The Do's and Dont's of Soil Ameliorations for Dry Saline Land

SNAPSHOT

Farmer name: Matt Starick
Location: Punthari - 15km north-west of Mannum, SA
Farm size: 1500 ha
Enterprise: Cropping
Rainfall: 300 mm (GSR)
Rotation: Legume /canola then 3 cereals

Key messages

- On heavy soils, surface-spreading sand and manure to can lead to dramatic improvements to dry saline scalded areas.
- Seeding directly into thick manure layers can inhibit crop germination in year one.
- Attempting to incorporate sand and manure into the top 30 cm of soil can be extremely detrimental as saline/sodic clays are brought into the surface layer.
- At present, the safest amelioration strategy is to apply a non-saline layer to germinate and grow crops. Maintaining this cover will reduce rootzone salinity over time.

TREATMENTS

Straw mulch

Sand mulch
Low-rate @150-250 t/ha
High-rate @ 250-500 t/ha

Manure

Dry saline land patches.

INTRODUCTION

The soil at Matt Starick's farm near Mannum, South Australia, ranges from shallow limestone ridges to 'good' deep sand, gutless sand, duplex soils and heavy loam flats. "You name a Mallee soil, we probably have it,' Matt said.

A patch of dry saline land began appearing on the duplex soils after the original topsoil eroded, leaving the heavy clay subsoil closer to the surface. The patch is gradually getting worse and needs very high levels of rainfall to improve (to lower surface salinity) for a crop to establish.

Soil salinity in the bare patches ranged from 2.5 – 4.1 dS/m (EC1:5) in the top 10 cm (Table 1), which is extremely saline, but also quite variable. The highest salinity areas had generally suffered wind erosion, exposing more clay to the surface and making it more susceptible to further degradation.

INTRODUCTION

The aim of this trial was to test if different soil amendments could:

- Improve crop germination by spreading sand and manure on top of patches.
- Reduce capillary rise of salt from the subsoil to the surface by spading these topsoil treatments into the top 30 cm.

The trial was set out on a dry saline land patch approximately 3 ha in size in May 2022. Treatments were surface spread in 10 m x 50 m strips and included:

- 8-10 cm of sand
- Manure
- Sand/manure mix

Table 1. Initial soil tests in bare patches in March 2022, before the treatments were applied in May.

	Depth (cm)	Salinity ($EC_{1:5}$)
Control	0-10	2.5
	10-20	3.0
	20-30	2.4
Sand	0-10	2.5
	10-20	2.6
	20-30	2.1
Sand/Manure	0-10	4.1
	10-20	3.0
	20-30	2.3
Manure	0-10	4.0
	10-20	3.2
	20-30	2.7

Half of each strip was deep ripped and spaded to 30 cm depth (see Figures 1-4). This was to try and change the soil texture, dilute the salinity, improve infiltration and salt leaching, increase rooting depth and improve the soil fertility by incorporating the ameliorants (see Figures 1-4). The site was sown to barley in 2022 and 2023.

The size and severity of the saline patches was initially highest within the manure and sand/manure mixed strips (Table 1).

Figure 1. Spreading manure and sand treatment strips, May 2022

Figure 2. The trial spader worked to approximately 30 cm in heavy clay after deep ripping.

Figure 3. Manure, sand/manure and sand strips spaded and left on the surface

Figure 4. Trial site overlay on Aug 2023 Google Earth image, 2nd season after treatment

RESULTS AND RECOMMENDATIONS

The site was monitored through visual assessments of crop growth and soil salinity tests.

Impacts on soil salinity

The 2022 season had high early season rainfall and very high late season rainfall, which generally reduced surface salinity. This is evident in the Control soil salinity levels, which were lower in 2023 than in 2022 (Figure 5). However, the very dry 2023 season saw any bare patches return to very high salinity levels, particularly in the surface layers.

In the spaded strips, salinity levels were either maintained or increased in the top 20 cm (Figure 5). The exception is the sand/manure and manure strips, which had a minor reduction in salinity from the 2022 rainfall.

In the non-spaded areas, soil salinity continued to decline, with sand layer proving the most effective in lowering topsoil salinity (Figure 6). Impacts on soil salinity extended to 30 cm depth. Salinity in the original 10-20 cm soil layer (now at 20-30 cm depth as it is under 10 cm of sand mulch) dropped from 2.6 dS/m in 2022 to 0.7 dS/m in February 2024.

The surface sand mulch has been highly effective in restoring soil health. It helps cover crops establish, which provide residues that protect the soil from summer heat. Because sand has coarse particles, it also limits salts wicking to the surface.

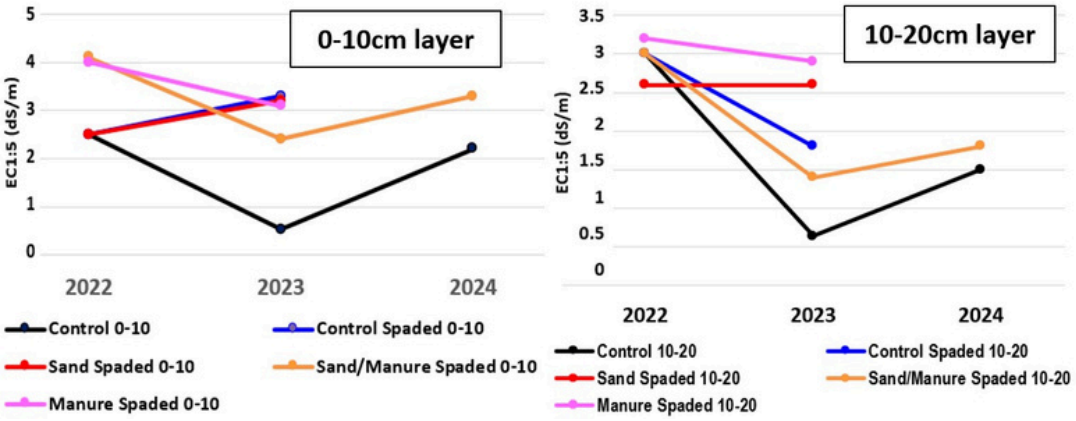

Figure 5. Salinity comparisons between control & all spaded treatments

Impacts on crops

Surface sand produced immediate and lasting crop impacts (Figures 8 and 9). These strips had an 8/10 growth rating in 2022 and 10/10 in 2023. Other surface mulches performed well by the second season.

The manure and sand/manure mix areas did not establish well in 2022, most likely because:

1. The manure was initially too rich (uncomposted) for the crops, and
2. Higher initial surface salinity topsoil levels in these strips (Figures 7 and 10).

However, the manures would have composted *in situ* over the first year and by year two the benefits were clear. Both the manure and sand/manure strips improved to an 8/10 growth rating in 2023 (Figures 7 and 11), despite the lower rainfall season. This is likely due to the manure and manure/sand acting as a less saline surface layer for seeds to germinate in, protecting the soil over summer to stop salt wicking to the surface, and nutrition supplied by the manure.

While the soil test results (Figure 6) showed soil salinity was still too toxic for crop growth, these soil samples were taken from the worst areas which still presented as small zones of patchy growth in 2023 (Figure 11). The majority of the plot was vastly improved.

It will be interesting to see the longer-term impacts of each of these surface treatments, and which sustains the best ongoing benefits.

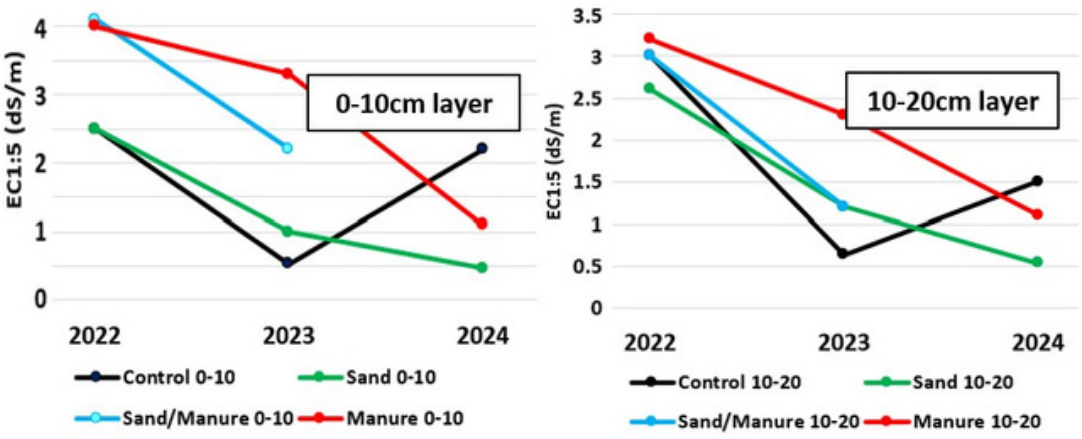

Figure 6. Salinity comparisons between control & all 2022 surface-spread treatments

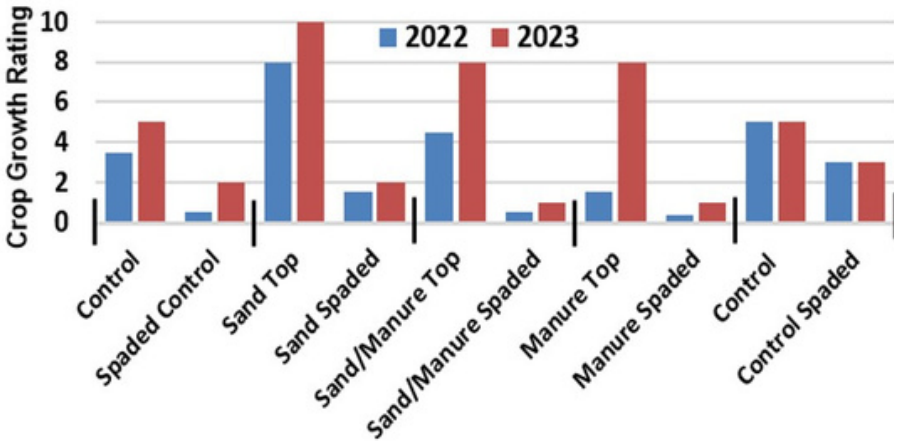

Figure 7. Mid-season plant growth rating (0-10) for each treatment over two years

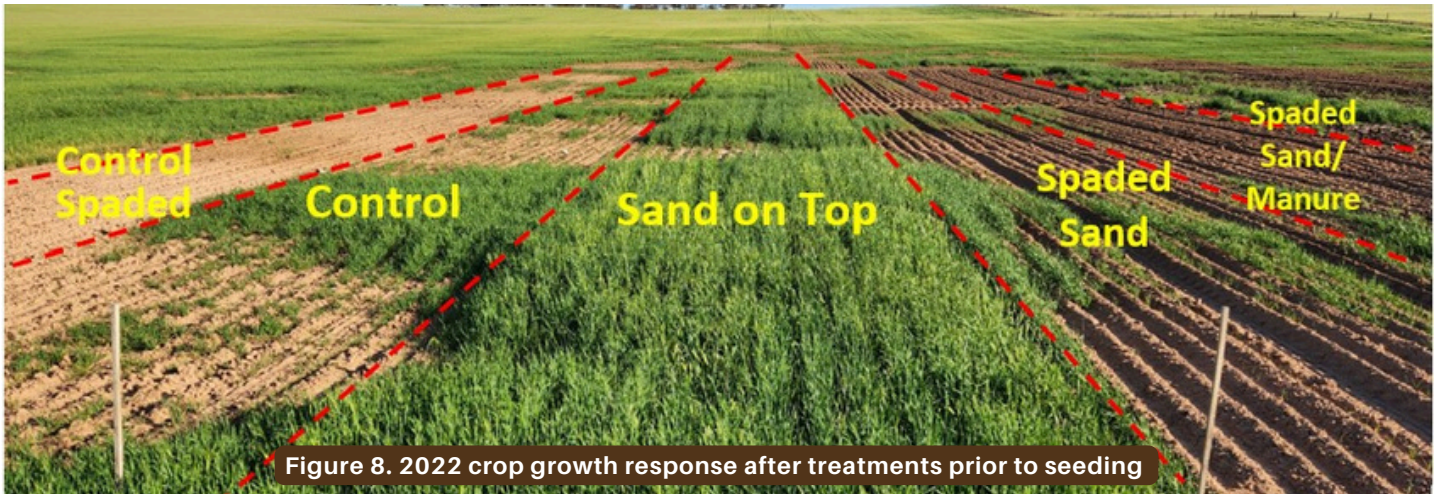

Figure 8. 2022 crop growth response after treatments prior to seeding

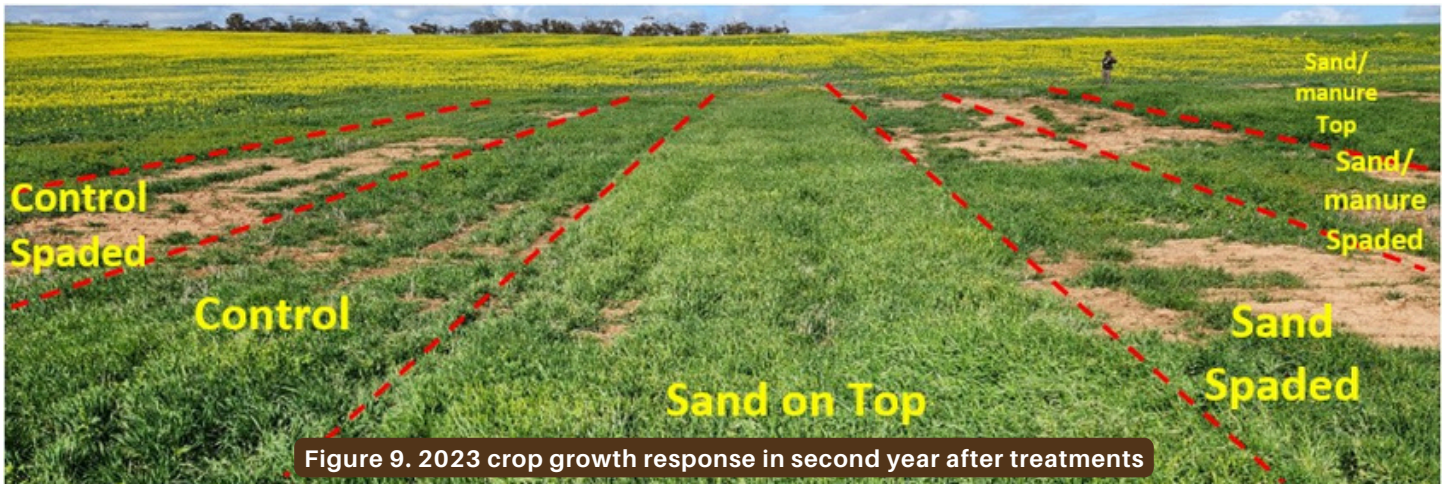

Figure 9. 2023 crop growth response in second year after treatments

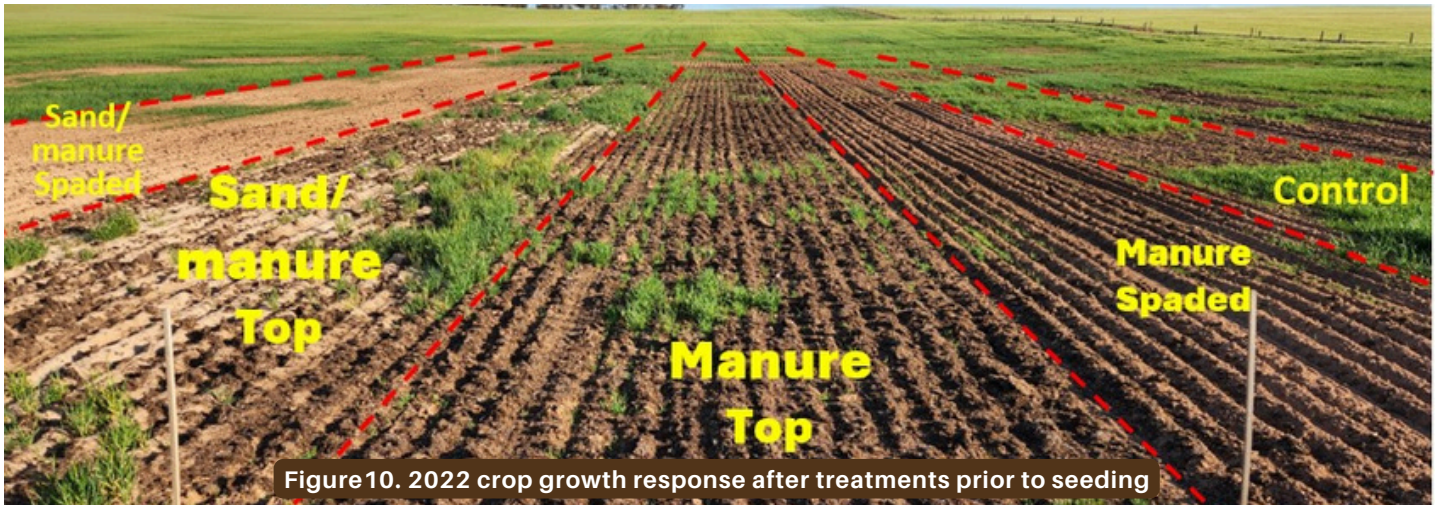

Figure10. 2022 crop growth response after treatments prior to seeding

Figure11. 2023 crop growth response in 2nd year after treatments

INCORPORATING AMENDMENTS HAD A NEGATIVE IMPACT ON CROPS

Areas that were deep ripped and spaded generally performed worse than the control (Figures 1, 2, 8, 9, 10, 11), with very little crop germination along the strips in 2022, and very limited, patchy crop establishment in 2023. This likely stems from:

- Spading bringing hostile soil to the surface, creating a difficult environment for germinating seedlings.
- Surface sealing from the sodic clay brought to the surface.
- The beneficial impacts of the increased sand and manure mixed through the profile were far outweighed by the negative impacts of the hostile clay brought to the surface.

In 2023 there was very little change in crop growth within the most severe, spaded patches, despite the wetter 2022 season (Figure 7). These degraded strips will be covered in sand to rehabilitate them.

ALTERNATIVE SOIL AMELIORATION METHODS TRIAL AT OTHER SITES

A Reefinator was used at Wunkar in the Northern SA Mallee (see case study 'stony patch amelioration for dry saline land') on shallow calcrete that had a very hardsetting clay loam layer at 10 cm with the stone.

Multiple passes saw the stone broken to 25 cm. This generally had a positive impact on crop growth when it was also mixing in surface-spread sand or manure, but less of an impact if no amendments were mixed in. While the soil mixing was very aggressive, it did not bring hostile sodic and saline clays to the surface. However, surface-spreading sand, and to a lesser extend manure and straw,, had a much bigger impact on crop growth and soil salinity. The mulches provided soil cover over summer, and once the crop germinated, ongoing stubble cover. This led to significant reductions in topsoil salinity over two growing seasons and three summers.

It was concluded that where fixing saline land is the primary objective, Reefinating is not necessary, and money and effort should be concentrated on appropriate surface amelioration strategies.

DEEP RIPPING WITH ACTIVE INCLUSION

A prototype deep ripper with active inclusion was trialled on patchy dry saline land near Truro (see Dittrich case study). This consisted of a deep ripping tine to approximately 50 cm, with large and long inclusion plates below surface discs that push surface material down these subsoil slots at 60 cm intervals. This was an attempt to improve root penetration through heavy, hostile, saline clay to improve crop growth and maintain cover to reverse surface salinisation.

Unfortunately, this site had no close source of sand, so a thin layer of grapemarc was the only material added to mix to depth along with the topsoil layer. While this site did show some areas of improved surface growth and deeper root penetration due to these rip lines, it was not consistent throughout the trial. There will need to be more trial demonstration work done, using a range of surface materials and machinery set-ups before any recommendations for this technique can be made with confidence.

Again, surface-spreading straw produced enough summer soil cover to significantly reduce surface layer salinity, leading to dramatically improved volunteer growth after opening rains in 2023. This reinforces the value of focussing on soil surface amelioration, until further research is conducted on incorporating amendments.

NEXT STEPS

As dry saline land is not a big issue on the farm, Matt is happy to wait and see what the research uncovers before attempting to ameliorate further. “The process was very labour intensive and I couldn’t do it on a large scale. It won’t be economical until the process is refined,” he said.

The next step at the trial site will be to cover the bare spaded areas with a layer of sand. It is hoped that as crops germinate and provide cover, soil salinity will reduce in the underlying clay soil, and that the positive impact of mixing sand and manures into the top 30 cm may lead to improvements to crop growth over time.

Ongoing monitoring of all site treatments will be important to gauge the long-term impacts and efficacy of the surface sand layers that may gradually mix with the clays beneath, as well as the manure layers as they break down over time. The rehabilitated areas are not expected to become saline again unless there is severe erosion and the bare clay layers are exposed to the surface over multiple seasons.

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

Trial run by Chis McDonough, Insight Extension for Agriculture.
Thanks to Matt Starick for hosting the trial.

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

Produced June 2024