Stony Soil Amelioration For Patchy Dry Saline Land

SNAPSHOT

Farmer name: Travis Thiel
Location: Wunkar, SA
Farm size: 3500 ha
Enterprise: Cropping and sheep
Rainfall: 300 mm
Rotation: Continuous cropping (wheat, barley, vetch or chickpea) | One crop, one pasture for sheep.

Key messages

- Sand mulch was the most effective and practical treatment option.
- Manure was initially too rich (uncomposted) but improved crop growth over time. It should provide nutrition and organic matter for the long-term benefits.
- Straw mulch significantly reduced surface salinity, even after the first summer, showing the importance of always maintaining soil cover.
- Reefinating had some beneficial impact by mixing the soil, diluting the salts and breaking stone for better root growth, particularly when incorporating applied sand. However, reefinating-in the sand mulch only produced a slight advantage over surface sand applications.
- Continuously cropped areas showed a greater reduction in saline patches over two years than grazed volunteer pasture areas. This was because the cropped areas maintained more soil cover.
- Dry saline land areas left bare had a dramatic increase in surface salinity (up to 6 times crop toxicity levels) after the dry summer period leading into the 2024 season.

TREATMENTS

Figure 1. shallow stony areas impacted by dry saline land

Figure 2. Typical dry saline land area appearing after dry summer/autumn

INTRODUCTION

The soils on Travis Thiel's farm are about 70% loam, 20% red flats and 10% rocky calcareous country. Dry saline land patches have always been present on the rocky loam and grey calcareous soils. They are small problem areas (<1% of the farm) that Travis has not treated in the past.

THE TRIAL

The trial was set up in January 2022 on a stony, calcareous soil with large patches of variable salinity levels (Figures 1, 2, 11, 12). Salinity levels ranged from extremely severe in manure strips to least severe in the reefinated control. The initial blue bars in Figures 11 and 12 were soil tests taken before treatments were applied, from the worst saline patches within each plot. 1 dS/m is considered toxic to most cereal and pasture plants, although surface levels can quickly change for a period after high rainfall.

One section of the paddock was fenced to exclude animals and test the impacts of grazing on dry saline land (Figure 3). In 2022, the fenced area was sown to cereal and the rest of the paddock was volunteer pasture. Both areas were sown to cereal in 2023. The treatment strips were each 60 m long by 10 m wide, and included:

- Control
- Sand at approximately 8-10 cm depth (roughly 1000t/ha)
- Pig manure spread to 8-10 cm depth (roughly 250t/ha)
- Hay straw spread to 10-15 cm depth (roughly 40t/ha)

The amendments were surface spread. Half of each amendment strip (except straw) was then mixed into the top 25 cm using a Reefinator (Figures 4 and 5). A Reefinator aggressively rips, breaks and rolls shallow, stony soils. The machine was chosen for its ability to break up the stone and hard setting clay layer and to mix in the various treatments applied at this site. It was thought this would help dilute the saline surface layer and reduce the evaporation and capillary rise that brings salt to the surface. Strong summer winds blew some of the surface applied sand onto the surface manure strip on one of the worst saline scald areas. This provided an extra sand/manure area for comparison.

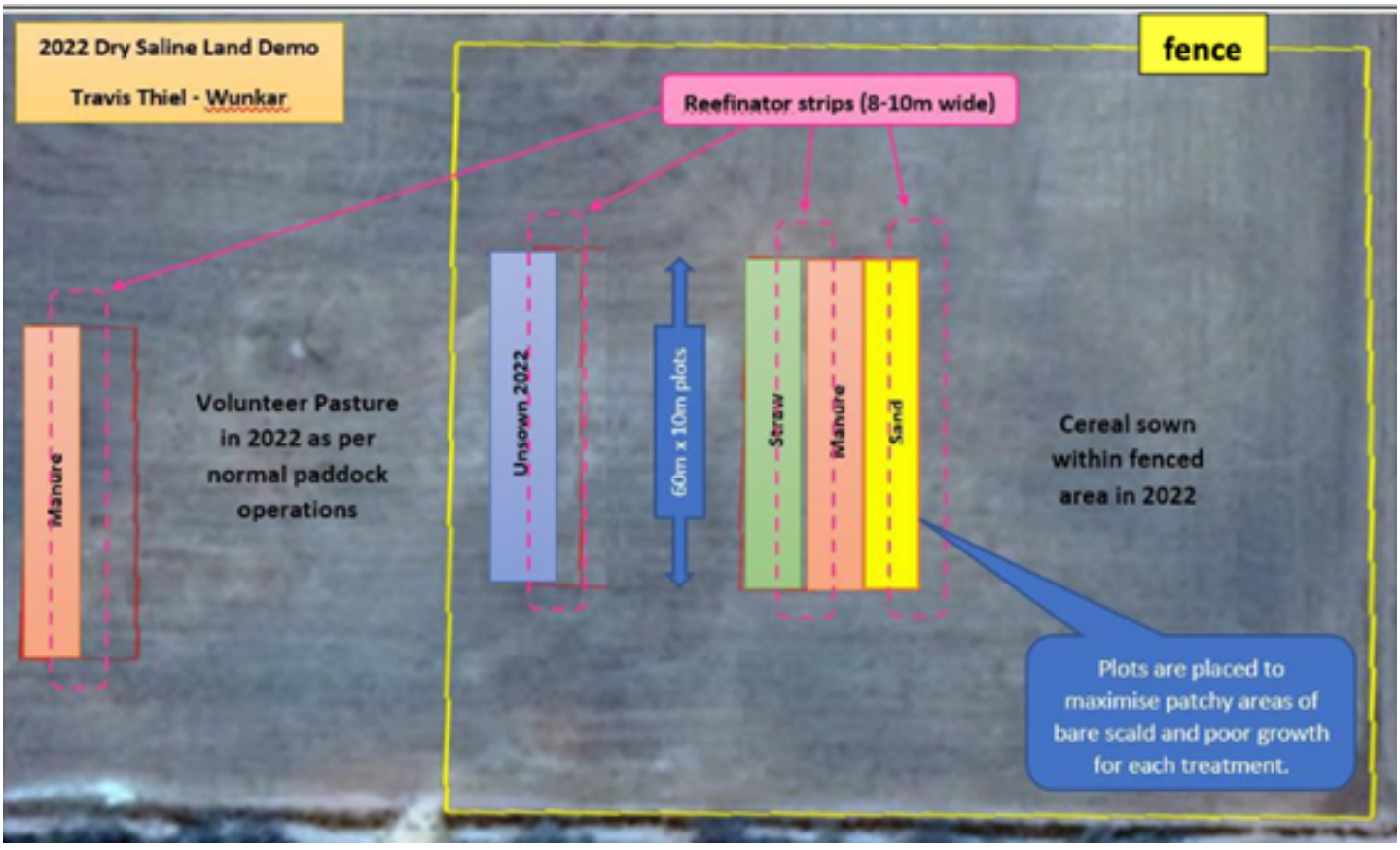

Figure 3.Trial plan showing treatment strips and reefinated areas

Rainfall

2022 had a fairly dry start that brought significant salt to the surface. However, 35 mm of rain at the end of May reduced topsoil salinity resulting in increased plant germination and a general decrease in the size and severity of saline patches. 2022 finished with above average rainfall that leached some surface salinity deeper in the profile. The 2023 season was hot and dry through to March, bringing salt back to the surface layers. Average rainfall in June likely had little impact on soil salinity, and the season had a very dry finish apart from one large November rain.

Figure 4. Reefinator in action

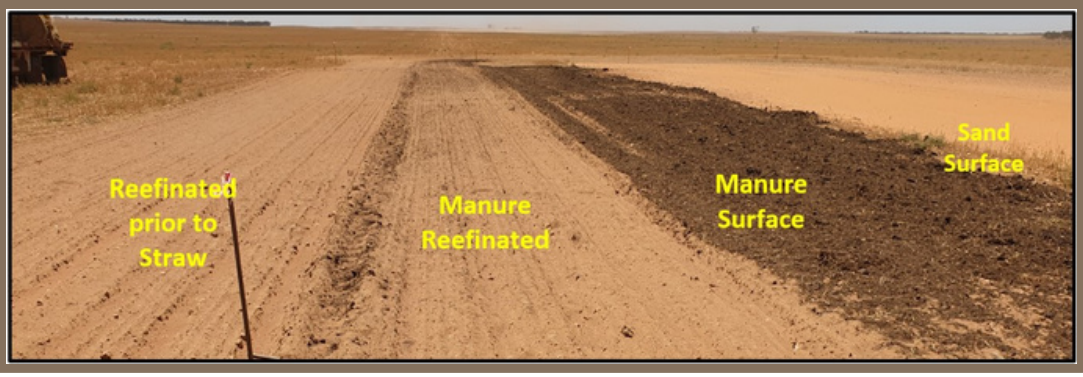

Figure 5. Pig manure and sand mulch treatment strips prior to Reefinating (above)

Figure 6. Site preparation, Reefinating half strips (left)

RESULTS

Given the large variability in the dry saline land patch size and severity, treatments were assessed based on how well each promoted plant growth in the most severe saline areas.

All treatments in the cropped area improved soil salinity to a depth of 20 cm (Figure 11), partially due to significant rainfall before testing, followed by a wet spring entering the 2023 season. Figure 7 clearly shows that sand, the sand/manure mix, or Reefinated sand gave the best crop growth results on the most severe saline patches. This was due the added sand providing a low salinity layer for seeds to germinate in, and acting as a mulch for the following two summers.

Overall, the expense and effort of Reefinating the sand, given its minimal growth increase impact over surface sand alone, may be hard to justify. However, Figure 14 does show that Reefinating alone helped dilute the surface salinity enough to allow for a greater coverage of volunteer pasture, which is very useful if maintained.

Trial manager Chris McDonough said, “If you are going to reefinate, you’re doing it for all the other reasons of rootzone soil access, not just for dry saline land management.”

Sand

The most noticeable visual differences in crop growth were where sand was placed on the soil, or where sand was Reefinated into the topsoil. In 2022, these areas were the first to emerge (Figure 8), which was likely due to both the large reductions in measured soil salinity, as well as the having more plant available water retained around the seed during the dryish start to the season.

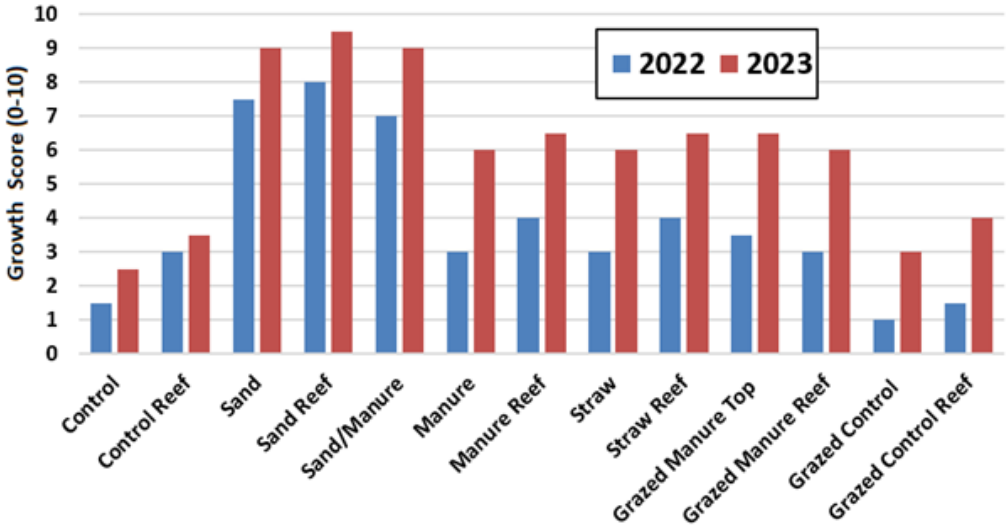

Figure 7. Plant Growth rating in worst patches of each treatment plot in 2022 and 2023

Topsoil salinity under the sand mulch dropped from 3.6 dS/m in December 2021 to 0.4 dS/m in February 2024, while the sand layer remained at low 0.31 dS/m (Figure 9). In future it would be safer to apply the sand much closer to seeding (rather than in January) to avoid the risk of wind erosion removal (Figures 13 & 15).

Figure 8. Patchy crop germination on surface manure (left), excellent germination on sand (right), June 2022

Manure

The manure strip was placed on a scald patch with extremely toxic salinity levels (over 7 dS/m EC1:5 from 0-10 cm). Emerging seedlings had to work hard to grow through the manure. In 2022, this effect was obvious in the volunteer pasture area (Figure 9), however, the crop did eventually push through without showing obvious signs of too much heat or nutrition from the raw, thick manure layer. By 2023 the manure had composted further and stabilised, and crop growth was far greener and healthier in the less saline areas of these treatment strips (Figures 15 & 16).

Figure 9. Patchy crop establishment through thick manure layer, 2022

Figure 10. Generally improved 2022 crop germination across treatments

Applying the high rates of manure (up to 50 t/ha) was also a challenge. Travis speculates that if they could have spread the manure more evenly it might have worked better. “We piled it and used a loader to push it around but it didn’t work as well as it should have. Manure needs to be fine enough to pass through the reefinator pegs which are about 100 mm apart. Clumps of manure block the machine up then just drag it so it won’t bust up rocks very well. Maybe finer chicken manure would work better,” he said.

Impacts on topsoil salinity were similar between manure mulch and manure reefinated into the soil (Figure 11). Despite starting with a very high topsoil salinity of 7.4 dS/m, salinity dropped to 3.2 dS/m by May 2022, and 1.8 dS/m by February 2024. While this level is still considered toxic for crops, resulting in very patchy growth on these worst areas, the manure layer is still providing surface cover that prevents salt accumulating in the surface. Over time we expect this desalinisation, and the organic matter and nutrition from the manure to further support crop growth.

Straw

Reefinating then spreading straw initially had a bigger impact on soil salinity than spreading straw mulch alone (Figures 6, 10 & 11). Salinity levels from 0-10 cm dropped from 3.2 dS/m in December 2021, to 0.71 dS/m in May 2022 possibly due to the salt dilution from mixing layers, and the increased leaching after rain. However, salinity increased to 0.9 dS/m in later tests which may be due to uneven distribution of the straw (Figure 18).

While the surface straw significantly reduced topsoil salinity compared to the bare control (EC1:5 of 5 dS/m), it had nowhere near the level of consistently impressive crop growth of the surface sand treatment. Despite the measured salinity and the thick mat cover of straw, the crop still managed to emerge well in both strips.

This, along with other trial sites show that straw spreading remains a viable option for dry saline land management where sand may not be accessible or practical.

The changes to soil salinity may be slower and the cover must be maintained (not overgrazed, burnt or eroded) to achieve significant improvements with straw mulch.

Reefinator

Reefinating generally imporved plant growth as it mixed the treatments into the soil, diluted salts in the topsoil and broke stone allowing for better root penetration. With a highly patchy site and limited soil testing it was not clear if reefinating led to lower soil salinity over time. Reefinating is expected to improve this sites production prospects throughout the season, compared to the undisturbed section.

Reefinating the ungrazed volunteer pasture area (Figure 14) led to a clear increase in plant germination. This was maintained throughout the 2022 season. While Reefinating alone is not as impactful as surface sand, Reefinating can be initially beneficial and encourage soil cover. Maintaining the soil cover should lead to gradual, long-term improvements.

Grazing / pasture

Dry saline land is highly vulnerable during pasture phases. Sheep tend to camp and bare these areas, increasing evaporation and salt accumulation, especially over summer, while reducing the seed source needed for land rejuvenation when leaching rains arrive.

In the grazed area, the dry saline land patches had less cover over summer, with all areas remaining toxic at 0-10 cm entering the 2023 season (red lines in Figure 12). Figure 14 also shows more substantial crop growth in the ungrazed areas than the grazed areas through the fence on the edge of the scald.

In 2022, sowing crops produced greater plant growth on the original bare scald zones than in volunteer pasture sites. This suggests that deeper soil mixing and seed placement, coupled with leaching rains, facilitated plant germination and growth. Volunteer pasture seeds often remain on the more saline, crusty surface, hindering their germination and growth.

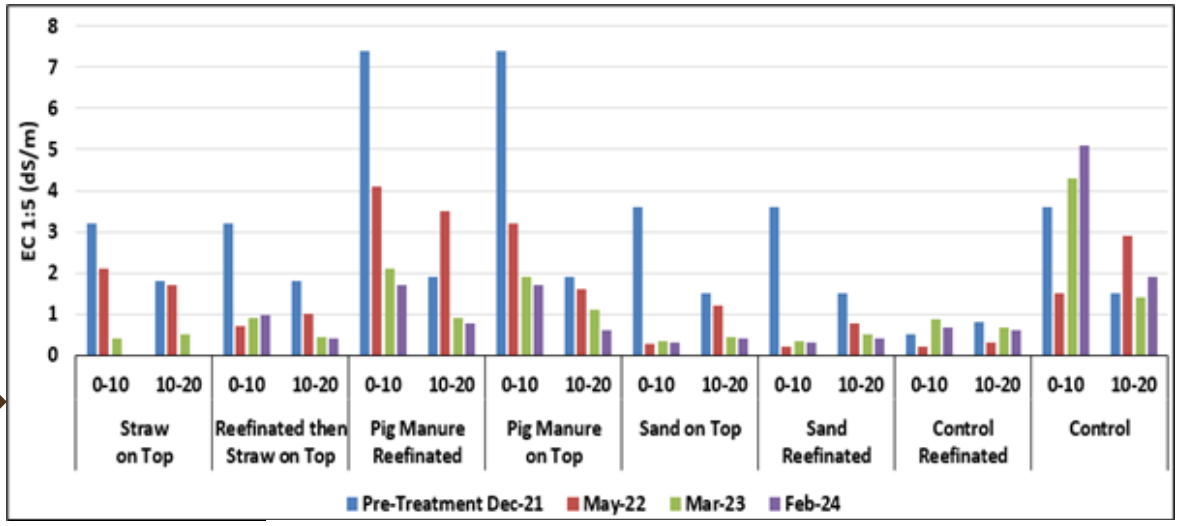

Figure 9. Patchy crop establishment through thick manure layer, 2022

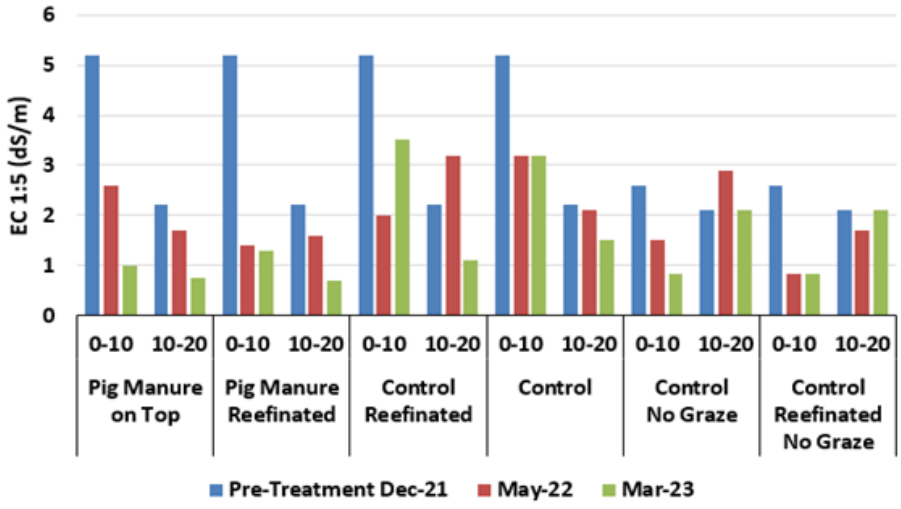

Figure 12. Soil salinity levels for treatments over 2 years on the grazing / pasture sections

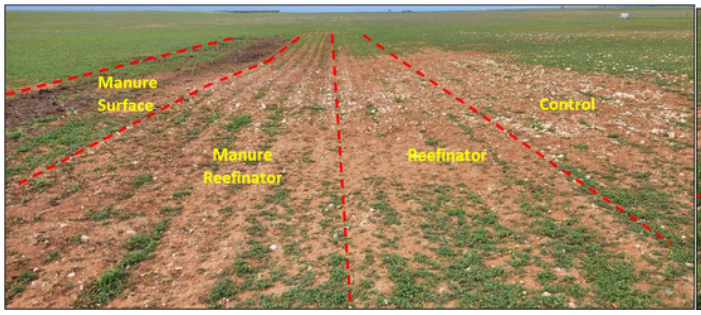

Figure 13. Volunteer pasture strips in treatments in June 2022, after summer grazing

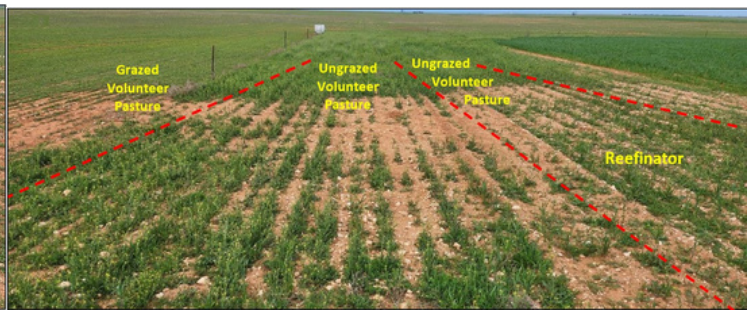

Figure 14. Reefinating alone improved ungrazed volunteer pasture growth, 2022

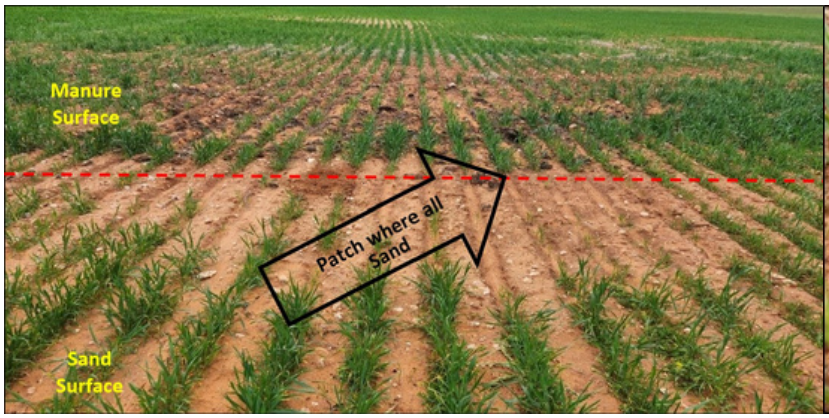

Figure 15. Severe saline patch, where wind removed all sand onto surface manure, 2022

Figure 16. 2022 applied 8 cm surface sand on scald in 2023

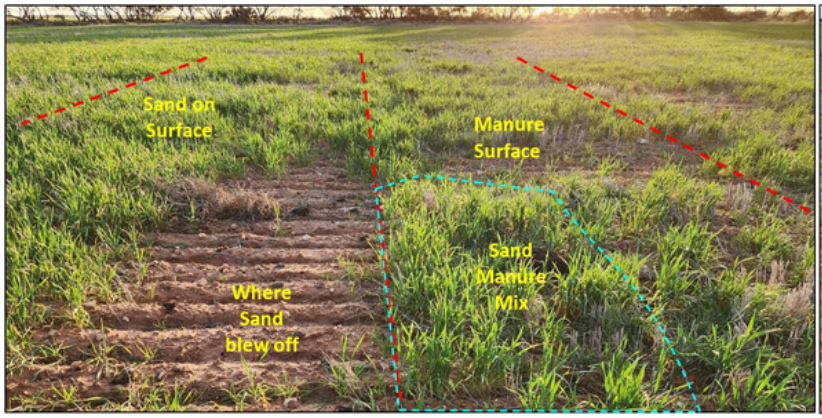

Figure 17. 2023 crop growth in surface sand and manure treatments

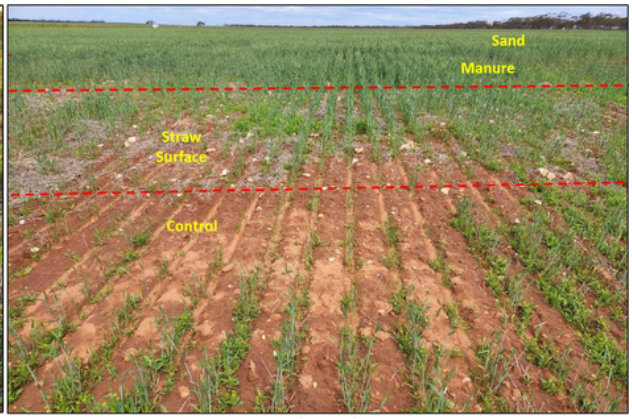

Figure 18.Impact of surface straw in 2023 season compared with bare control

NEXT STEPS

To Travis, the stand-out treatment was reefinating then spreading sand. “Ideally I would reefinate, then spread sand, then reefinate again to mix the soil and crushed up rocks together. But mixing in sand seems to be winner,” he said.

However, Travis found the time, cost and effort of using the Reefinator on top of spreading amendments was too high.

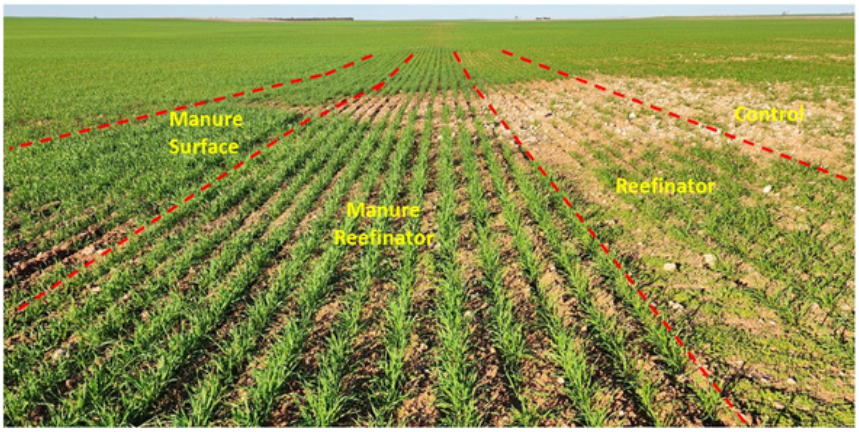

Figure 19. Grazed section, 2023 improvement in manure plots in 2nd season

From a practical perspective, just spreading sand is effective enough and Travis says that if he had a big block or area of dry saline land, he would just plant trees or salt bush.

As the patches of dry saline land are not a major issue on Travis’ farm, he is not yet treating them. However, Travis said, “if I had to tackle this problem on a larger scale, sand would be the choice. It gives the plant something to grow in. The limestone doesn’t give it anything to grow in.”

This project is being led by Mallee Sustainable Farming and has been funded through the Australian Government’s Future Drought Fund, and is supported by the South Australian Drought Resilience Adoption and Innovation Hub. Project delivery partners are AIR-EP, Primary Industries and Regions South Australia (PIRSA), South Australian Research and Development Institute (SARDI), Trengove Consulting, Ag Consulting and Research, Northern Sustainable Soils, and Insight Extension for Agriculture. Case studies compiled by Alluvio Pty Ltd.

PROJECT INFORMATION

The site was established by Chris McDonough, Insight Extension for Agriculture in conjunction with the Wunkar Agricultural Bureau.
Thanks to Travis Thiel for hosting the trial.

Building resilience to drought with landscape scale remediation of saline land.
Activity ID - 4-H8FU6SC

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