treatments was positive, with a relative yield gain greater than 30% above the control, although variability was high.
- Longevity of tillage response is variable, and amendment choice has a role to play.
- Understanding longevity is linked to profit outcomes
- We are exploring a range of techniques in our new project to more closely examine longevity of response.

Thank you

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https://shiny.csiro.au/soil-sandbox/

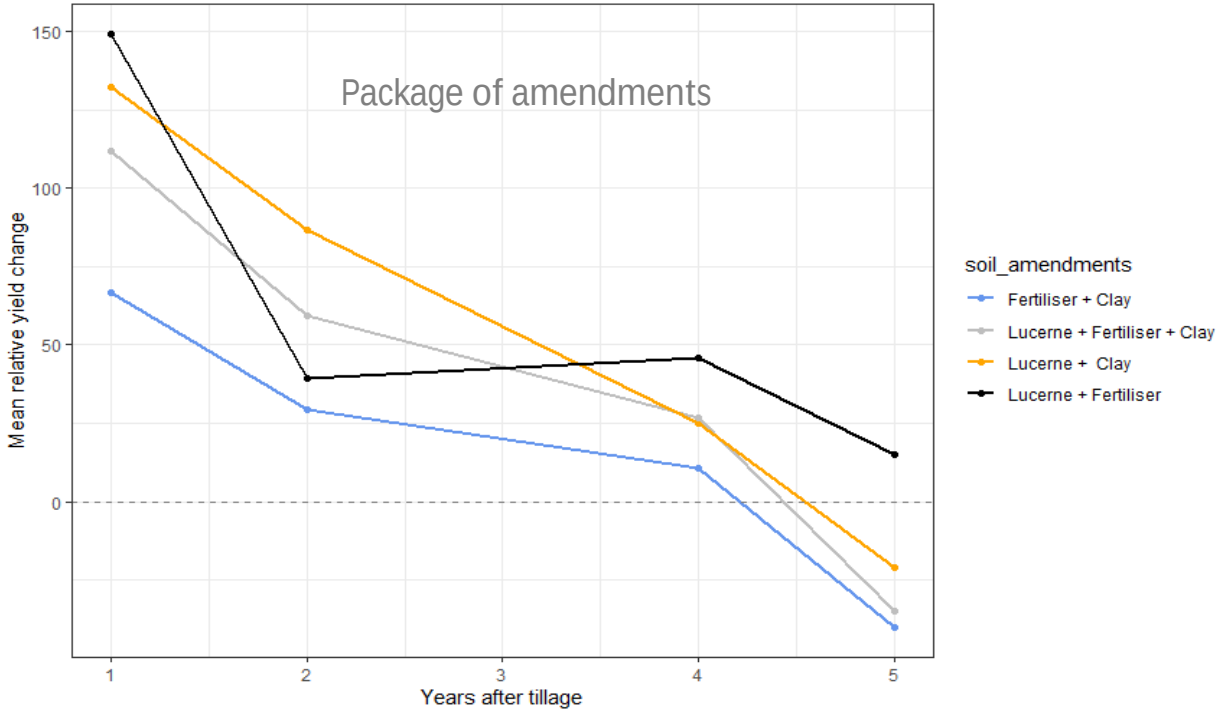
Fact sheets for soil constraints

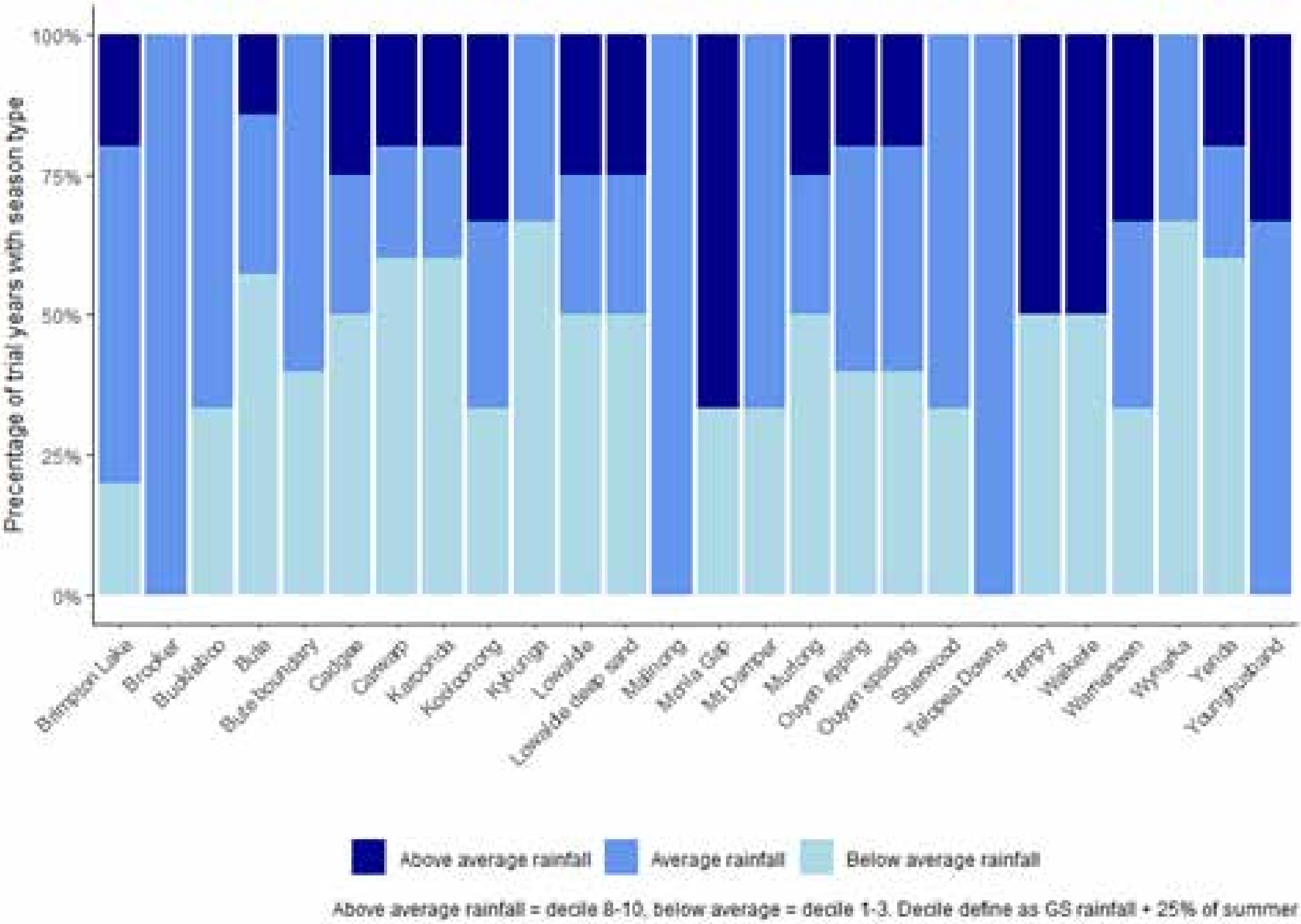
https://grdc.com.au/resources-and-publications/all-publications/factsheets/2022/physical-soil-constraints-fact-sheet

Table 1. Definitions of various soil amelioration techniques used in sandy soils

Amelioration technique	Mechanism
Liming	Application of lime (calcium carbonate) to increase soil pH by displacing hydrogen and aluminium ions from the cation exchange complex. Often achieved via surface spreading.
Gypsum	Application of gypsum (calcium sulphate) to increase structural stability of sodic soils displacing sodium cations from the cation exchange complex. Often achieved via surface spreading.
Deep Tillage	**Mechanical disruption of soil horizons below the seedbed, commonly > 40 cm, where the aim is to disturb compacted layers with minimal soil mixing.**
Delving	Like deep ripping, but with tines designed to introduce subsoil clay to the surface layers to improve water and nutrient retention.
Spading	**Tillage practice that mixes and inverts topsoil layers, often implemented to burry non-wetting surface horizons.**
Inclusion	A deep ripping practice with inclusion plate trailing each tine, allowing for surface horizons to 'drop' into the subsoil in the same pass.
Multi-tool	A hybrid machine which aims to achieve a level of deep ripping and spading within the same machinery pass.
Clay spreading	The processing of surface spreading mined clay to increase water and nutrient holding capacity.

Longevity at Karoonda




Precentage of trial years with season type
100%
75%
50%
25%
0%
Brooker
Bute
Bute boundary
Lowaldie
Lowaldie deep sand
Mt Damper
Sherwood
Yenda
Above average rainfall
Average rainfall
Below average rainfall
Above average rainfall = decile 8-10, below average = decile 1-3. Decile define as GS rainfall + 25% of summer