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Yield benefits and economic analysis of laterite crushing on ironstone sheet soils – year 3

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Key messages

- Benefit cost analysis using the small yield benefit (up to 100kg/ha) found on shallow ironstone areas in this paddock (0−3cm topsoil over ironstone sheet) showed a nil to negative return on investment.
- In 2019, the season was too dry to measure a yield response.
- In 2020, in-season data was collected but the season was dry with a hard finish (0.7t/ha paddock average) and no yield difference was measured. While laterite crushing may increase plant available water capacity, recent seasons have provided very little moisture.
- Yield maps are critical for ongoing monitoring of paddock machinery-scale treatments where soil variability can confound treatment effects.

Aims

This research aims to evaluate the yield and economic benefits of using laterite crushing (in this trial the Reefinator was used) on ironstone sheet soils in the Lake Grace area. this practice is currently being used by growers on ironstone laterite soils around the state. Ironstone soils have high phosphorous fixation, low water holding capacity, and where ironstone sheets are shallow, they restrict rooting depth and general soil workability.

Methods

The site selected for this trial was characterised by scattered areas of ironstone gravel and sheets of cemented ironstone beneath relatively shallow topsoil. Two areas of heavy ironstone sheet were identified as north-east (NE) and south-west (SW) blocks. The trial compares 12m wide strips passed with a Reefinator on 22 February 2018, with nil (undisturbed) strips over 15 replicates of 470 m long passes. Monitoring in 2019 did not occur. In 2020, Latrobe barley was dry sown on 2 May.

Ten paired sample (PS) points across the paddock were measured in the growing season for calibrated Normalized Difference Vegetation Index (NDVI) at fourth node (GS34) to flag leaf emergence (GS38) (Figure 1). The site was harvested on 13 November. The crop was low in volume and therefore a weigh trailer was not used. The header recorded average yields across treatment strips and the average paddock yield was 0.7t/ha.

Results and discussion

Topsoil was sampled from three paired sampling points across the site on 16 March 2018. No notable differences were seen between laterite crushed plots and nil (control) plots. The samples taken at a site with ironstone sheet at 0−3cm showed a high phosphorous buffering index (PBI) of 78 in both treatments compared to sites with ironstone sheet below 3cm depth that had a lower PBI of 28.

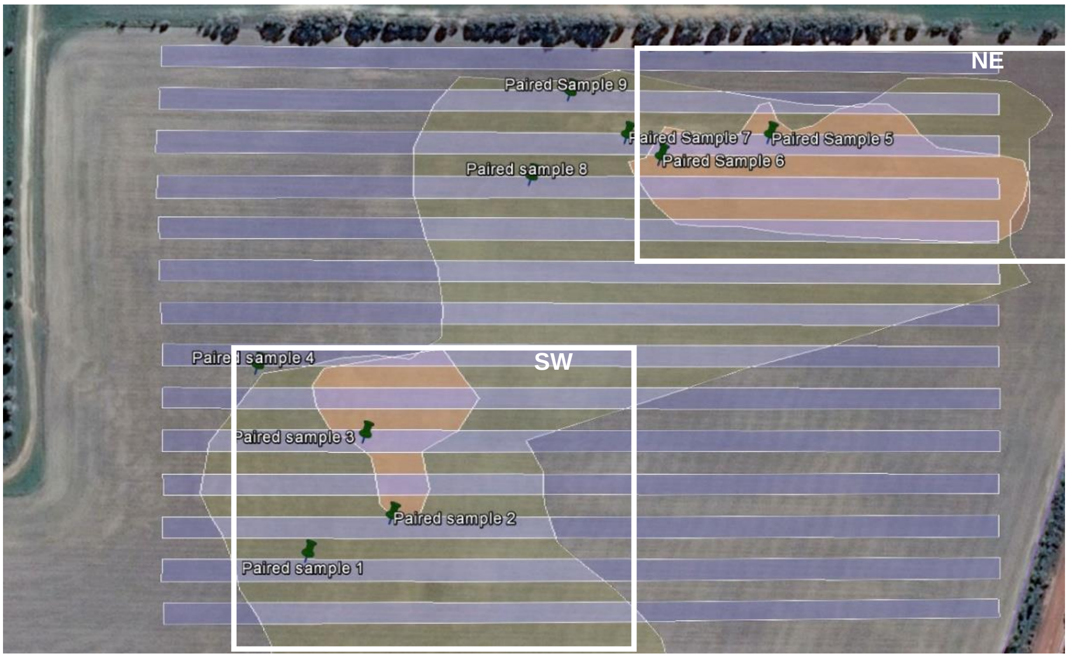

Figure 1. Trial layout and location of paired sample points for in-season monitoring. Purple strips indicate the Reefinator plots. Yellow and orange shading indicates ironstone sheet soil. There are shallow ironstone areas in the NE and SW blocks outlined.

In season dry matter (kg/ha) was calculated from NDVI calibration curves where dry matter cuts and NDVI had a strong positive correlation (R=0.946). NDVI readings taken at late stem elongation were calibrated to dry matter cuts and this linear relationship transformed the data into dry matter (kg/ha). The difference in plant biomass at some locations, such as sample point 3, was clearly visible (Figure 2 and 3). However, there was no significant difference in biomass between Reefinator-treated and nil plots (p=0.792). The variability between different sample points is shown in Figure 2.

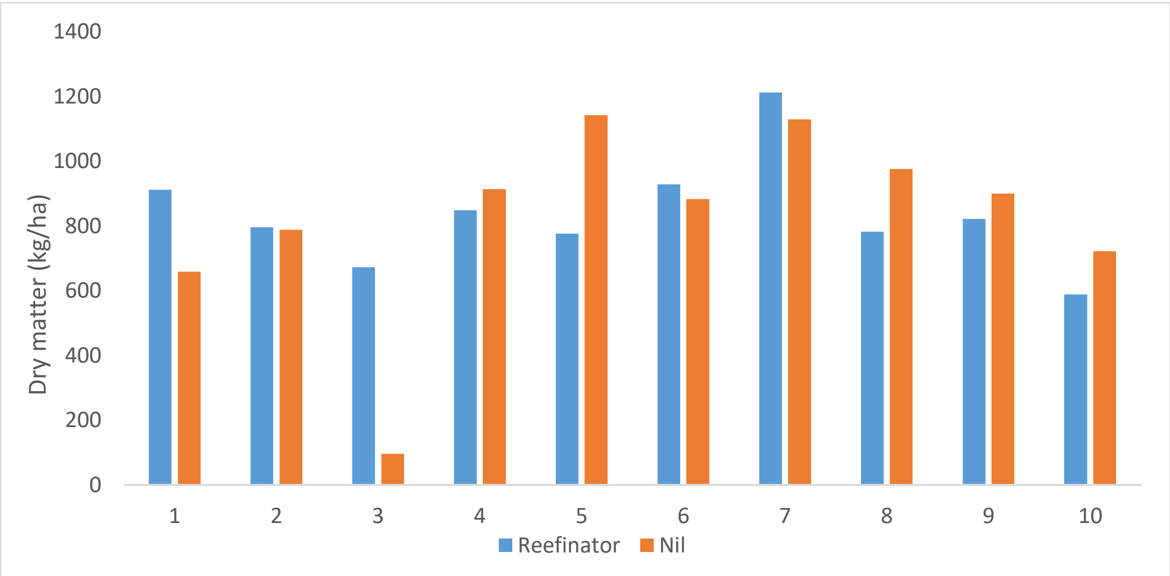

Figure 2. Calibrated dry matter (from NDVI) of treatments at each paired sample point at GS34-38 (13 August).

Figure 3. At sample point 3, laterite crushed soil was visibly distinct from untreated soil with establishment visibly better on treated soil.

Yield

Yield data in 2020 is limited. The grower decided not to use a weigh trailer due to the low volume of harvested grain, and high variability along the 500m long treatment strips that the grower believed would dilute any treatment effects that may have been present. Yield data was recorded by the header, but the map was not recovered from the header. The average yield from the trial area was 0.7t/ha. Harvest height was low and there were losses from the header front as a result. Based on the French and Schulz water use efficiency model and farm rainfall records, and using 90mm for evaporation, water use efficiency was very good at 22.

An overarching limitation of this study is the inherent variability within the paddock that cannot be controlled. As soil types and depth to ironstone changes, the effect of the laterite crushing varies. As such, there are areas identified in the paddock that may be responsive to treatment and other areas that are not responsive due to other limiting factors that affect crop establishment and yield. The past two seasons have been limiting in terms of seasonal conditions. While crushing the laterite may increase plant available water capacity (PAWC), recent seasons have provided very little moisture. This means that areas that may have a higher PAWC after treatment with the Reefinator have not had the opportunity to hold more water due to the low rainfall seasons.

Economic analysis

An economic analysis using the model ROSA (Ranking Options for Soil Amelioration; DPIRD) was conducted using 2018 yield data and modified inputs and costs. This indicated a negative economic return on a treated area of shallow laterite. Using a 5% rate and a $400/ha cost with a 10% yield improvement generates a near breakeven return and benefit-cost ratio (BCR) of 0.9 over 10 years. At 5% yield increase as indicated by the 2018 results at this site, the return is worse at 0.5 BCR. Discounting negates the cumulative benefit of small annual yield increases.

There is little reason to expect more than a small improvement to yield. Making gravel from ironstone to 20cm depth barely increases plant available water capacity (PAWC) in the surface layers and has no impact on the deeper layers. While crop density is improved, the major limitations of root volume and soil water are little changed.

Conclusion

Variability across the site in terms of soil type and ironstone distribution, as well as low rainfall seasons has reduced the ability to study yield response to laterite crushing. Data collected in 2018 indicates there may be a small yield benefit of about 0.1t/ha when using R on shallow laterite areas. A lack of spatial yield data has also made it difficult to study yield responses.
In this instance, areas where the ironstone was more than 5cm deep were either unresponsive to treatment, or treatment reduced productivity. At the observed response rate, there is negligible return on investment after ten years. Given the cost of crushing only areas of surface laterite should be treated.

It is recommended that further investigation be undertaken with particular attention to understanding the spatial variability of responsive soil and cost effectiveness of only targeting responsive areas. It is acknowledged that this activity was undertaken in seasons with very low rainfall, it is not known if responses would be different in higher rainfall seasons.

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