Deep ripping sandy soils on upper and eastern Eyre Peninsula

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Location
Streaky Bay, Mt Damper, Minnipa & Arno Bay
Dion and Tiffany Williams, Nigel and Lauren Oswald, Wes and Jacqui Daniell, Ben and Kathy Ranford
Rainfall
Av. GSR/2022 GSR
Streaky Bay: 303/384
Mt Damper: 218/263
Minnipa: 242/332
Arno Bay: 254/255
Soil type
Streaky Bay: Calcareous loamy sand with increasing carbonate at depth
Mt Damper, Minnipa and Arno Bay: white siliceous sand over poorly structured clay
Plot Size
Streaky Bay and Arno Bay: 30 m x 4 m x 3 reps
Minnipa: seeder width x 100 m, non-replicated demonstration
Mt Damper: 30 m x 10 m x 3 reps
Yield limiting factors
Dry conditions in June and July.
Hostile subsoil layers - carbonates and boron.
Layers of high soil strength on unripped plots.

Key messages

- **Production constraints on sandy soils can be overcome with strategic deep tillage and the application of soil amendments, however, the response varies for different crops and seasons.**
- **Ripping at Arno Bay and Minnipa provided higher grain yield than the unripped controls, but not at Mt Damper or on a calcareous sand at Streaky Bay in 2022.**
- **Knowledge of soil constraints and the depth at which they are present in the soil profile is key for choosing the most appropriate soil modification strategy for each site.**

Why do the trial?

Sandy soils account for a significant proportion of Eyre Peninsula's agricultural soils (with approximately 20% consisting of either deep siliceous sands or sand over clays and another 30% as calcareous sands or loamy sands). Sandy soils have multiple constraints which can result in large differences between water limiting potential and actual crop yields. Recent trial work on the Eyre Peninsula conducted under the GRDC sands research and impacts programs has indicated that production constraints on sandy soils can be overcome with strategic deep tillage and the application of soil amendments. However, the response varies for different crops and seasons. For details of past trial results, see the articles in the 2019, 2020, 2021 EPFS Summaries (EPFS Summary 2019, p. 99-104; Validating research outcomes to treat production constraints on sandy soils of Eyre Peninsula and EPFS Summary 2020, p. 84-87; Treating production constraints on the sandy soils of upper and lower Eyre Peninsula - Year 2; EPFS Summary 2021 p. 39-43; Treating production constraints on the sandy soils of upper and lower Eyre Peninsula - Year 3).

In 2022 the impact of deep ripping and other treatments on crop growth and yield was assessed on several Eyre Peninsula demonstration sites established on sandy soils. Monitoring was conducted under an AIR EP project funded by the Australian Government's 'Future Drought Fund' (FDF). Given that deep tillage boosted crop growth and yield three years after implementation on three out of four GRDC sandy soil impacts amelioration sites on Eyre Peninsula (EPFS Summary 2021 p. 39-43), it was decided that deep ripping treatments should be the basis for the selection of monitoring sites.

These trials aimed to:

- Compare the production of deep ripped soil to unmodified controls on different sandy soils on upper and eastern Eyre Peninsula.
- Identify if the addition of manures or other organic material provided additional benefits.

This article summarises crop growth responses from treatments in 2022.

How was it done?

In collaboration with AIR EP, landholders, David Davenport (Davenport Soil Consulting) and PIRSA-SARDI researchers four demonstration sites were selected including:

- Mt Damper - monitoring of the spading and ripping site established in 2019 under the GRDC Sands Impacts project (EPFS Summary 2019, 2020 and 2021).
- Streaky Bay and Arno Bay - new replicated trials established under the EP Landscape's Board "Regenerative Agriculture Program" (EPLB RAP) funded by the National Landcare Program project with additional support from the Soils for Life 'Paddock Labs' project.
- Minnipa - a new deep ripping demonstration.

Table 1. Summary of trial sites monitored in 2022.

Site ID/ Location	Demo type	Soil type	Establishment year and project	Key soil constraints	In season measurements	Treatments
Dion Williams Streaky Bay	Replicated smaller plot - 30 x 4 m	Highly calcareous loamy sand	2022- EPLB RAP/Soils for Life 'Paddock labs'	Physical, nutrients	Baseline soil, plant emergence, dry matter, grain yield	**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)+ Phosacid (40 L/ha) **Companion planting** - basal (25 kg/ha DAP) + vetch **+/- Deep tillage** - deep ripping with inclusion plates (IP)
Nigel Oswald Mt Damper	Replicated large plot - 30 x 18 m	Siliceous sand over clay	2019- GRDC Sands Impacts project	Water repellence, physical, nutrients	Baseline soils plant emergence, dry matter, grain yield	**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
Wes Daniell Minnipa	Unreplicated - large plot 15 m x 100 m	Siliceous sand over clay	2022- FDF sands project	Water repellence, physical, nutrients	Baseline soils, plant emergence, grain yield	**Control** - unmodified Ripped - deep ripping
Ben Ranford Arno Bay	Replicated smaller plot- 30 x 4 m	Siliceous sand over clay	2022- EPLB RAP/Soils for Life 'Paddock labs'	Water repellence, physical, nutrients	Baseline soils plant emergence, dry matter, grain yield	**Control** - 65 kg/ha DAP/ SOA **C based nutrition** Basal (25 kg/ha DAP/ SOA)+Manure (100 kg Bounceback) Basal (25 kg/ha DAP/ SOA)+Manure (100 kg Bounceback)+ Phosacid (40 L/ha) **Companion planting** - basal (25 kg/ha DAP) + peas **+/- Deep tillage** - deep ripping + soil mixing of top 20 cm

Treatments were designed to address soil constraints 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. 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.

Ripping at the Streaky Bay and Mt Damper sites was undertaken using a four tine Yeoman's plough with inclusion plates. At Arno Bay, ripping to 40 cm depth at a 0.5 m tyne spacing was conducted using a Bednar plough, whilst the landholder ripped a demonstration strip at Minnipa to bring clay to the surface.

Plant measurements included crop establishment, a measure of biomass production (NDVI and/ or biomass production) and grain yield assessments. Data from replicated sites was analysed using standard ANOVA models in Statistix 8.

What happened?

Intense storm activity in late January 2022 bringing up to 250 mm of rainfall in 24 hours resulted in most districts recording their highest rainfall totals ever for the summer period and full soil moisture profiles.

In 2022 all sites were sown by the landholders (Razor CL wheat at Streaky Bay, Vixen wheat at Arno Bay, Yallara oats at Minnipa and Butler peas at Mt Damper) and managed as per the rest of the paddock. Plant density was evaluated 4 to 6 weeks after sowing. Windy conditions and dry surface soils saw wind erosion on the Mt Damper and Arno Bay sites which resulted in high variation in crop establishment within plots. However, in most cases crop plant densities on these sites were around those expected for the crop type and rainfall zones. There was little difference in growing season rainfall compared to the long-term averages. However, January rainfall resulted in a full soil moisture profile at seeding which crops were able to draw on during dry periods in June and July. Cuts were taken in spring at all sites to assess the impact of treatments on biomass production. Good rainfall throughout the late winter and spring period provided ideal growing conditions for crops and pastures, whilst late spring rainfall slowed senescence on cereals, extending ripening and delaying harvest.

Streaky Bay

At Streaky Bay good early rainfall resulted in uniform wheat emergence with no significant difference ($P < 0.05$) on treated areas compared to the control (which had 106 plants/m^2). Assessments of winter and early spring growth; NDVI on 10 August and 19 September as well as dry matter cuts on 12 September, showed no differences (P values of 0.162, 0.414 and 0.175 respectively) in growth on the treated plots compared to the control (which had 6.3 t/ha of dry matter). Whilst the western side of the trial appeared visually greener, there was large spatial variation, and ryegrass was an issue across the site. Grain yields at Streaky Bay varied within treatments and across the site and there were no significant differences ($P = 0.89$) in yield between treatments (control averaged 3.0 t/ha of wheat).

Mount Damper

Despite having good subsoil moisture, drier periods in autumn and early winter at Mt Damper, Minnipa and Arno Bay resulted in dry topsoils and delayed seeding. Previous data from the Mt Damper site in 2019-2021 showed the biggest production increases on the spaded (+/- rip with inclusion plates) plots. In 2022 there was no difference in establishment ($P = 0.21$) or NDVI values on 5 August ($P = 0.33$) with controls averaging 58 plants/m^2 and NDVI of 0.37. When biomass was assessed on 6 October all treatments had higher NDVI values ($P = 0.008$) than the control which had a value of 0.41). However, as there was no difference ($P = 0.705$) in biomass between plots at this time (control averaged 4.4 t/ha of dry matter), this is likely due to earlier crop senescence on the control plots resulting in reduced NDVI reflection. There were also no significant grain yield increases ($P = 0.76$) at the Mount Damper site (with controls yielding 2.3 t/ha of peas).

Minnipa

At the Minnipa site winter NDVI assessments showed little difference in growth, but at biomass cuts in mid September the ripped treatment had 80% more dry matter than the control (which had 8.7 t/ha of dry matter), which resulted in 20% more oat grain yield on the ripped area compared to the control (which yielded 3.2 t/ha).

Arno Bay

At Arno Bay the landholder resowed the site at a 45-degree offset to the original sowing lines to try increase surface cover at emergence and reduce the erosion risk. As a result, plant densities were much higher than is normally recommended (120-140 plant/m^2) for this rainfall zone (Figure 1). Only the 55 kg/ha DAP with ripping and peas had higher plant numbers than the control which averaged 267 plants/m^2. Unfortunately, due to a mix up at sowing this treatment only had one replicate.

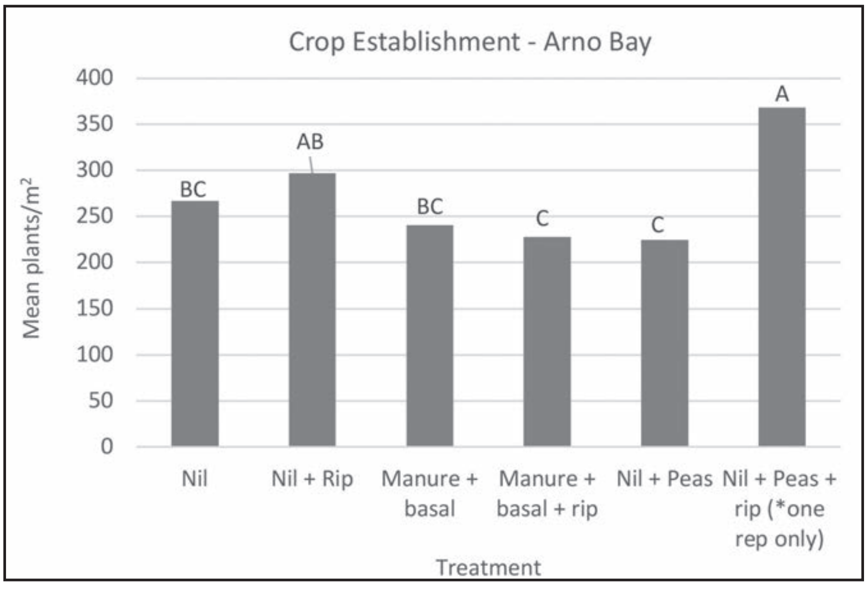

Figure 1. Plants/m^2 at Arno Bay at crop establishment. A different letter indicates a significant difference at P < 0.05.

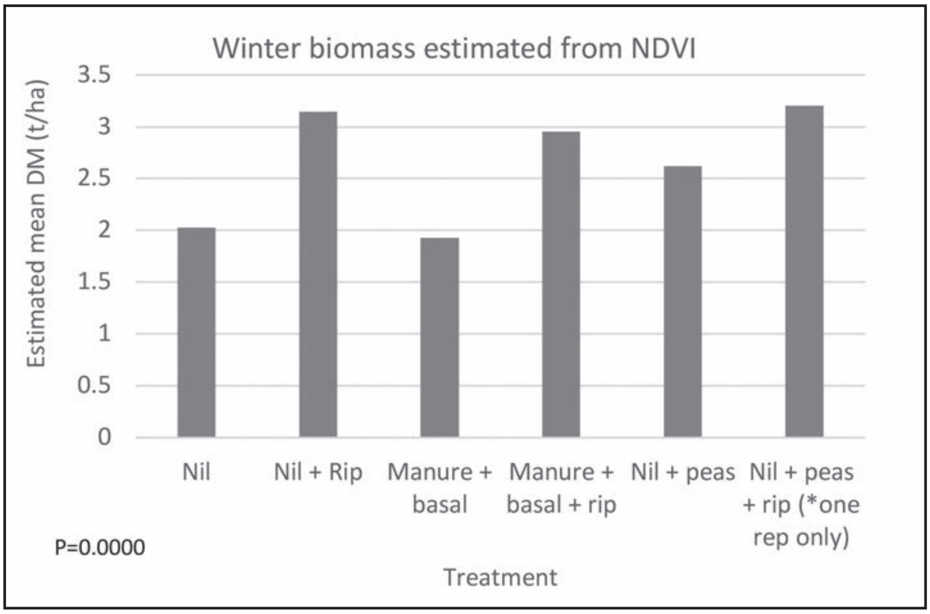

Figure 2. Estimated winter biomass from NDVI assessments on Arno Bay site taken in mid-August 2022.

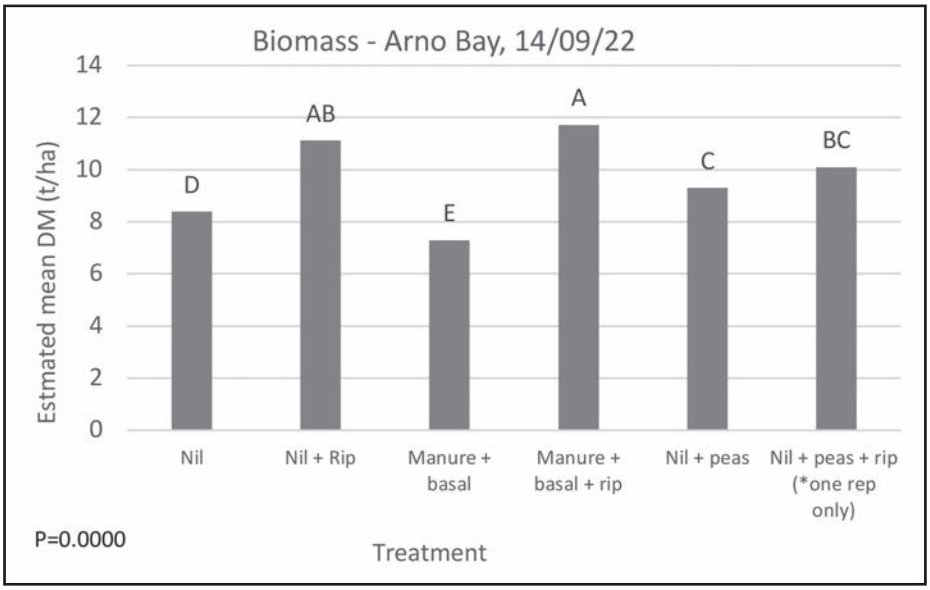

Figure 3. Spring biomass (t/ha dry matter) at Arno Bay. A different letter indicates a significant difference at P<0.05.

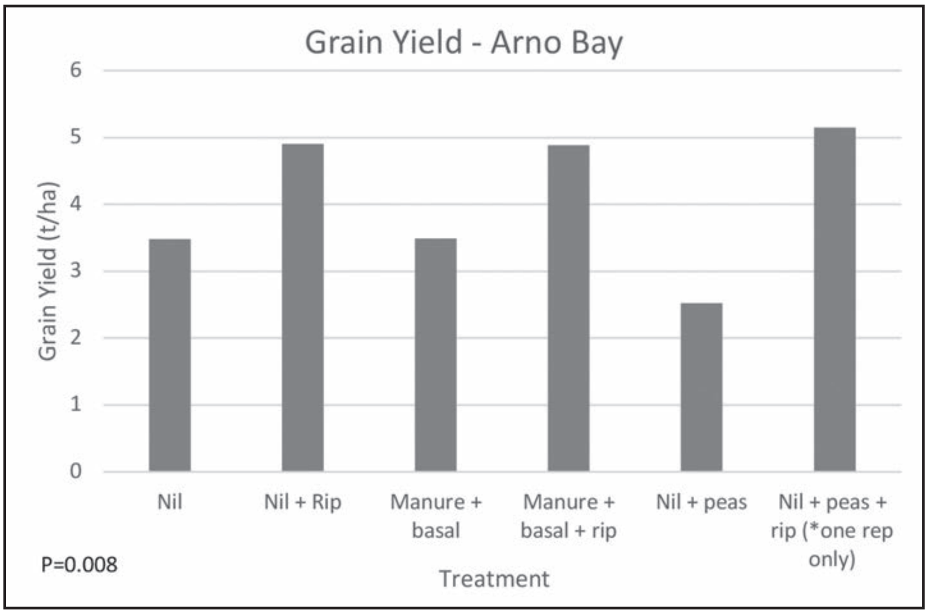

Figure 4. Wheat yields at Arno Bay, December 2022.

NDVI assessments were undertaken on 10 August. Calibration cuts were taken to convert NDVI values to estimated biomass (t/ha dry matter) (Figure 2). Data indicated that ripping improved crop growth (P=0.0059) compared to the corresponding unripped treatments Nil and Manure + basal treatments (Figure 2). Whilst Nil + Peas + rip was one of the treatments with the highest plant numbers at establishment (bearing in mind that this treatment had only one replicate), NDVI and biomass data suggested that there was not much difference in growth between the three ripping treatments (Figures 2 and 3).

Cuts were taken at anthesis to assess spring biomass (t/ha of dry matter). Results supported earlier crop establishment and NDVI data, with Nil + Rip and Manure + basal + rip having higher amounts of dry matter than their unripped comparison treatments (P = 0.0001) (Figure 3).

At this site there was little impact from amendments with all ripped treatments yielding more than the unripped treatments (Figure 4). Whilst severe powdery mildew was observed on the crop in early to late spring, visually it appeared that the severity of powdery mildew was much higher on the unripped treatments compared to the ripped treatments and was not associated with applied ameliorants.

What does this mean?

Due to favourable seasonal conditions grain yields were exceptional across the trial sites. As the soil constraints associated with these sites have a high impact on plant available water, the early rainfall makes interpretation of results problematic. However, some conclusions can be made including:

- Ripping on the Arno Bay site delivered substantial yield increases and even though there was higher biomass on these treatments there appeared to be less powdery mildew observed.
- At the Minnipa site there was a significant response to ripping suggesting treatment of a soil physical constraint by ripping.
- At the Arno Bay and Streaky Bay sites using a cheaper mineral/C based fertiliser mix with lower levels of nitrogen applied did not deliver a significant yield difference compared to mineral fertiliser alone.

In conclusion, these results support earlier work that suggests that whilst modification of soils with severe production constraints can increase biomass and grain yield, results are highly variable and maintaining these production increases across different crop types and seasons requires further investigation.

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