Deep ripping sandy soils on Eyre Peninsula

Joshua Telfer[1], Amanda Cook[1,2], Brianna Guidera[1] and Brian Hughes[1,2]

[1]SARDI; [2]The University of Adelaide

Location
Streaky Bay, Mt Damper, Minnipa, Kyancutta, Kielpa, Arno Bay

Dion and Tiffany Williams, Nigel and Lauren Oswald, Wes and Jacqui Daniell, Brett O'Brien, Mark Dolling

Rainfall
Av GSR/2023 GSR mm
Streaky Bay: 352/244
Mt Damper: 290/216
Minnipa: 280/169
Kyancutta: 249/134
Kielpa: 320/210

Plot size
Streaky Bay: 30 m x 4 m x 3 reps
Mt Damper: 30 m x 10 m x 3 reps
Minnipa: 12 m x 100 m
Kyancutta: 15 m x 100 m 2 reps x 2 soil types
Kielpa: 15 m x 100 m (unreplicated)

Yield limiting factors
Dry spring conditions limiting grain yield.

Hostile subsoil layers - carbonates and boron.

Layers of high soil strength on unripped plots.

Key messages

- **Soil variation can impact on effectiveness of deep ripping and other amelioration of sandy soils.**
- **Always soil test before undertaking soil amelioration as other soil constraints like low nutrition, soil acidity or soil toxicities may be present.**
- **Be careful assuming a good legacy of soil amelioration treatments as the effect often is not detected.**
- **Treatment effects impacted on crop development in a drier season like 2023, resulting in quicker crop growth earlier and less available soil moisture particularly later in the season.**

Why do the trial?

Sandy soils make up a significant portion of the agricultural lands on the Eyre Peninsula (EP), comprising approximately 20% of deep siliceous sands or sand over clays, and an additional 30% as calcareous sands or loamy sands. Many of these soils pose multiple constraints, often leading to substantial differences between water limiting potential for water availability and actual observed crop yields. Recent trials conducted under the GRDC sands research and impacts programs on the Eyre Peninsula have shown promising results on some of the sandy soil types seen on EP. It has been demonstrated that strategic deep tillage and the application of soil amendments can effectively address production constraints on sandy soils. However, the efficacy of these methods varies depending on the specific constraints of a soil, specific crops grown in the following years and seasonal conditions. For further insights into past trial outcomes, please refer to articles in the 2019, 2020, 2021 and 2022 EP Farming Systems Summaries (EPFS Summary 2019, p. 99; EPFS Summary 2020, p. 84; EPFS Summary 2021, p. 39, and EPFS Summary 2022, p. 52) regarding the treatment of production constraints on the sandy soils of the Eyre Peninsula. While there are examples of successful deep tillage operations and positive amended additions, continued monitoring into the effects of deep tillage is needed to have information on the legacy or length of effects, both negative and positive.

How was it done?

In previous projects in collaboration with AIR EP, landholders, Davenport Soil Consulting and SARDI researchers, four demonstration sites were implemented:

- Mt Damper - monitoring of the spading and ripping site established in 2019 under the GRDC Sands Impacts project.
- Streaky Bay and Arno Bay replicated trials established under the EP Landscape Board's "Regenerative Agriculture Program" (EPLB RAP), funded by the National Landcare Program project with additional support from the Soils for Life 'Paddock Labs' project.
- Minnipa - monitoring deep ripping on a siliceous sand.

Treatments were designed to address soil constraints such as soil compaction, non-wetting and low fertility, at each site and involved a mixture of strategic deep tillage with and without soil amendments (Table 1). At the Mt Damper site (original treatments applied in 2019) additional nutrients were applied to meet the nutrient needs of potential production increases from addressing constraints over the previous 3-year period. For the other sites treatments were implemented prior to sowing in 2022 and 2023. In 2023, a major focus of the Paddock Labs project was to support landholders to enhance soil function and reduce reliance on expensive mineral fertilisers. Treatments at the Streaky Bay and Arno Bay sites compared mineral fertiliser with and without carbon (C) based fertiliser, or sowing legumes in crop. The Streaky Bay site was self-regenerating medic pasture in 2023.

Table 1. Summary of trial sites monitored in 2023.

Year established	Site ID/ Location	Demo type	Soil type	Establishment year and project	Key soil constraints	Crop and In season measurements	Treatments
2019	Oswald Mt Damper	Replicated large plot - 30 x 18 m	Siliceous sand over clay	2019 GRDC Sands Impacts project 2022/23 FDF Sandy Soils project	Water repellence, physical, nutrients	2023 - Wheat 2022 - Field Peas Baseline soils (previous years), plant emergence, dry matter, NDVI, grain yield, post-harvest penetrometer resistance, residual soil water	Control - untreated Deep tillage - spading @ 30 cm, ripping @ 45 cm+IP, rip+IP @ 45 cm+spading @ 35 cm (tyne spacing = 50 cm). Soil amendments - ripping+IP+nutrients
2022	Williams Streaky Bay	Replicated smaller plot - 30 x 4 m	Highly calcareous loamy sand	2022 EPLB RAP/ Soils for Life 'Paddock labs' 2022/23 FDF Sandy Soils project	Physical, nutrients	2023 - Self regenerating medic pasture 2022 - Barley Baseline soil (2022), plant emergence, NVDI, dry matter production.	Control - 55 kg/ha DAP C based nutrition Basal (25 kg/ha DAP)+ Manure (100 kg/ha Bounceback) Basal (25 kg/ha DAP)+ Manure (100 kg Bounceback)+ Phos-acid (40 L/ha) Companion planting - basal (25 kg/ha DAP) + vetch +/- Deep tillage - deep ripping with inclusion plates (IP)
2022	Daniell Minnipa	Un-replicated large plot 15 m x 100 m	Siliceous sand over clay	2022/23 FDF Sandy Soils project	Water repellence, physical, nutrients	2023 - self regenerating medic pasture 2022 - Oats Baseline soils, (2022) plant counts, NDVI, dry matter, penetrometer resistance, residual soil water	Control - unmodified Ripped - deep ripping
2023	Dolling, Kielpa	Un-replicated large plot 15 m x 100 m	Acidic sand over clay	2022/23 FDF Sandy Soils project		2023 - Wheat Soil pH, plant emergence, dry matter, NDVI, tiller counts, post-harvest penetrometer resistance	3 Tyne Delver Controls Agroplow + Inclusion plate Grizzly Ripper Spader Grizzly + Spade Bednar
2023	O'Brien Kyancutta	Replicated (twice) large plot 15 m x 100 m	Siliceous sand over clay and Calcareous sand over clay	2022/23 FDF Sandy Soils project		2023 - Wheat Plant emergence, dry matter, NDVI, tiller counts, post-harvest penetrometer resistance	Lienert delver + spader Plozza plough (to 200 mm) Control Spader Scrub rip

Note: The site at Arno Bay from 2022 was not able to be monitored in 2023 due to treatment markers being removed, as well as being sown to a tillage radish and vetch cover crop. However, it was observed that the non-ripped treatments had lower plant establishment than the observed areas that had been ripped.

In 2023, four sites were monitored where previous ripping and associated treatments were implemented (Table 1), and two new machinery comparisons were conducted at Kielpa and Kyancutta, in collaboration with local farmers and contractors in order to compare deep soil modification operations. The Kielpa site had a soil acidity issue which was detected after the initial soil testing (Table 2) and the site had 2 t/ha of lime spread prior to ripping.

What happened?

Mount Damper - 2019 applied deep ripping and amendments

The 2023 mean yields for the treatments from the Mount Damper site are shown in Figure 1, and Figure 2 shows the NDVI for the different treatments. The NDVI is an indication of the greeness of the shoot biomass and often correlates with crop growth reflecting the speed of maturity across different treatments. The general site analysis of the treatments showed only the dune location (top of sand dune - central) was statistically significant if analysing all the data together (data not provided).

2023 was characterized by a particularly dry spring, which impacted on overall yields and advantaged earlier maturing crops. The deep ripping with inclusion plates and nutrition yielded closest or above the control in all positions on the dune, while most other treatments yielded lower than the control. The data broken down into dune position is shown in Figure 1 and Figure 2.

Table 2. Soil acidity pH (1:5 $CaCl_2$) at Kielpa, 24 March 2023.

Depth (cm)	Soil type	
	Red sand (east)	White sand (west)
0-5	5.2	5.0
5-10	4.6	4.7
10-15	4.4	4.4
15-20	6.6	4.6

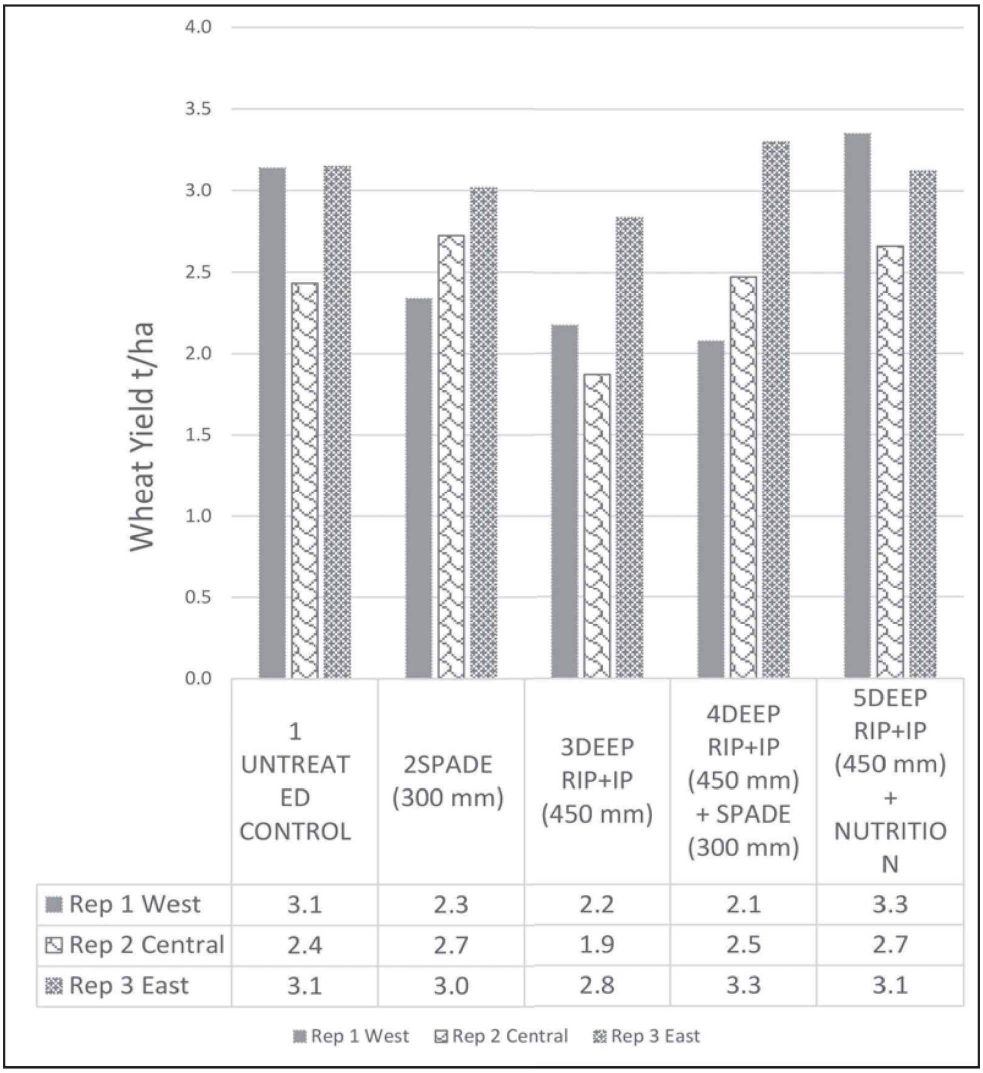


Figure 1. Mean wheat yield (t/ha) at three locations across a sand dune at Mt Damper (Oswald), 2023.

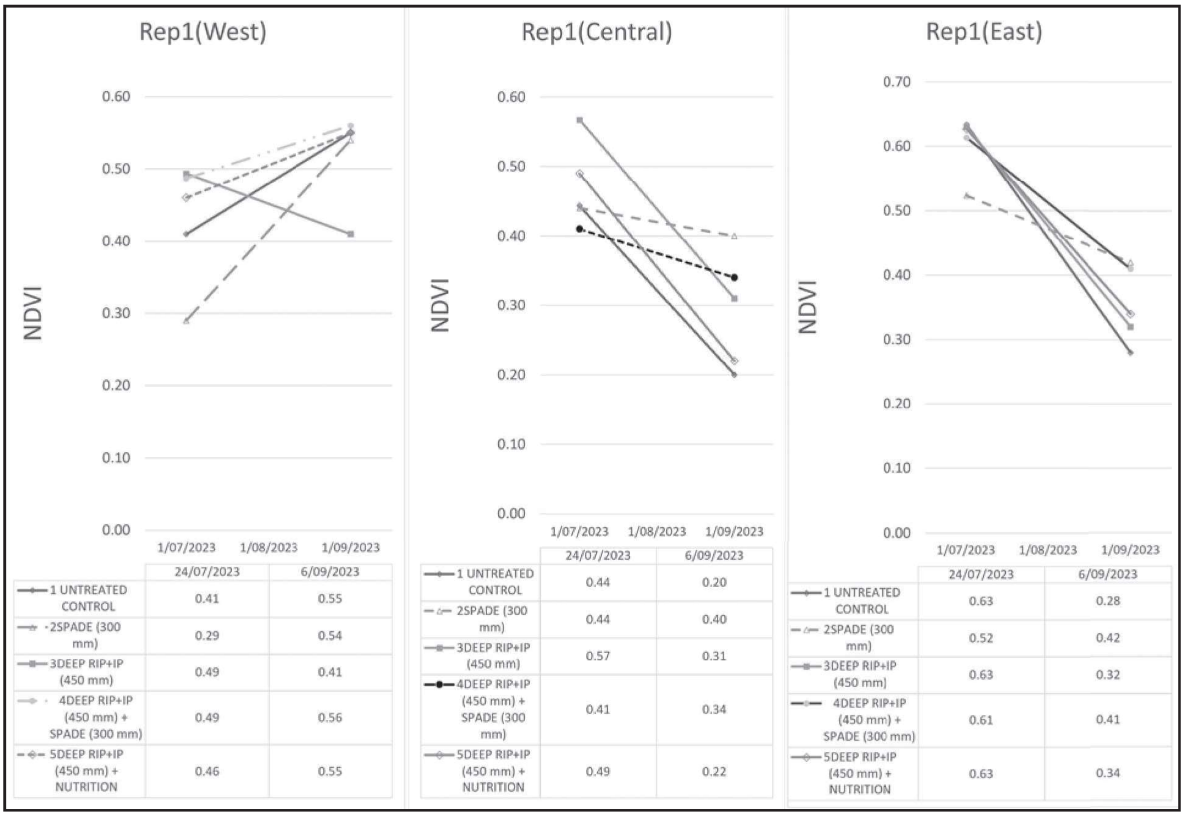


Figure 2. NDVI trends for the 3 different locations at Oswald's in 2023 showing different trends in maturity in a dry spring.

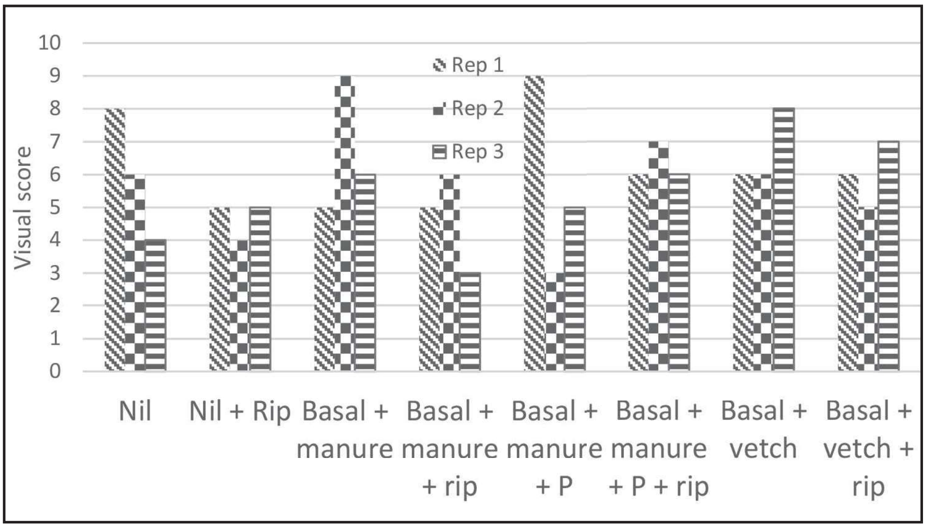


Figure 3. Medic growth visual scores at Streaky Bay, 15 September 2023.

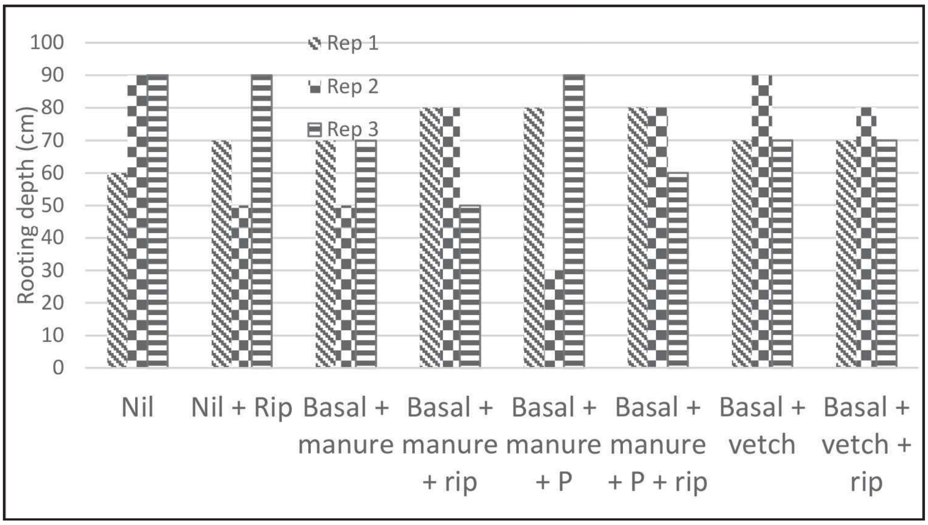


Figure 4. Medic rooting depth at Streaky Bay, 27 November 2023.

Streaky Bay - 2022 applied deep ripping and amendments

In 2023 this site was a self-regenerating medic pasture and there were no measurable residual effects from the deep ripping or nutritional treatments applied in 2022 (Figure 3 and Figure 4).

Minnipa - 2022 applied deep ripping

In 2023 this site was a self-regenerating medic pasture on a ripped siliceous sand. Similar to Streaky Bay, there were no residual effects in medic from the deep ripping treatments despite significant differences in oat biomass and yield in 2022 (Table 3). The penetrometer resistance taken in December 2023 after significant rainfall showed no differences in soil strength between the treatment areas (Figure 5).

Kielpa - 2023 applied ripping machinery comparison

The biomass responses for the ripping comparison at Kielpa are shown in Figure 6, and the penetrometer resistance reading post December 2023 rainfall are shown in Figure 7. The biomass responses show the grizzly ripper had the most improvement on biomass, with most other treatments being similar to the control plots. Control 1 has a noticeable compaction layer compared to the other treatments (Figure 7).

Kyancutta - 2023 applied machinery comparison

The Kyancutta site had a similar aim to the Kielpa site with different deep ripping machines compared on two different soil types. For the silicious sand ripping comparison, the spader and scrub ripper yields were very similar to the control. However, the delver type (finished with a spader) delivered 0.25 t/ha and the Plozza Plough around 0.5 t/ha of grain yield improvement over the control (Figure 9). This contrasts with the calcareous soil type, which had a lower overall yield, and in which all plots were lower than the silicious sand control. The deep ripping treatment in the calcareous soil showed an improvement with the delver with spader having 0.5 t/ha higher grain yield and little differences in other treatments.

In comparing the post December 2023 rainfall penetrometer resistance in the calcareous sand (Figure 9) the Plozza plough was not able to remove the compaction between 200-300 mm, which the spader, and to a lesser extent the scrub rip was able to. This was reflected in the yield trend with the delver-spader combination being the highest, followed by the spader, then the scub rip and control (Figure 8). This then highlights the potential of compaction in the 200-300mm zone restricting water extraction and root activity, and the possibility of mechanical removal of this layer in the future.

This contrasts with the lack of response in the penetrometer resistance to intervention for the siliceous sand soil type (Figure 10).

Table 3. Medic performance at Minnipa in 2023.

Treatment	Plant establishment (plants/m²)	NDVI (19 Sept)	Dry matter (19 Sept) (t/ha)
Ripped	38	23	1.17
Unripped	35	23	0.96

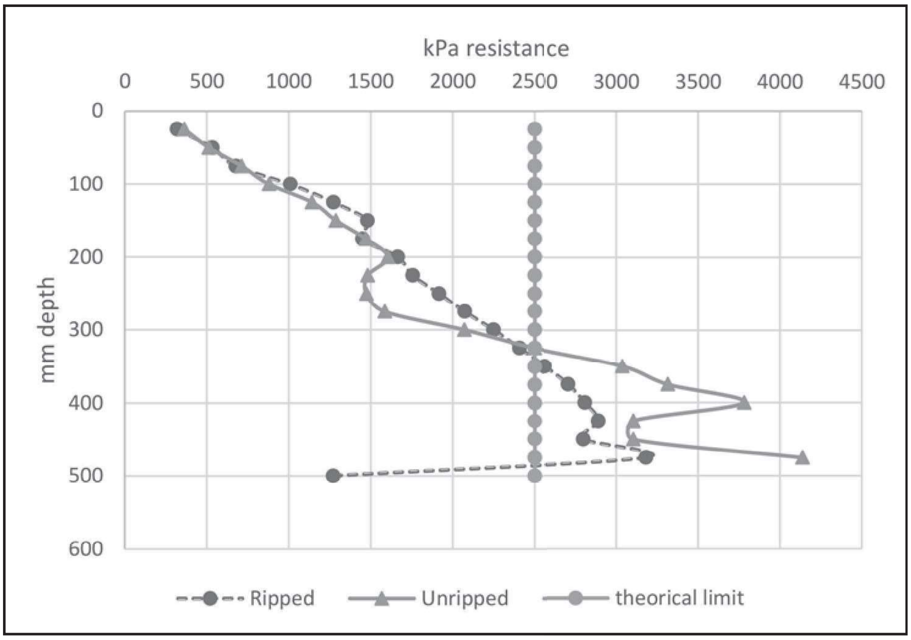
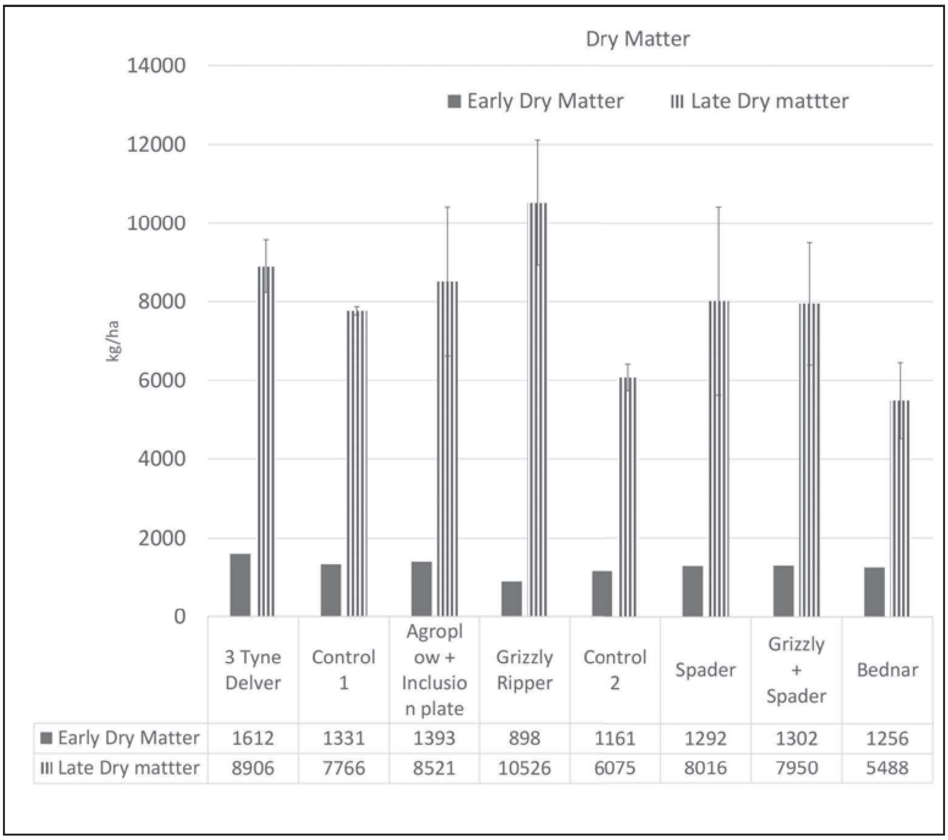


Figure 5. Penetrometer resistance (kPa) at Minnipa, December 2023 (median of four depth probes).



	3 Tyne Delver	Control 1	Agroplow + Inclusion plate	Grizzly Ripper	Control 2	Spader	Grizzly + Spader	Bednar
Early Dry Matter	1612	1331	1393	898	1161	1292	1302	1256
Late Dry mattter	8906	7766	8521	10526	6075	8016	7950	5488

Figure 6. Mean wheat dry matter production (kg/ha) in red sand (east) for the different treatments at Kielpa, 2023 (early dry matter taken 27 July 2023 and late dry matter taken 9 October 2023).
Error bars on Late Dry Matter are standard deviation from the treatment means. The order of the graph reflects the layout of the trial (North to South).

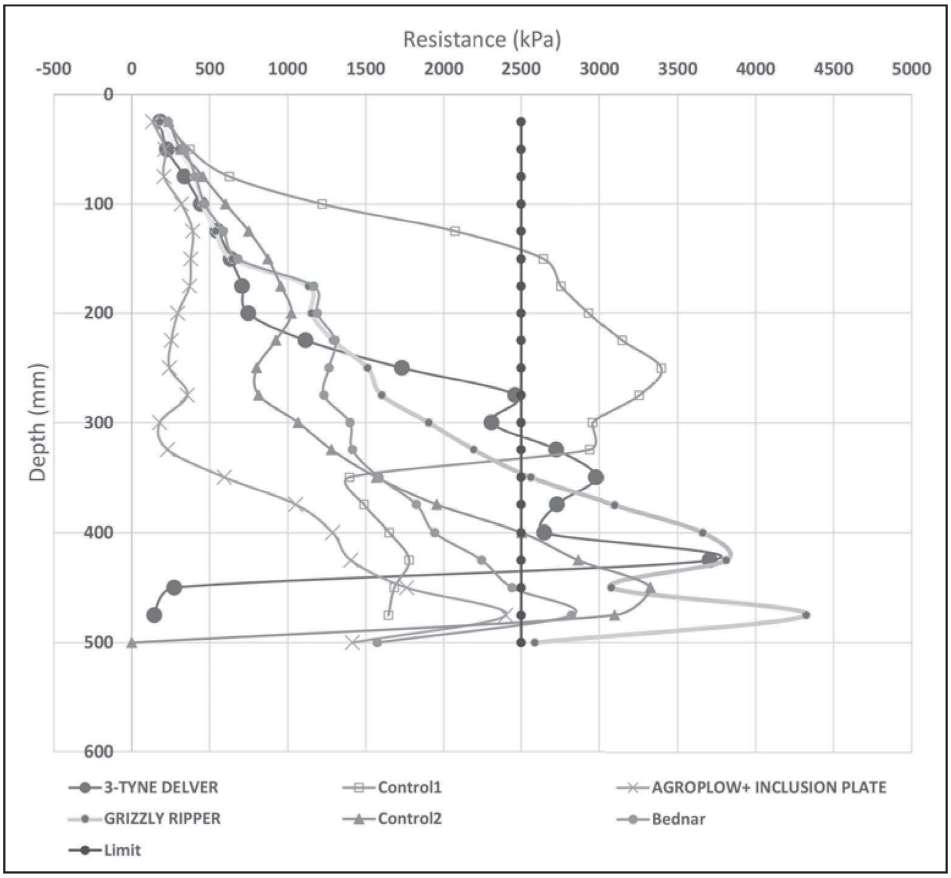
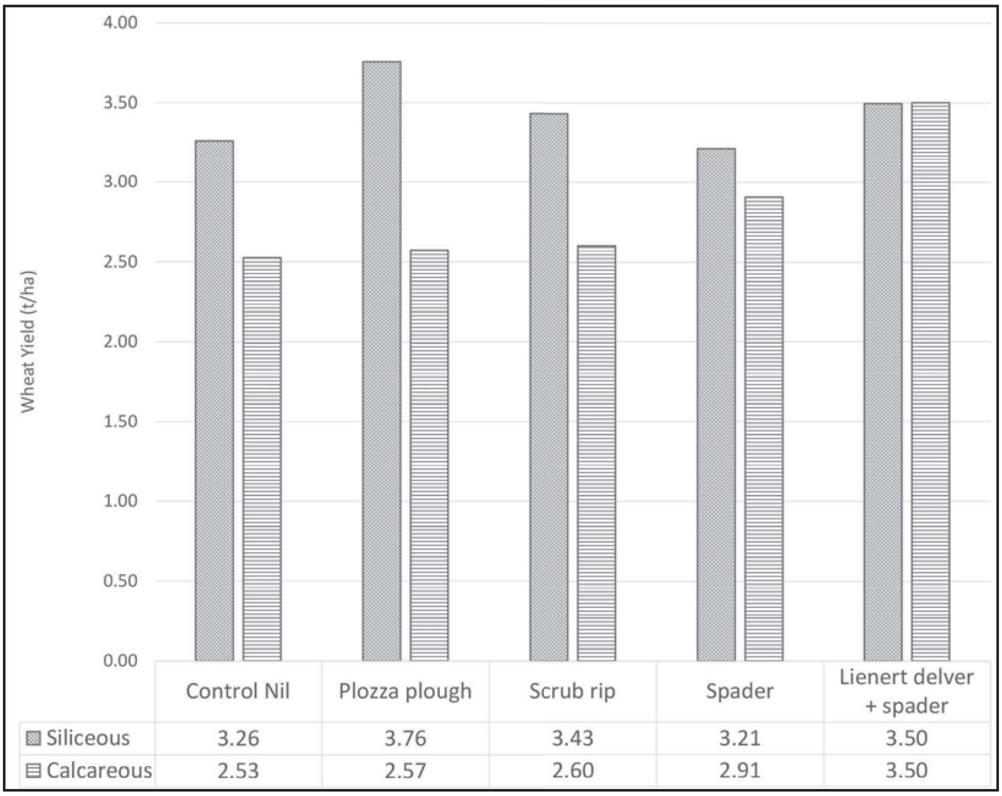


Figure 7. Penetrometer resistance (kPa) at depth for some of the treatments compared the theoretical soil strength limit of 2,500 kPa, 11 December 2023.



	Control Nil	Plozza plough	Scrub rip	Spader	Lienert delver + spader
Siliceous	3.26	3.76	3.43	3.21	3.50
Calcareous	2.53	2.57	2.60	2.91	3.50

Figure 8. The wheat yield (t/ha) of the different treatments for the two different soil types at Kyancutta in 2023.

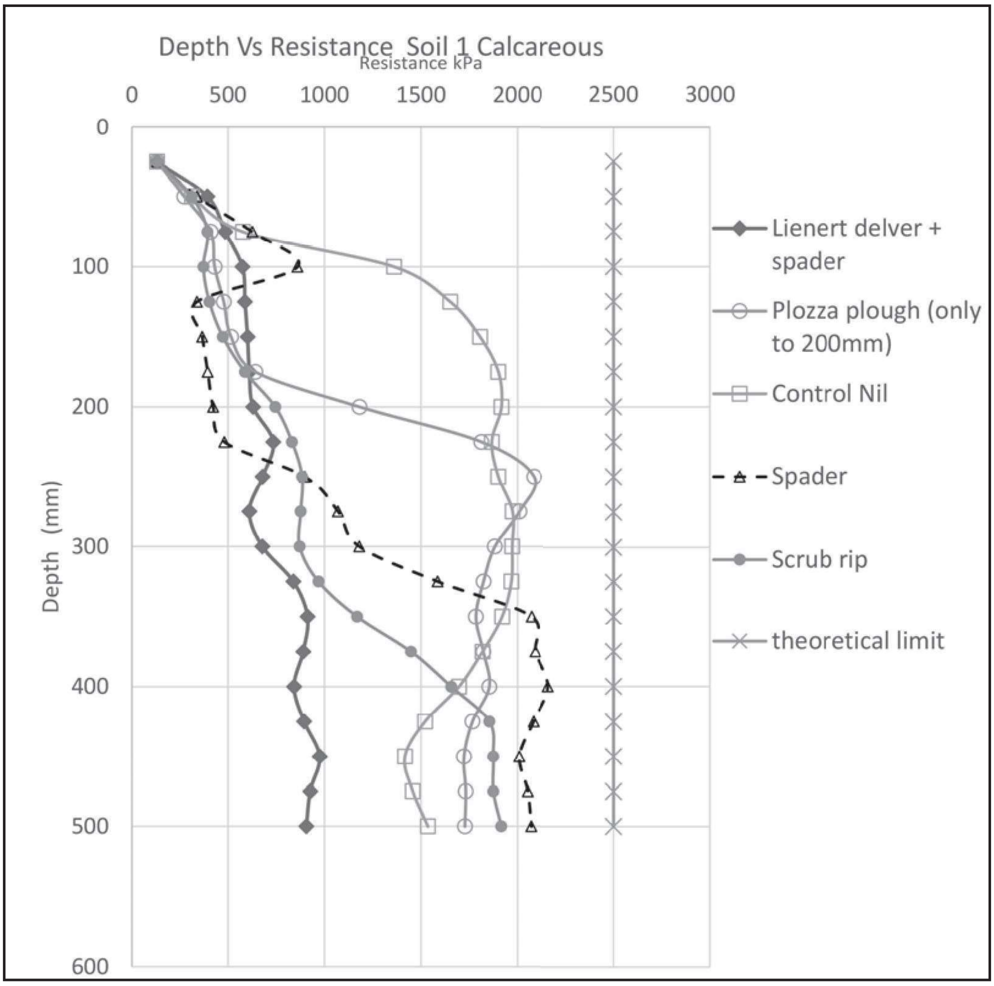


Figure 9. Penetrometer resistance (kPa) in the calcareous soil at Kyancutta in December 2023.

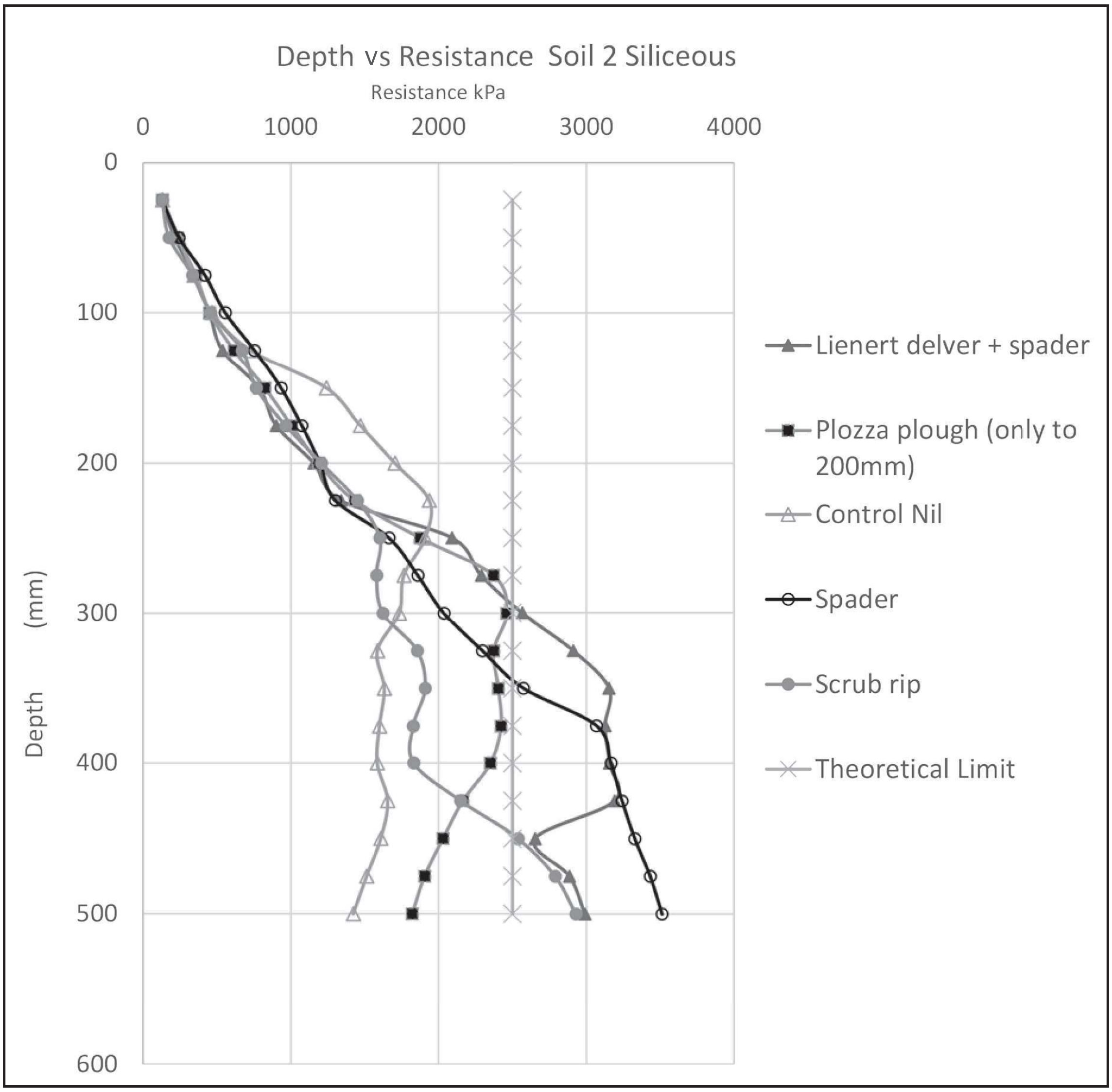


Figure 10. Penetrometer resistance (kPa) in the siliceous sand at Kyancutta in December 2023.

What does this mean?

At the Mt Damper (Oswald) site, the most significant difference was the influence of the dune position. In 2023 in drier spring conditions a number of the treatments performed worse than the control for wheat grain yield. This may be partly due to the season with a dry spring limiting grain filling due to higher early biomass and earlier crop maturity. Most treatment means were lower than the control, except the ripping with inclusion plate with additional nutrition. It has been speculated that due to higher yields in previous seasons, that some of the treatments are being limited by lower fertility. Any treatments which had delayed crop senescence and grain filling would have been disadvantaged in a very dry spring that occurred in 2023. This may indicate the need for additional nutrient applications following amelioration, to properly account for additional nutrient removal due to previous higher biomass and grain yields.

The Minnipa (Daniell) site had an improvement in oat production in 2022 with harvest biomass improving by 6.9 t/ha and grain yield improving by 0.6 t/ha following the ripping of a silicious sand over clay. However in 2023 there were no differences in medic dry matter production. Similar to the Streaky Bay site, the medic pasture didn't seem particularly adapted to take advantage of any improved conditions following the ripping in the 2022 season. There were no differences between the ripped and control treatments with the soil penetrometer readings (Figure 5) and no differences in the medic root depth measurements by the end of 2023. This doesn't negate possible differences in subsequent seasons. However, there appears to have been significant reconsolidation since the initial intervention.

Penetrometer readings have been generally taken across the plots, and not just confined to the rip line. If penetrometer techniques were implemented to capture data from both on rip lines and the non-rip lines, it might be possible to pick up more legacy effects, whereas the current method just captured data in random locations in the plots.

Similarly, while medic is adapted to the calcareous sand at Streaky Bay, there were no measurable agronomic responses of the residual ripping and nutrient response treatments.

At Kielpa (Dolling's) the results of the deep ripping machinery comparisons were mixed, with differences in soil penetrometer data in the two control strips demonstrating some of the variability across the site, and these differences were also reflected in the biomass differences seen in the two controls as well (Figure 6). The two treatments with spading performed very similarly (Spading and Grizzly + Spading), and had higher biomass means than the adjacent control 2, though interestingly the Grizzly alone had the highest dry matter production. Only the Bednar was lower than either of the control plots in the later biomass cuts (Figure 6). Generally, there was poor correlation between biomass production and the differences seen in penetrometer readings.

The site needs to be resampled in autumn 2024 to investigate the impact of the lime spread, though the control also was spread at 2 t/ha. However, liming doesn't typically affect crop production in the year of application, but the movement of soil through the different soil amelioration treatments would affect pH.

At Kyancutta (O'Brien's), the plozza plough increased yield by 0.5 t/ha in the silicious sand ripping comparison. The other interventions were all similar to the control. In the calcareous soil, despite having a lower overall yield potential, showed an improvement with the delver with spader of 0.5 t/ha grain yield. The Plozza plough was not able to remove the compaction between 200-300 mm which potentially restricts water extraction and root activity due to compaction.

When considering ongoing soil amelioration, it is important to consider the impact of nutrition if you are producing more biomass and removing higher crop yields. This may interact with phenology which can delay crop growth stage which may be detrimental in a dry finish. Soil variation had a big impact in the effectiveness of soil amelioration. This is seen at Mt Damper across the sand dune, at Kielpa with variation in soil penetrometer controls, and at Kyancutta with different responses from adjacent but different soil types. Soil constraints other than compaction such as acidity and low water holding capacity can impact yield responses. The ability to predict a crop response to a particular soil amendment remains challenging with an interplay between soil water holding capacity, soil compaction, crop establishment and soil nutrition considerations, and as well as more specific site issues such as water repellence or acidity.

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