Treating production constraints on the sandy soils of upper and lower Eyre Peninsula - Year 3

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Location
Buckleboo, Mt Damper, Karkoo, Cummins - Graeme & Heather, Tristan & Lisa Baldock, Nigel Oswald, Reece Modra, Scott & Maryanne Mickan

Rainfall
Av GSR / 2021 GSR
Buckleboo: 215 / 134 mm
Mt Damper: 218 / 210 mm
Karkoo: 338 / 366 mm
Cummins: 327 / 336 mm

Soil type
Buckleboo: Buckleboo red sand
Mt Damper: sand over sodic clay
Karkoo: clayspread sand over clay
Cummins: shallow sand over sodic clay

Plot size
Large plot trial 30 m x 12-18 m wide x 3 reps

Yield limiting factors
Seven week dry period from end of August to late October at peak growth period of flowering and grain fill.

Despite above average rainfall in October most of this fell in the last week of the month and was too late to benefit crops, particularly on lentils at Buckleboo.

Hot windy days in the first week of September caused moisture stress at flowering.

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.**
- **Deep tillage boosted crop growth and yield three years after implementation on three out of four sites.**
- **Spading at Mt Damper provided higher grain yield than deep ripping with inclusion plates.**
- **Incorporated organic and nutrient amendments have provided additional yield in some years, but with inconsistent benefits.**
- **Knowledge of soil characteristics throughout the profile is vital for identifying key production constraints and determining an appropriate and effective management strategy.**

Why do the trial?

These trials aimed to:

- Compare a range of soil modification practices used to treat physical, chemical, and nutritional production constraints on different types of sandy soils on upper and lower Eyre Peninsula.
- Compare deep ripping to deep ripping with topsoil inclusion plates, and to spading.
- Identify if the addition of fertilisers, gypsum or organic material provided additional benefits.

This article summarises crop growth responses from treatments in the third crop post amelioration. For details of past trial results, see Eyre Peninsula Farming Systems Summary 2019, p. 99-104; Validating research outcomes to treat production constraints on sandy soils of Eyre Peninsula, and EPFSS 2020, p. 84-87; Treating production constraints on the sandy soils of upper and lower Eyre Peninsula - Year 2.

How was it done?

In collaboration with AIR EP, four replicated trials were established in 2019. Two on the upper EP at Buckleboo and Mt Damper, and two on lower EP districts at Karkoo and Cummins (EPFSS 2019, p. 99-104) as part of the GRDC Sandy Soils project (CSP00203).

Treatments were designed to address identified soil constraints and included a mixture of strategic deep tillage with and without the application of soil chemical and nutrient amendments (Table 1) that were implemented prior to sowing in 2019. Nutrient treatments at Buckleboo and Mt Damper were calculated as the additional nutrients required to supply potential production increases from addressing constraints over a 3 year period (i.e. monitoring period for the trials).

In 2019, the sites were all sown with wheat (Chief CL at Mt Damper and Scepter at Buckleboo, Karkoo and Cummins). In 2020 upper EP sites were sown with cereals (Scepter wheat at Mt Damper and Compass barley at Buckleboo) with both lower EP trial sites sown to 44Y90 canola. Plant density evaluated 4 to 6 weeks post sowing showed little difference in crop establishment between treatments in 2019 and 2020, apart from on the Karkoo site in 2019 where the clayed control and the clay + rip treatments recorded 14 to 19 % more wheat plants than plots which were ripped with inclusion plates (EPFSS 2019, p. 99-104).

Table 1. Summary of replicated trial sites.

Co-operator/Site ID/ Location	Key Soil Constraints	In season Measurements	Treatments
Karinya Ag (TB) with Buckleboo Farm Improvement Group, Buckleboo	Physical, nutrients	Plant emergence, dry matter, grain yield	**Control** - untreated **Deep Tillage** - deep ripping @ 35 cm, deep ripping @ 45 cm [+/- inclusion plates (IP)] **Soil amendments -** ripping + IP + fluid nutrients (APP, high cost nutrition package, or low cost nutrition package).
Nigel Oswald (MF) Mt Damper	Water repellence, physical, nutrients	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 = 50cm). **Soil amendments** - ripping + IP + nutrients
Modra (RM) Karkoo	Physical, nutrients Note: Water repellence had been treated by previous clay spreading.	Plant emergence, grain yield	**Control** - clayspread **Deep tillage** - clay + ripping @ 40 cm, clay + ripping @ 40 cm + IP **Soil amendments** - clay+ripping @ 40 cm + IP + 5 t/ha OM (lucerne pellets)
Mickan (SM), Cummins	Water repellence, Soil acidity, physical (Shallow sodic B horizon resulting in waterlogging), nutrients	Plant emergence, grain yield	**Control** - limed **Deep tillage** - Ripping @ 30 cm, clay + ripping @ 40 cm IP **Soil amendments** - clay + ripping @ 40 cm + IP + 5 t/ha gypsum

Opportunistic biomass assessments were undertaken on some sites during spring (including Buckleboo, Mt Damper and Karkoo in 2019, and Buckleboo and Mt Damper in 2020). In 2019 ripping with inclusion plates resulted in flowering biomass increases of at least 33% compared to the control at Buckleboo, with the spading + ripping + IP, and rip + IP + nutrient treatments at Mt Damper producing more spring biomass than control plots (EPFSS 2019, p. 99-104). In 2020 the deeper ripping (45 cm) treatments with deep placement of nutrients improved biomass production at Buckleboo, with ripping with inclusion plates and spading also resulting in more biomass growth at Mt Damper (EPFSS 2020, p. 84-87). The biomass differences seen at Buckleboo and Mt Damper in 2019 and 2020 were reflected in grain yield differences (EPFSS 2019, p. 99-104 and EPFSS 2020, p. 84-87).

What happened in 2021?

In 2021 all sites were sown by the landholders and managed as per the rest of the paddock. The upper EP sites were sown with Scope CL barley at Mt Damper and Hurricane lentils at Buckleboo, with both lower EP trial sites sown to wheat.

Plant density

Plant density was evaluated 4 to 6 weeks after sowing. Mild temperatures and damp soils saw good conditions for crop establishment with only Karkoo showing any difference in crop establishment between treatments (Figure 1). Deep ripping with inclusion plates resulted in 8 to 28% less wheat plants compared to the clayed control (which had 89 plants/m^2 at establishment) and deep ripping without inclusion plates (Figure 1).

Biomass

Above average rainfall in early winter saw good early crop growth at all sites. Opportunistic biomass cuts were taken at Buckleboo and Mt Damper in late winter/early spring. Dry conditions ensued from mid August to late October. Whilst Mt Damper, Cummins and Karkoo had good subsoil moisture levels due to earlier rains, subsoils at Buckleboo dried out rapidly with the crop showing some signs of moisture stress and having variable crop growth. Spring biomass assessment in mid September did not show any treatment trends.

August biomass at Mt Damper was generally low (<2.0 t/ha), however the treatments that included spading produced >0.9 t/ha additional biomass over the control (which averaged 0.9 t/ha, Figure 2).

Grain yield

Dry conditions from the end of July forced crops to draw heavily on stored soil moisture during flowering and grain fill. The Buckleboo and Cummins trials were harvested by the landholders in late November/early December, yielding an average of 0.6 t/ha on the lentils at Buckleboo and 3.7 t/ha on the wheat at Cummins (Figures 3 and 4).

At Buckleboo all treatments where additional nutrients had been deposited in subsurface layers by ripping yielded about the same (0.6 t/ha) and had significantly higher yields than the control (0.45 t/ha, Figure 3).

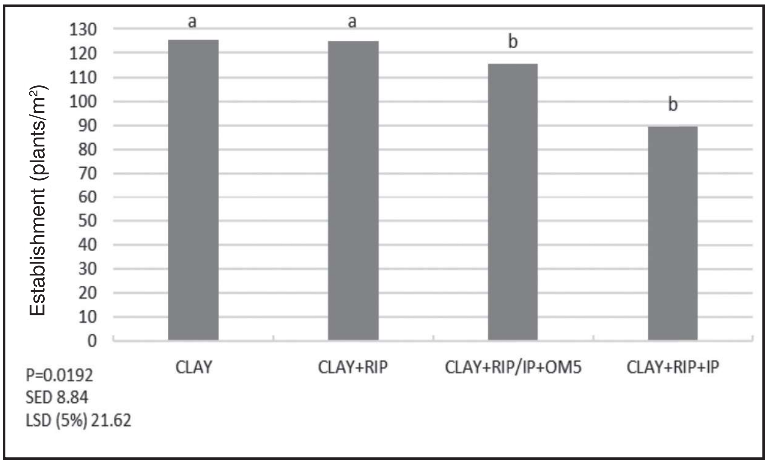

Figure 1. Plants per square metre at Karkoo at crop establishment. A different letter indicates a significant difference at P<0.05.

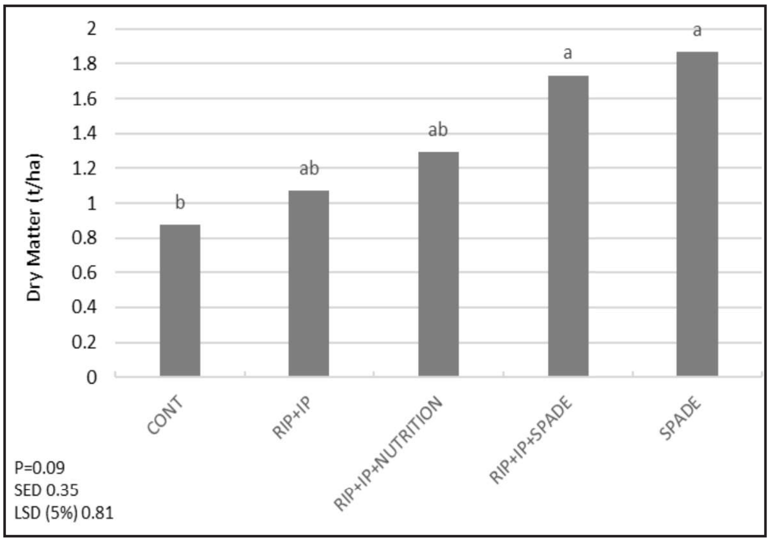

Figure 2. Winter dry matter biomass (t/ha) at Mt Damper. A different letter indicates a significant difference at P<0.1.difference at P<0.05.

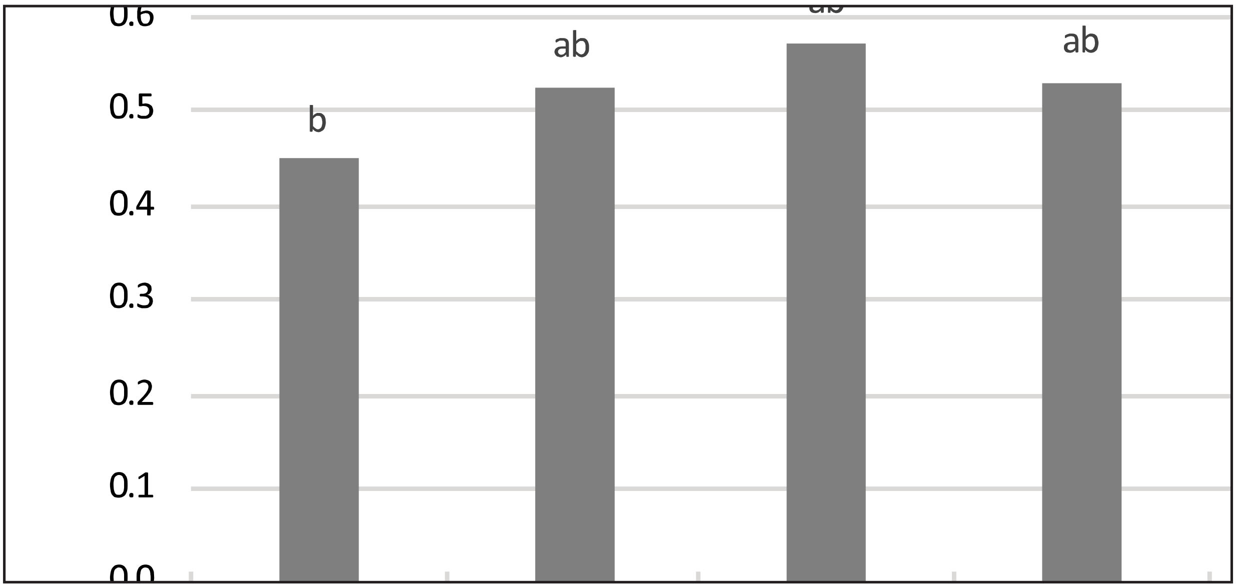

Figure 3. Lentil yield (t/ha) at Buckleboo. A different letter indicates a significant difference at P<0.05 difference at P<0.05.

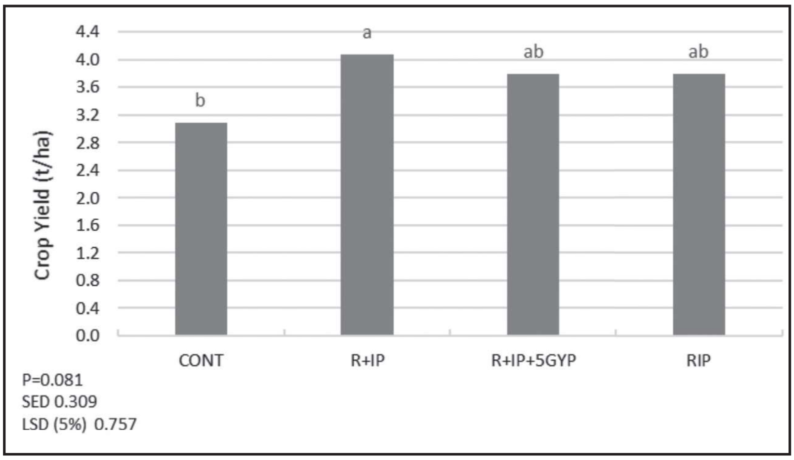

Figure 4. Wheat yield (t/ha) at Cummins. A different letter indicates a significant difference at P<0.1.

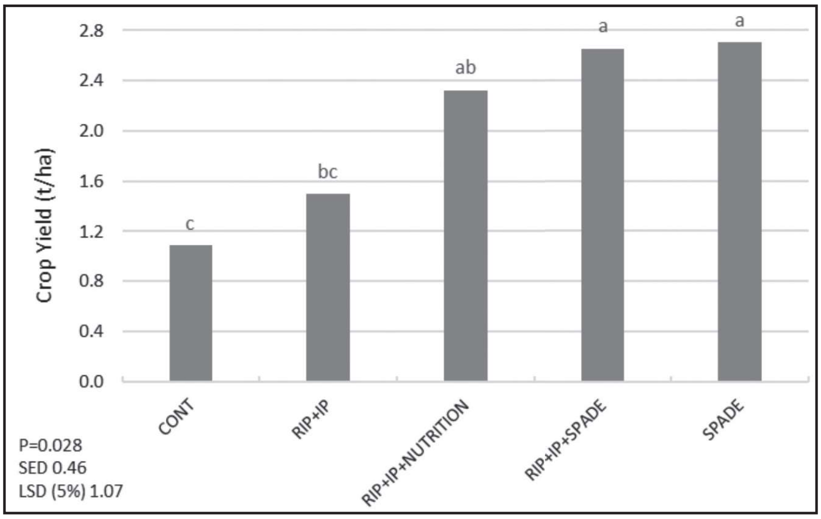

Figure 5. Wheat yield (t/ha) at Mt Damper. A different letter indicates a significant difference at P<0.05.

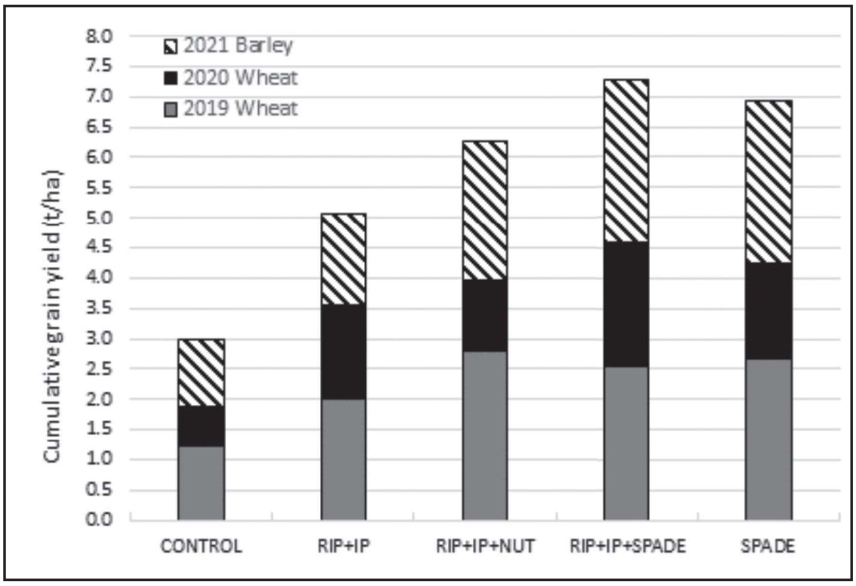

Figure 6. Cumulative grain yield (t/ha) of three cereal crops at Mt Damper.

At Cummins the ripping+inclusion plates treatment yielded significantly more (4.1 t/ha) than the untreated controls (which averaged 3.1 t/ha); there was no additional benefit from the application of 5 t/ha of surface applied gypsum (Figure 4).

Harvest cuts were taken by hand at Mt Damper and Karkoo in December (4 x 1 m crop row per plot) and extrapolated to grain yield (t/ha). The average barley yield for all treatments at Mt Damper was 2.1 t/ha. Spaded plots and rip + IP + nutrition had higher yields (ranging from 2.3 to 2.7 t/ha) than the control and rip + IP, which averaged 1.1 t/ha and 1.5 t/ha (Figure 5).

At Karkoo the average wheat yield across the site was 5.8 t/ha (with individual plots yielding 4.8 to 7.2 t/ha). Although the average grain yields were 0.8 to 1 t/ha higher on the ripped treatments compared to the control (which yielded 5.2 t/ha), these yield increases were not significant ($P>0.05 = 0.11$).

What does this mean?

In 2019 and 2020 it was hypothesised that rainfall timing and distribution was the major factor limiting crop growth and grain yield. In 2021, mild temperatures and good soil moisture combined with a lack of wind events at emergence saw no difference in crop establishment between treatments at all sites except Karkoo. Clay spreading at Karkoo has overcome water repellence, but the treatments with the highest level of soil disturbance (rip+ inclusion plate with or without OM) saw reduced emergence in 2021. This might be a result of uneven sowing depth following ripping with inclusion plates, or perhap the "topsoil slotting" of surface clay (residual from heavy clay spreading operations) deeper into the soil profile using inclusion plates has reduced its benefit in ensuring even germination. A more thorough mixing of the soil profile using a spader or other rotary machine might overcome these issues.

At Mt Damper, the more complete mixing of the profile to 30 cm using the spader resulted in much higher biomass in late winter compared to ripping with inclusion plates. These trends carried through to crop yield with the treatments which had the highest biomass at the end of winter also having the highest wheat grain yields. This may be due to the more uniform mixing and complete de-compaction of the top 30 cm that is achieved with rotary spading in comparison to deep ripping. The two treatments that included spading provided the highest cumulative grain yield after three years, providing more than 4 t/ha of additional grain (Figure 6).

Whilst the lentils at Buckleboo had good crop establishment, dry conditions in late winter saw a rapid drying and reformation of hardsetting subsurface layers, inducing restrictions to root development and crop growth. This might explain the lack of difference in winter biomass growth at this site and, as biomass production was checked by dry conditions, might explain the limited yield difference between treatments in lentils at this site.

Good growth across lower Eyre Peninsula saw high levels of biomass produced, with little visual difference between plots on either the Karkoo or Cummins trial sites. However, whilst the yield differences between treatments at Karkoo were not significant, at Cummins there was a significant yield increase compared to the controls in all ripped treatments. Ripping through a physically constrained layer in this shallow sand over clay has proven beneficial three years after it was deep ripped.

These trials 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 it can take some time following modification to see benefits.

Acknowledgements

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