Treating production constraints on the sandy soils of upper and lower Eyre Peninsula - Year 2

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Location
Kimba, Mt Damper, Karkoo, Cummins
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Rainfall
Av. GSR/2020 GSR
Kimba: 215/251 mm
Mt Damper: 218/110 mm
Karkoo: 334/366 mm
Cummins: 361/336 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 x 12-18 m x 3 replicates

Yield limiting factors
Below average growing season rainfall resulting in very low moisture levels.
Hot windy days in the first week of September caused moisture stress at flowering.

Key messages

- **Production constraints on sandy soils can be overcome by mechanical intervention and the application of soil amendments, however, the response can vary between sites and years.**
- **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?

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 production including water repellence, soil acidity, compaction and low organic carbon levels leading to poor biological cycling and nitrogen mineralisation. Estimates of the yield gap (the difference between water limiting potential and average actual crop yield) are between 1.8 and 2.1 t/ha on Upper Eyre Peninsula and as much as 2.3 t/ha on Lower Eyre Peninsula (http://yieldgapaustralia.com.au/maps/).

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 EPARF and LEADA grower groups (now AIR EP), four replicated validation trials were established in 2019 at Kimba, Mt Damper, Karkoo and Cummins (EPFS 2019, p 99). Soil analysis 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 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.

Treatments were designed to address identified soil constraints and included a mixture of physical interventions with and without the application of soil chemical and nutrient amendments (Table 1) and were implemented prior to sowing in 2019. Nutrient treatments at Kimba 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. Plant density was evaluated 3 weeks post sowing and only the Karkoo site showed significant differences in crop establishment between treatments, with the clayed control and the clay+rip treatment recording between 14 and 19% more wheat plants than where inclusion plates were used. Opportunistic biomass at flowering was assesed at Kimba, Mt Damper and Karkoo with ripping with inclusion plates resulting in biomass increases of at least 33% compared to the control at Kimba, and at Mt Damper the spading ripping+IP, and rip+IP+nutrient treatments producing more spring biomass than the control.

Table 1. Summary of replicated trial sites.

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

2019 grain yield at Kimba saw increases of 25 to 30% from ripping+IP+nutrients compared to the control, and at Mt Damper whilst physical interventions saw a doubling of grain yields over the control, high variability across the site meant that only the rip+IP+nutrients gave a significant yield increase. Ripping at Karkoo gave an 18% increase in grain yield compared to 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 and at Cummins there were no improvements in grain yield from treatments.

What happened in 2020?

In 2020 all sites were sown by the landholders and managed as per the rest of the paddock. The upper EP sites were sown with cereals (Scepter wheat at Mt Damper and Compass barley at Kimba) with both of the lower EP trial sites sown to 44Y90 canola. Good opening rains of 25 to 43 mm were received in all districts at the end of April with a further 20 to 40 mm in early May. All sites except Mt Damper were sown by the end of the first week in May and germinated quickly. However, Mt Damper wasn't sown until 24 May and cool dry conditions had slowed growth when crop establishment was assessed in June.

There was some evidence of soil drift at crop emergence on the ripped plots at Cummins and Karkoo and the spaded plots at Mt Damper. A fifth trial was intended to be established at Wharminda to validate the use of modified tyne designs and wetting agents to mitigate production impacts from water repellent surface soils. However, continued low rainfall and very dry soil profiles (<2% gravimetric moisture to 20 cm) into late June made the risk of wind erosion and crop failure too high so the trial was postponed until 2021.

Plant density

Plant density was evaluated 4 to 6 weeks after sowing. There was no difference in plant density between the control or treated plots at any of the sites at this time. Very much below average rainfall was received at all sites from May to the end of July, with average August rainfall. Good rainfall in late winter and spring saw improved crop growth at Cummins, Karkoo and Mt Damper, but very dry conditions combined with poor subsoil moisture saw the crop at Kimba struggle during spring for a second year.

Biomass

Opportunistic biomass cuts were taken at Kimba and Mt Damper in August. At Kimba deeper ripping (45 cm) yielded 0.5 to 0.9 t/ha more biomass than the control (which yielded 2.4 t/ha), however, there was no additional biomass response from the use of inclusion plates or extra nutrition in 2020. Only the rip+IP with APP or high cost nutrient package gave increased August biomass compared to ripping at 35 cm in 2020 (Figure 1).

August biomass at Mt Damper was generally low (<1.0 t/ha), with rip+IP+spading the only treatment to produce more biomass than the control (which yielded 0.6 t/ha) (Figure 2).

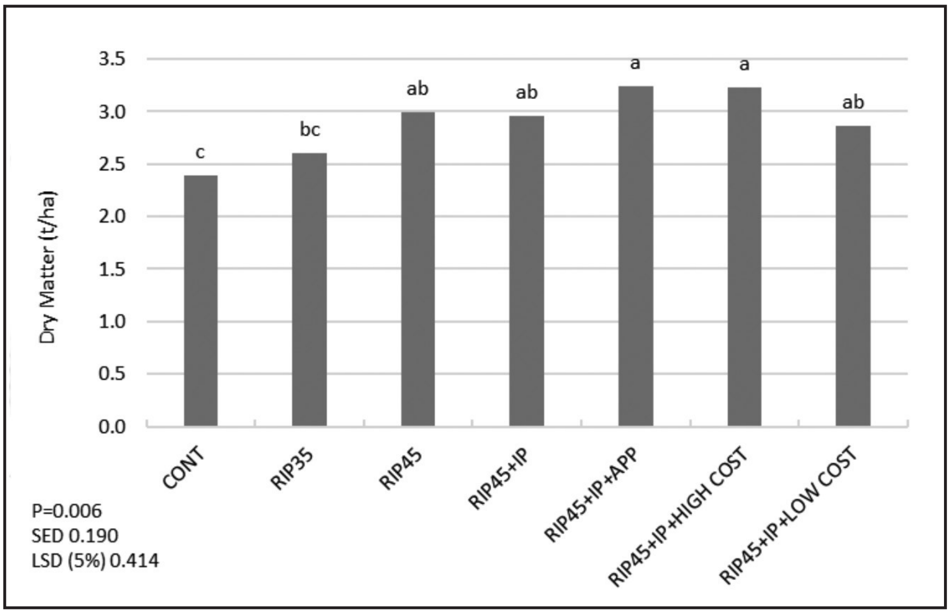

Figure 1. Winter biomass (t/ha) at Kimba. A different letter indicates a signficant difference at P<0.05.

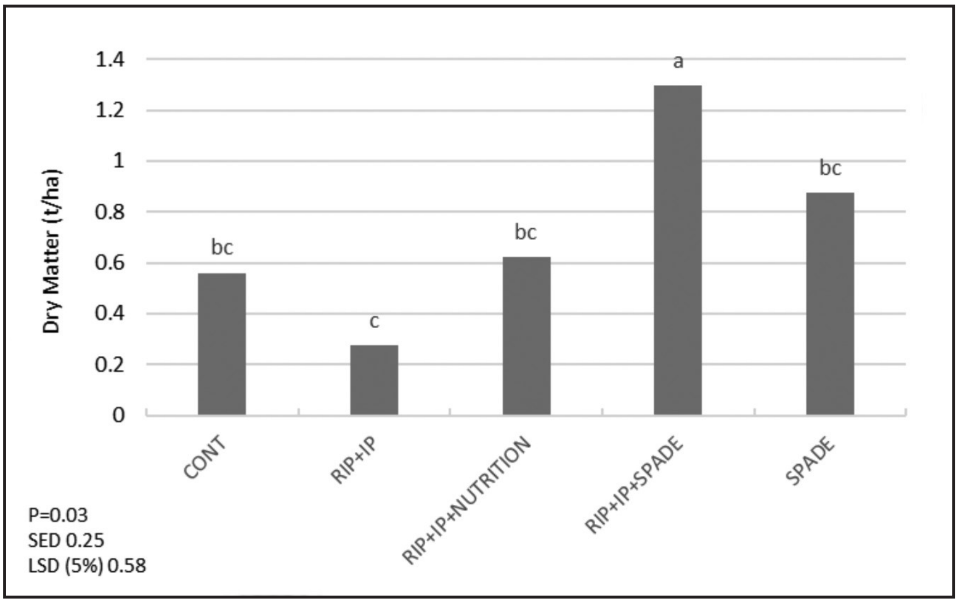

Figure 2. Winter biomass (t/ha) at Mt Damper. A different letter indicates a signficant difference at P<0.05.

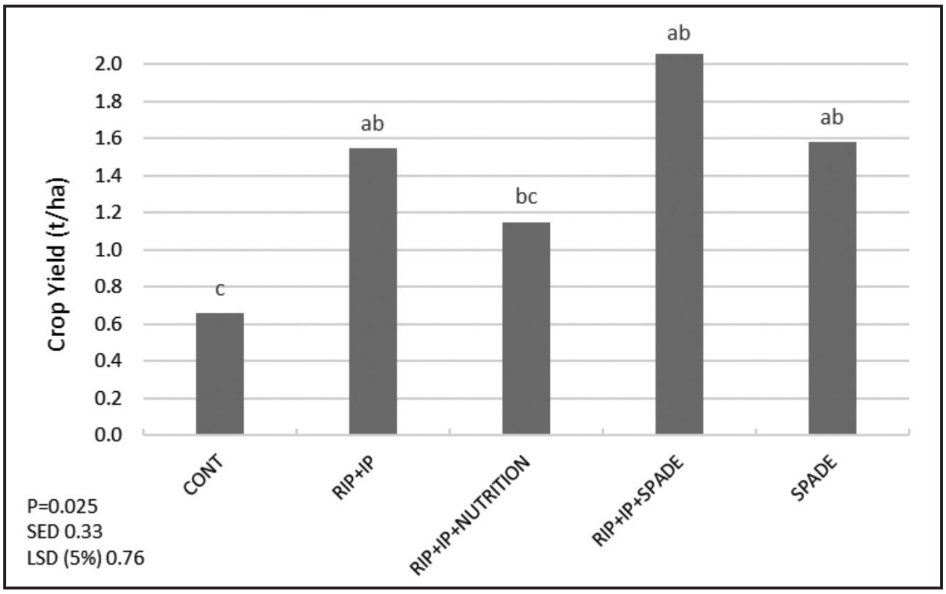

Figure 3. Wheat yield (t/ha) at Mt Damper. A different letter indicates a signficant difference at P<0.05.

Grain yield

At Kimba, Cummins and Karkoo the trials were harvested by the landholders in late October/ early November, yielding an average 1.7 t/ha, 2.7 t/ha and 2.3 t/ha respectively. There was no additional yield response from any of the treatments at any of these sites in 2020.

Harvest cuts were taken at Mt Damper on December 14. The heads were cut from 4 x 1 m rows, threshed and grain weights extrapolated to yield in t/ha. Grain yields varied greatly from 0.7 t/ha on the control to 2.1 t/ha on the rip+IP+Spade treatment. Whilst all treatments at this site except rip+IP+nutrients yielded more grain than the control there was no difference between the spaded plots and the ripping+IP (Figure 3).

What does this mean?

As in 2019 it is hypothesised that rainfall timing and distribution was the major factor in the results seen in 2020. All sites had good opening rainfall and the Kimba, Cummins and Karkoo sites which were sown by the first week of May, germinated well and had rapid early growth. Germination and early growth was slow at Mt Damper which wasn't sown until the end of May, and biomass growth at all sites was hindered by dry conditions between May and the end of July. Although April to October rainfall was more than 2019, much of it fell in October (ranging from 60 mm at Karkoo to 105 mm at Kimba) and was too late to improve grain fill in the barley at Kimba or canola on lower Eyre Peninsula.

Despite improved biomass at Kimba from ripping to 45 cm, this did not translate to improved grain yield this season. There are a number of factors which might have contributed to this, including:

- Hot drying winds in early September which caused some damage to flowering barley.
- Dry conditions throughout the growing season causing moisture stress.
- Below average rainfall to the end of September resulting in little subsoil moisture at grain fill.

In contrast, the crop at Mt Damper was able to better utilise the late spring rain on plots that had been physically altered (rip+IP and Spaded), resulting in substantial grain yield gains, even where spring biomass was not different to the control (Figures 2 and 3).

On Lower Eyre Peninsula good opening rains might have reduced the expression of water repellence at Cummins, with warm conditions providing ideal conditions for early canola growth. Meanwhile below average rainfall from May to August meant that waterlogging, which is common at the site, was not expressed in 2020 and might explain the lack of response from treatments.

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.

Key questions that remain unanswered include:

- How long before responses from soil applied amendments 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 2021.

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