Validating research outcomes to treat production constraints on sandy soils of Eyre Peninsula

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Location
Kimba, Mt Damper, Karkoo, Cummins
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Rainfall
Av GSR/2019 GSR
Kimba: 215/150 mm
Mt Damper: 218/250 mm
Karkoo: 334/307 mm
Cummins: 361/334 mm
Soil type
Kimba: 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 long x 12 - 18 m wide), 3 replicates
Yield limiting factors
Variable germination on Mt Damper site due to wind erosion on spaded plots.
Below average growing season rainfall resulting in very low stored soil moisture levels.
Hot windy days in the first week of October causing moisture stress at flowering.

Key messages

- **Production constraints on sandy soils can be overcome by mechanical intervention and the application of soil ameliorants, but the response can vary between sites and rainfall years.**
- **Despite observing large differences in crop growth between treatments at some sites, the variability within plots meant production responses were often not significant.**
- **Knowledge of the characteristics of the soil profile at depth is vital for identifying key production constraints and determining an appropriate and effective management strategy.**

Why do the trial?

There are around 5 million hectares of sandy soils under agricultural production in the low to medium rainfall areas of south-eastern Australia. These soils have multiple constraints limiting crop rooting depth and water extraction including water repellence, soil acidity, compaction and low organic carbon levels leading to poor biological cycling and nitrogen mineralisation. This can result in large differences between water limiting potential and actual crop yields.

In 2016 GRDC invested in a research program to help grain growers identify and overcome the primary constraints to poor crop water-use on sandy soils in the low-medium rainfall environment (CSP00203). The 'Sands Impacts' component of this project enables grower groups to test outcomes from the research component by applying targeted mitigation and amelioration interventions to overcome production constraints.

How was it done?

In collaboration with the Eyre Peninsula Agricultural Research Foundation and Lower Eyre Agricultural Development Association grower groups, four replicated validation trials were established at Kimba, Mt Damper, Karkoo and Cummins. Soil sampling was undertaken using a hydraulic drill rig to collect soil cores to a depth of 100 cm in March 2019 for site characterisation, pre-season nutrition and water repellence. Changes in texture and depth to carbonate were recorded and soil cores sub-sampled by profile layer, with composite samples sent for comprehensive laboratory analysis. Penetrometer resistance was also tested at each site to identify layers of high soil strength which might be affecting production.

The soil sampling identified subsurface layers of high soil strength and layers of low soil fertility at all four sites. Surface water repellence was also an issue at the Mt Damper and Cummins sites. Whilst the Karkoo site has had historical issues with surface water repellence, this was overcome when the paddock was clayspread (at around 250 t/ha) in the early 2000's. The Cummins site also had an acidic sandy A horizon with a highly bleached layer overlying a shallow sodic B horizon which causes regular waterlogging at the site.

Treatments were designed to address identified soil constraints and included a mixture of physical interventions with and without the application of soil ameliorants (Table 1). Additional nutrients treatments at Kimba and Mt Damper were calculated as the additional nitrogen, phosphorus, potassium, sulphur and trace elements needed for the difference between district average crop yield and water limited potential yield over a 3 year period (i.e. to supply potential production increases from addressing constraints).

Table 1. Summary of replicated trial sites (all sites were sown with wheat in 2019).

Co-operator / Location	Key soil constraints	In season measurements	Treatments
Baldock (TB) with Buckleboo Farm Improvement Group, Kimba	Physical, nutrients	Plant emergence, dry matter, crop yield	**Control** - untreated **Physical interventions** - deep ripping @ 35 cm, deep ripping @ 45 cm [+/- inclusion plates (IP)] **Soil ameliorants** - ripping+IP+ fluid nutrients (APP, high cost nutrition package, or low cost nutrition package)
Foster (MF) Mt Damper	Water repellence, physical, nutrients	Penetrometer resistance, plant emergence, dry matter, crop yield	**Control** - untreated **Physical interventions** - spading @ 30 cm, ripping @ 45 cm+IP, rip+IP @ 45 cm+spading @ 35 cm. **Soil ameliorants** - ripping+IP+nutrients
Modra (RM) Karkoo	Physical, nutrients. Note: Water repellence had been treated by previous clay spreading.	Penetrometer resistance, plant emergence, dry matter, crop yield	**Control** - clayspread **Physical interventions** - clay+ ripping @ 40 cm, clay+ripping @ 40 cm+ IP **Soil ameliorants** - 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	Penetrometer resistance, plant emergence, crop yield	**Control** - limed **Physical interventions** - ripping @ 30 cm, clay+ripping @ 40 cm IP **Soil ameliorants** - clay+ripping @ 40 cm+IP+5 t/ha gypsum

Treatments were applied in March and April 2019. At all sites except Kimba, soil ameliorants were spread on the soil surface prior to implementing physical interventions. At the Kimba site a liquid tank attached to the deep ripper (BigFIG's Paxton Plough) allowed different rates of nutrients to be applied as a liquid stream behind the ripping tyne. Very dry conditions over summer and autumn, with only 14 mm of rainfall between December 2018 and the end of March, made implementation of ripping treatments difficult at all sites. The ripping tynes brought up large clods of compacted sand at the Kimba, Mt Damper and Cummins sites. Landholders at each of these sites needed to roll the site after ripping to level the site ahead of sowing. Whilst the tracked tractor and commercial deep ripper used at the Karkoo site was able to achieve better traction than those used at other sites, the ripping tynes brought up large limestone boulders on several plots. As a consequence the farmer had to remove the boulders and the Karkoo site also required rolling prior to sowing.

The trials were all sown with wheat by the landholder and managed per the rest of the paddock. In-crop measures included plant establishment and grain yield. Opportunistic sampling for spring biomass was also gathered at Kimba, Mt Damper and Karkoo. Soil penetration resistance was measured when the sites were at field capacity, except at Kimba where this was not achieved due to poor in-crop rainfall (less than 150 mm of growing season rainfall), but only crop production measurements will be reported on in this report.

What happened?

Opening rains in May and June allowed all sites to be sown by late June. There was some evidence of soil drift from spaded plots at Mt Damper at crop emergence. Good July conditions saw rapid germination and crop growth at all sites, however very dry conditions in late winter, combined with poor subsoil moisture saw the crop struggle at Kimba during spring.

Plant density

Plant density was evaluated 3 weeks post sowing. There was no difference between the control or treated plots at Kimba or Cummins. Differences in crop establishment between treatments were only observed on the Karkoo site, with the clayed control and the clay+rip treatment recording between 14 and 19% more wheat plants than where inclusion plates were used (Figure 1).

At Mt Damper, average plant numbers at crop establishment were 27 to 38% lower on treated plots than the control (which had 96 plants/m2) (apart from on the rip+IP+spading treatment). However, very high variability in emergence across this site meant that these differences were not significant (Figure 2).

Biomass

Biomass at flowering was assesed at Kimba, Mt Damper and Karkoo. There was no difference in biomass production between the control and treatments at Karkoo. At Kimba ripping with inclusion plates resulted in an increase in biomass production of at least 33% compared to the control which yielded 5.4 t/ha. However, there was not a signficant benefit compared to ripping+IP alone (7.5 t/ha) from the addition of nutrients (Figure 3).

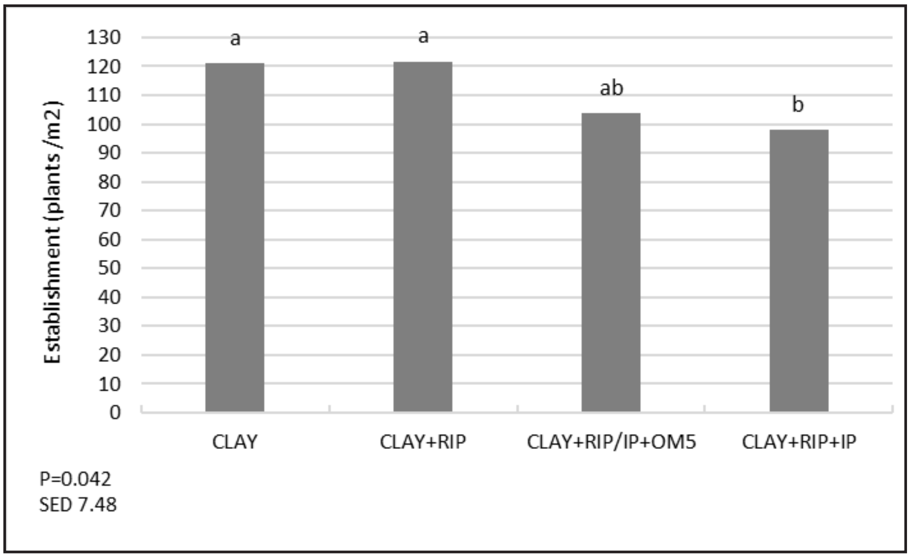

Figure 1. Plant densities at crop establishment at Karkoo. (Treatments that do not share a letter are significantly different from each other at P<0.05).

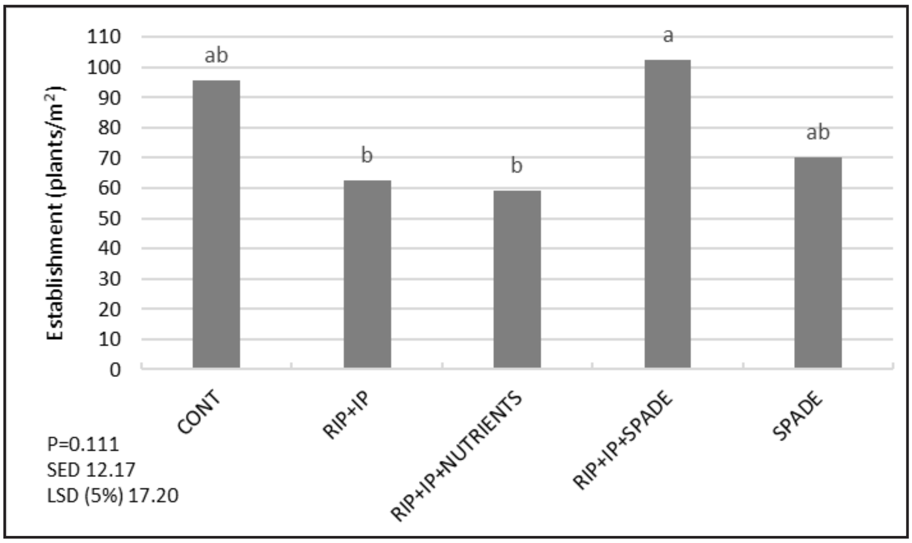

Figure 2. Plant densities at crop establishment at Mt Damper. (Treatments that do not share a letter are significantly different from each other at P<0.05).

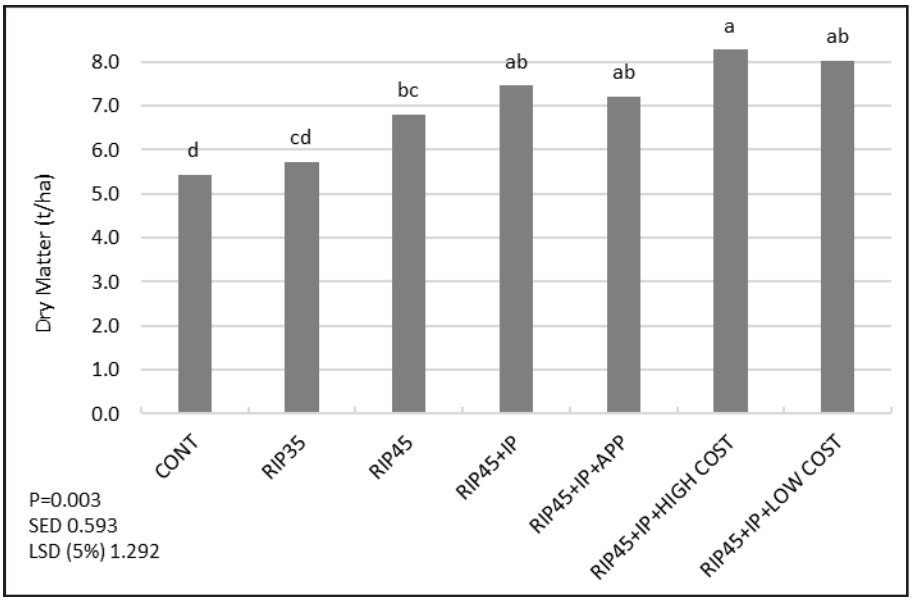

Figure 3. Spring biomass (t/ha) at Kimba. (Treatments that do not share a letter are significantly different from each other at P<0.05).

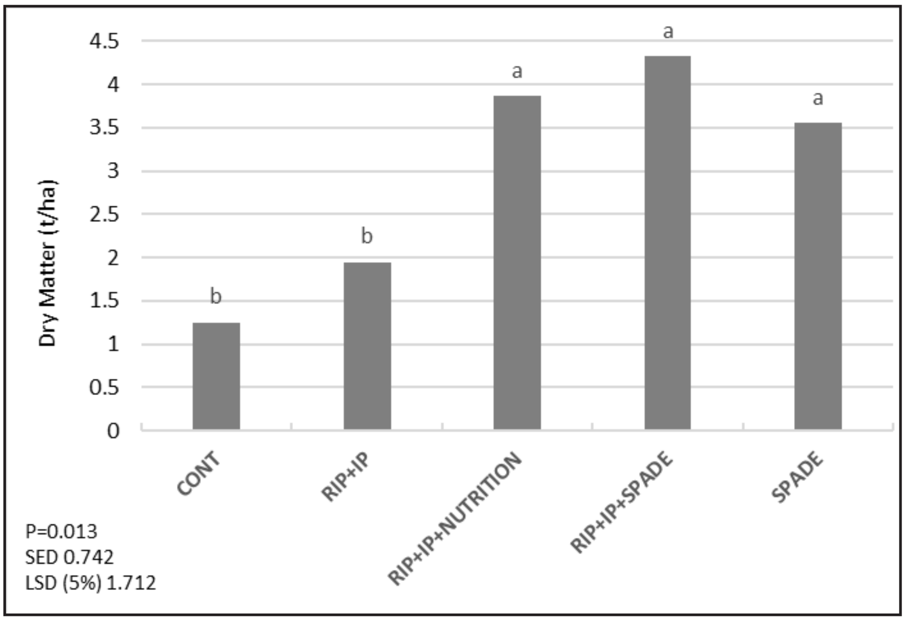

Figure 4. Spring biomass (t/ha) at Mt Damper. (Treatments that do not share a letter are significantly different from each other at P<0.05).

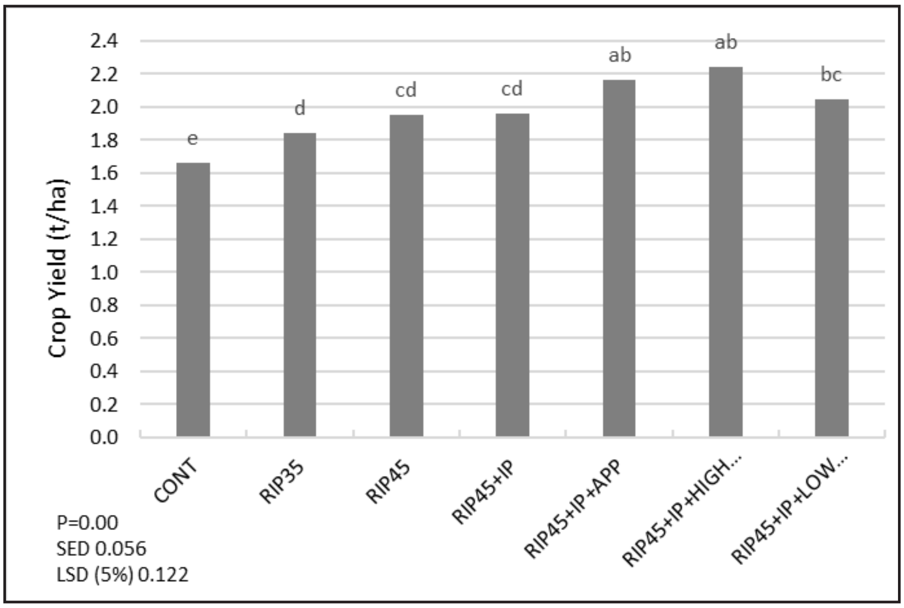

Figure 5. Wheat yield (t/ha) at Kimba. (Treatments that do not share a letter are significantly different from each other at P<0.05).

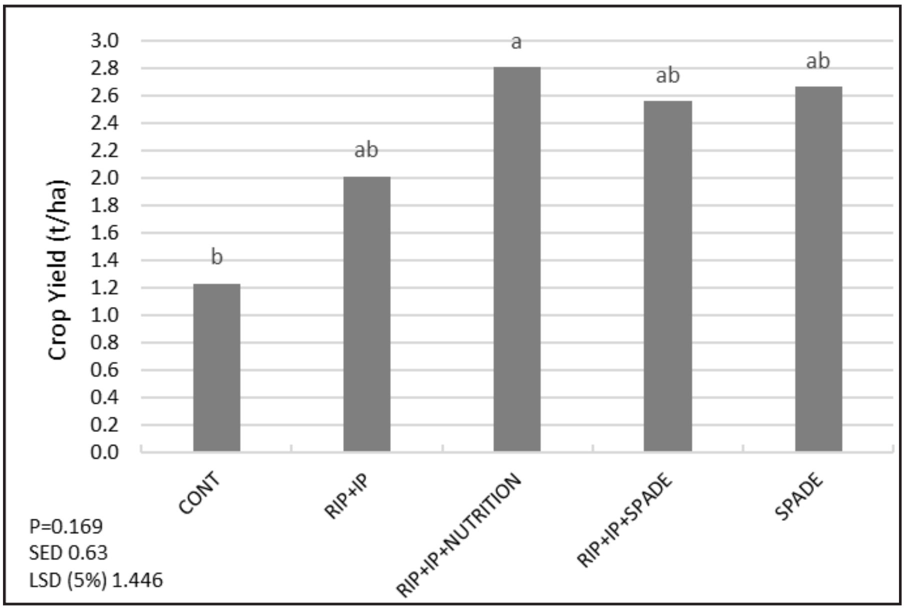

Figure 6. Wheat yield (t/ha) at Mt Damper. (Treatments that do not share a letter are significantly different from each other at P<0.05).

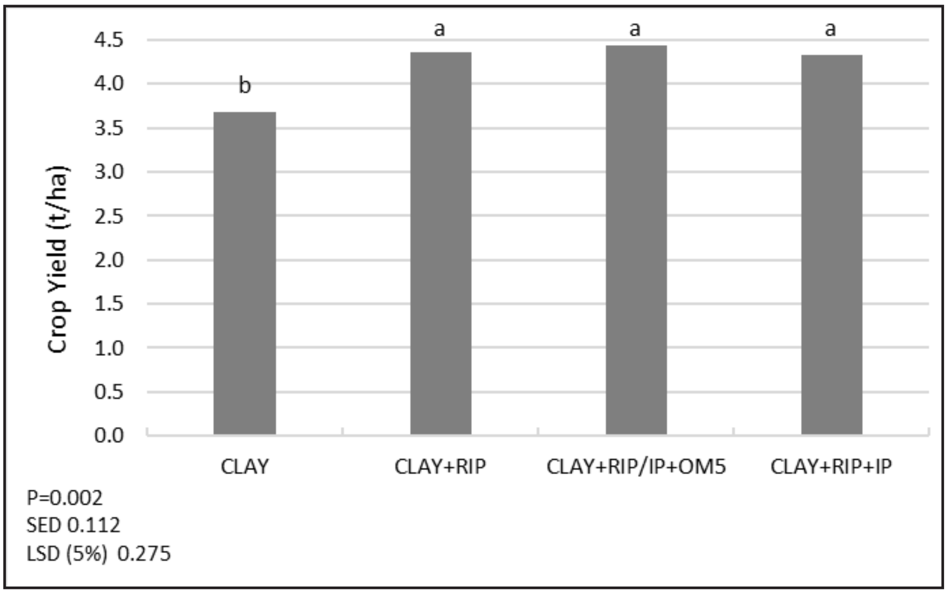

Figure 7. Wheat yield (t/ha) at Karkoo, 2019 (Treatments that do not share a letter are significantly different from each other at P<0.05).

At Mt Damper the spaded and rip+IP+nutrient treatments produced more than three times the spring biomass of the control (which yielded 1.3 t/ha) and double that of ripping+IP alone (Figure 4).

Grain yield

The trend of improved production from the ripping+IP+nutrients observed in the spring biomass at Kimba translated to grain yield increases of 25 to 30% (+0.4 to 0.6 t/ha) compared to the control (1.7 t/ha) and an additional 5 to 24% (0.1 to 0.4 t/ha) where extra nutrition was not applied (Figure 5). Whilst the high cost nutrition treatment yielded higher than the low cost treatment, it did not yield higher than where APP was applied in this season (Figure 5).

Whilst the grain yield from the spaded plots and the rip+spade at Mt Damper were more than double the control (which yielded 1.2 t/ha), only the rip+IP+nutrients was significantly different from the control (Figure 6). This is likely due to the high variability in response across the site.

At Karkoo there was an increase in grain yield by 18% from ripping compared the clayed control (which yielded 3.7 t/ha), however the use of inclusion plates and incorporation of organic matter did not result in additional grain yield responses in this season (Figure 7).

There was no yield response from any of the treatments at the Cummins site.

What does this mean?

Using mechanical interventions such as spading and ripping with inclusion plates resulted in improved grain yield of around 18% at some sites, with the addition of soil ameliorants producing an extra yield benefit. However, the results in this season were variable across the sites. This might be the result of a number of factors including:

- Highly variable seasonal conditions across the sites (i.e. very dry conditions at Kimba with more moderate seasonal rainfall at Mt Damper and on lower Eyre Peninsula) and the addition of extra nutrition at depth.
- Variability in crop emergence and growth resulting from factors such as soil drift following spading, and gross soil disturbance from ripping.
- Ripping with inclusion plates reduced crop establishment on some sites this season. Hopefully this impact will be reduced in future years as the soils settle.

A major factor in increasing yields on soils with production constraints is improving access to soil water. Good opening rains in May at Mt Damper meant that the expression of water repellence might have been less than normal. Meanwhile below average growing season rainfall on lower Eyre Peninsula meant that waterlogging, which is common at the Cummins site, was not expressed in 2019; this might explain the similarity in production from the treatments and control. At Kimba very much below average rainfall resulted in little moisture for crops to access in subsoil layers.

These trials support earlier work which suggests that 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.

Key questions that remain unanswered include:

- How long before responses from soil applied ameliorants can be expected?
- How long the gains may last?
- What are the implications for soil carbon?
- What are the costs/benefits of these treatment options?

Production on these trial sites will continue to be monitored in 2020 and 2021.

Acknowledgements

The GRDC funded Sandy Soils project (CSP00203) is a collaboration between CSIRO, University of South Australia, Primary Industries and Regions SA, Mallee Sustainable Farming Inc, AgGrow Agronomy and Trengove Consulting. The author would also like to thank the landholders involved in this project; Graeme and Heather and Tristan and Lisa Baldock, Matt and Rhianna Foster, Reece Modra and Scott and Mary-Anne Mickan as well as the Eyre Peninsula Agricultural Research Foundation (EPARF), Lower Eyre Agricultural Development Association (LEADA) and the Buckleboo Farm Improvement Group (BigFIG) for their support of these trials.