# Applying ameliorants improved crop establishment and growth on dry saline land patches on Eyre Peninsula in 2022

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**Location**
Karcultaby, Minnipa, Buckleboo & Tumby Bay

**Rainfall**
Av GSR/2022 GSR
Karcultaby: 232/268
Minnipa: 241/332
Buckleboo: 196/194
Tumby Bay: 252/252

**Soil type**
Calcareous silty clay loam with increasing sodic subsoil layers and increasing clay and corbonate at depth.

**Soil test**
Saline and sodic subsoil layers often with high boron and carbonate at depth.

**Plot size**
Karcultaby and Minnipa:
30 m x 4 m x 3 replicates
Buckleboo:
15 m x 100 m, non-replicated
Tumby Bay: seeder width x 200 m, non-replicated

**Yield limiting factors**
Dry conditions in June and July at Buckleboo.

## Key messages

- **The application of ameliorants, including sand and manures can provide improved plant establishment and growth on dry saline land.**
- **Understanding the nature of site soil constraints and of the applied ameliorants is key to maximising crop production benefits.**
- **The improved cover on treated areas, if maintained over summer, is expected to reduce evaporation and the capillary rise of salts to the surface, which could provide production benefits over multiple years.**

## Why do the trials?

Patches of poor crop and pasture growth within paddocks, caused by the accumulation of salts in soil layers and not associated with saline water tables, are a common and persistent issue across the lower rainfall areas of Eyre Peninsula. Whilst these dry saline patches, historically referred to as 'magnesia patches', have been present for many years (Kennewell 1999), the results of a recent landholder survey (McDonough and Scholz, 2021) identifies landholder concerns that both the area of land impacted, and severity of production loss has increased in recent years.

In 2021 an AIR EP project, funded by the Australian Government's National Landcare Program in conjunction with the Eyre Peninsula Landscape Board, investigated the differences in soil characteristics between areas of good crop growth and poor crop growth on sites at Karcultaby and Buckleboo. Results indicated that the soil profile in the better production zones had better drainage due to coarse carbonate fragments in the soil profile and less "wicking ability" limiting the capacity capillary rise of salts (Masters and Guidera, 2021).
Growers have tried several management approaches with varying levels of success, including the addition of soil ameliorants such as sand or organic matter to the topsoil. Under a project funded by the Australian Government's Future Drought Fund and in collaboration with landholders, AIR EP and PIRSA-SARDI researchers, several demonstration sites were established in 2022 to assess a range of treatments, aimed at reducing the impact of these salts on crop and pasture production. This article summarises plant growth responses from treatments during the 2022 season.

## How was it done?

Four demonstration sites (a mix of unreplicated 'farmer scale' and smaller replicated sites) were established in 2022 at Karcultaby, Minnipa, Buckleboo and Tumby Bay. Analysis of a composite soil sample in May 2022 showed that at Karcultaby and Minnipa salinity in the 0-10 cm layers was relatively low (<0.24 dS/m) but increased quickly in subsurface layers (0.77 dS/m in the 30-60 cm layer at Karcultaby and 0.54 dS/m at Minnipa). At Buckleboo salinity in the 0-10 cm layer was high (>1.0 dS/m and remained high throughout the profile). A composite sample across the site at Tumby Bay revealed slight salinity from 0-20 cm (0.23 dS/m) with increased salinity from 20-30 cm (0.68 dS/m).

Treatments were designed to investigate the production benefits of applying either a soil ameliorant (sand or manure) to the soil surface, or an alternative crop option on the dry saline affected area compared to the control crop (Table 1).

*Table 1. Summary of dry saline land demonstration sites in 2022.*

| Co-operator Location | Demonstration type | Crop type and sowing date | Measurements | Treatments |
|---|---|---|---|---|
| Cook Karcultaby | Soil ameliorants (Replicated) | Barley (Scope CL) | Baseline soil salinity, plant emergence, NDVI, dry matter, grain yield | Control - untreated<br>Soil ameliorants<br>Surface manure @ 8 t/ha<br>Surface sand @ 300 t/ha |
| Minnipa Ag Centre | Soil ameliorants (Replicated) | Wheat (Scepter) | Baseline soil salinity, plant emergence, NDVI, dry matter, grain yield | Control - untreated<br>Soil ameliorants<br>Surface manure @ 8 t/ha<br>Surface sand @ 300 t/ha |
| Karinya Ag Buckleboo | Soil ameliorants (Unreplicated) | Oats (Yallara) and Vetch (Timok) | Baseline soil salinity, NDVI, dry matter, grain yield | Control - untreated<br>Double sowing<br>Soil ameliorants<br>Low-rate sand @ 150-250 t/ha<br>High-rate sand @ 250-500 t/ha |
| McCallum Tumby Bay | Plant options (Unreplicated) | Barley (Spartacus CL) | Baseline soil salinity, plant emergence, NDVI, dry matter | Control – Spartacus barley @75 kg/ha<br>Plant options<br>a. Moby barley @ 40 kg/ha<br>b. Moby barley (40 kg/ha) + vetch (25 kg/ha)<br>c. Moby barley (@ 40 kg/ha) + vetch (@ 25 kg/ha) + tillage radish (@ 2 kg/ha) |

At Karcultaby and Minnipa the soil ameliorants were surface applied prior to seeding. At Buckleboo, the dry saline patch sown was sown with vetch/oats in early April try and get some cover on the site with the demonstration strips of sand being spread on top using a land-plane scraper in May. The sand demonstration strips were 15 m wide x 100 m long and crossed over two areas of better growth and two areas of salt scald. Plant measurements included crop establishment, a measure of biomass production (NDVI and/or biomass production). Grain yield was taken at Karcultaby and Minnipa. The Buckleboo site was sprayed out ("brown manured") at anthesis whilst the Tumby Bay site was cut for hay. Data from replicated sites was analysed using standard ANOVA models in Statistix 8.

## What happened?

Intense storm activity in late January 2022 bringing up to 250 mm of rainfall in 24 hours resulted in most districts recording their highest rainfall totals ever for the summer period and full soil moisture profiles. In 2022 all sites were sown by the landholders and managed as per the rest of the paddock. The Karcultaby and Minnipa sites were sown to cereal crops (Scope barley at Karcultaby and Scepter wheat at Minnipa), whilst the Buckleboo and Tumby Bay sites were sown to mixed species cover crops (Yallara oats and Timok vetch at Buckleboo and mixtures of barley +/- vetch and tillage radish at Tumby Bay). At Buckleboo the western end of the demonstration site was double sown (with double seed and fertiliser) with the eastern end of the trial only sown once.

### *Crop establishment*

Plant density was evaluated 4 to 6 weeks after sowing at Karcultaby, Minnipa and Tumby Bay. Two assessments of crop establishment were undertaken at Karcultaby due to staggered emergence, however the treated areas did not have higher plant numbers than the untreated control (which averaged 62 plants/$m^2$ on 7 June and 74 plants/$m^2$ on 24 June). At Minnipa there was no difference in crop establishment between the surface manure treatment and the control (which averaged 117 plants/$m^2$). However, the surface application of sand reduced plant establishment by 30% (Figure 1).

Results from soil analysis indicated that the salinity of the A horizon material used for the sand treatment at Minnipa was moderately saline (0.54 dS/m) which at a rate of approximately 300 t/ha might explain the poorer establishment on the sand spread plots. Both manure samples (sheep manure at Karcultaby and feedlot waste at Minnipa) had high salinity (1.0 ds/m at Karcultaby and 2.3 dS/m at Minnipa), but were applied at a lower rate (8.0 t/ha) than the sand so did not appear to affect crop establishment in the same way.

At Buckleboo NDVI readings were taken using a handheld 'Green seeker' on 5 August to assess differences in crop growth on the treated areas compared to untreated controls (Table 2). Assessments were undertaken on the two sand treatments (low rate of 150-250 t/ha and high rate of 350-500 t/ha) and three untreated control strips, including a 'control 0' located at the northern edge of the dry saline land patch which had generally better growth. NDVI assessments were taken at four points ('bays'), where crop growth was impacted by differing salinity levels or management practice.

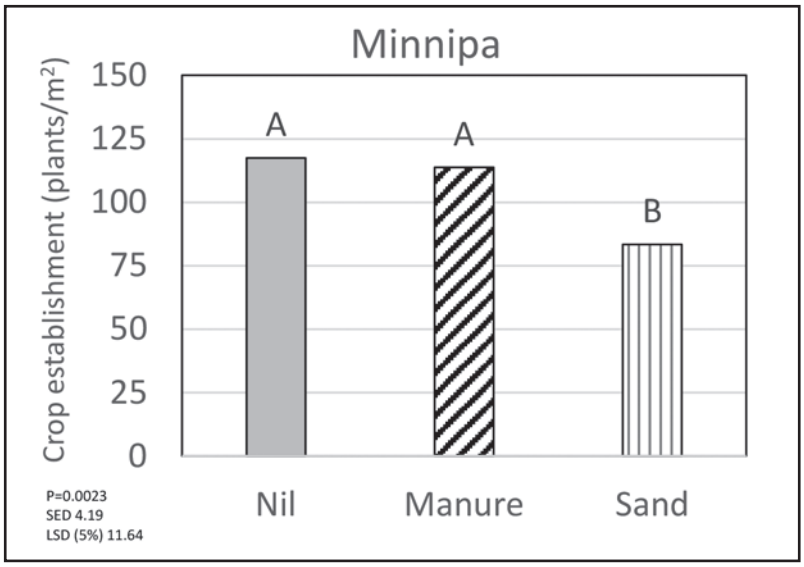


***Figure 1. Plants/m² at Minnipa at crop establishment. A different letter indicates a significant difference at P<0.05.***



***Table 2. NDVI values on Buckleboo site, 5 August 2022.***

| | BAY 1: Lower salinity (Double sown) | BAY 2: Western scald (Double sown) | BAY 3: Lower salinity (Double sown) | BAY 4: Eastern scald (Single sown) |
|---|---|---|---|---|
| **Control 0 (better production area)** | 0.73 | 0.75 | 0.73 | 0.53 |
| **Low rate sand (150 – 250 t/ha)** | 0.85 | 0.84 | 0.84 | 0.68 |
| **Control 1** | 0.79 | 0.37 | 0.82 | 0.54 |
| **High rate sand (350-500 t/ha)** | 0.89 | 0.63 | 0.87 | 0.78 |
| **Control 2** | 0.84 | 0.38 | 0.71 | 0.51 |

The matrix in Table 2 shows the high spatial variability of salt impact on crop growth within dry saline patches. NDVI values of 0.73 to 0.84 in the untreated areas with low salinity in controls 0 (an unaffected control strip at the northern edge of the dry saline patch), 1 and 2 were much higher than readings of 0.37 to 0.54 where high salinity resulted in bare scald. These values also showed much improved growth on the sand treated strips when compared to adjacent control scald areas at both the low and high rate of sand.

Crop establishment was assessed at Tumby Bay on 10 June (35 days after sowing) (Figure 5). Unfortunately, rabbits from a coastal reserve adjoining the paddock caused some damage to the southern edge of the demonstration with little crop establishment for approximately 40 m into the paddock. The affected area was excluded from the plant establishment assessments, with plant counts taken from a transect across each treatment beginning about 60 m in from the southern paddock boundary. Due to the high degree of spatial variability in salinity impacts on the site (due to microrelief within the flat paddock), four paired plant counts were taken for each treatment on adjacent 'good' and 'poor' patches and averaged for the treatment (Figure 2). Results showed 12-20% higher plant numbers on the mixed species treatments compared to the barley control (which had 80 plants/m$^2$) on the unaffected (good) area (Figure 2). On the 'poor' area there were 30% higher plant numbers on the Moby barley+vetch treatment (73 plant/m$^2$) compared to the barley control (which had 56 plants/m$^2$), but establishment on the barley+vetch+tillage radish was not different to control in this area.

### *Biomass*

A dry period in June and July followed by wet spring conditions brought average to slightly above average growing season rainfall across the region. Opportunistic growth assessments (NDVI and biomass cuts) were taken at each site. Winter biomass cuts at Karcultaby on 17 August showed improved crop growth (P = 0.026) on both the surface applied manure (4.3 t/ha) and sand (3.9 t/ha) treatments compared to the control (which yielded 2.2 t/ha of dry matter) (Figure 3). This improved growth was also supported by NDVI (P=0.032) assessments on that date. In early spring these differences were not significant at 95% confidence level but were at 90% (P=0.058).

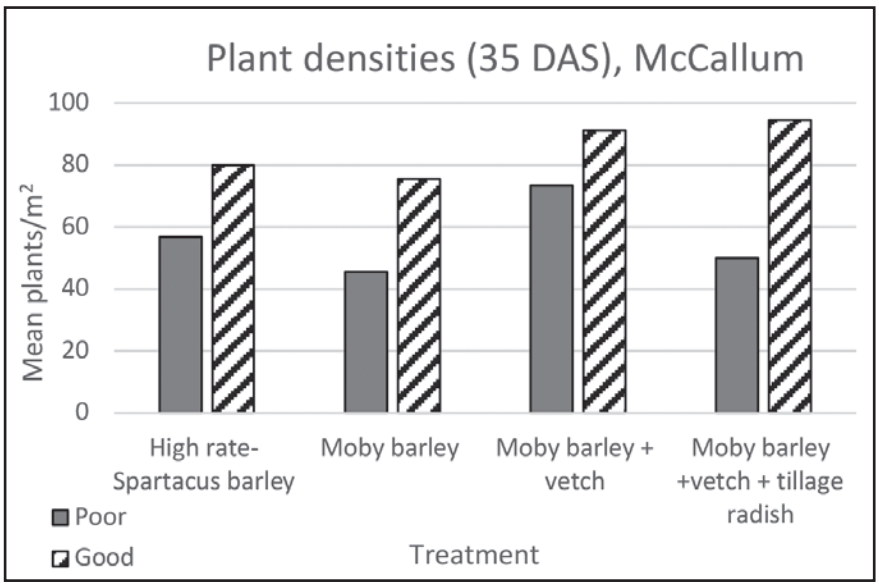


***Figure 2. Plants/m² at Tumby Bay at crop establishment on 10 June 2022. Poor = areas of poor plant establishment; Good = areas of good plant establishment.***

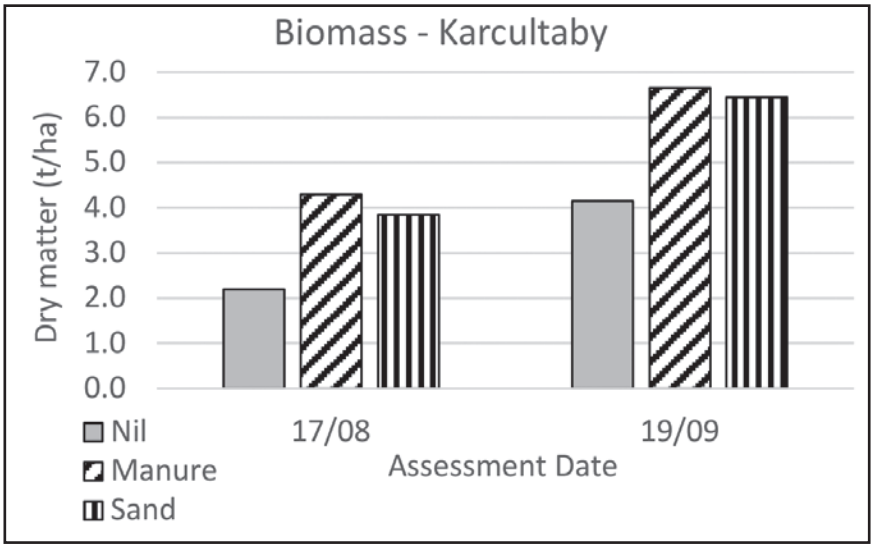


***Figure 3. Dry matter (t/ha) at Karcultaby on 17 August and 19 September 2022.***

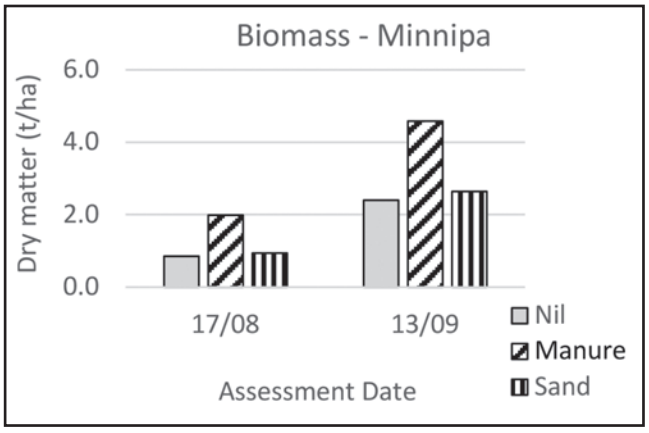


***Figure 4. Dry matter (t/ha) at Minnipa on 17 August and 13 September 2022.***

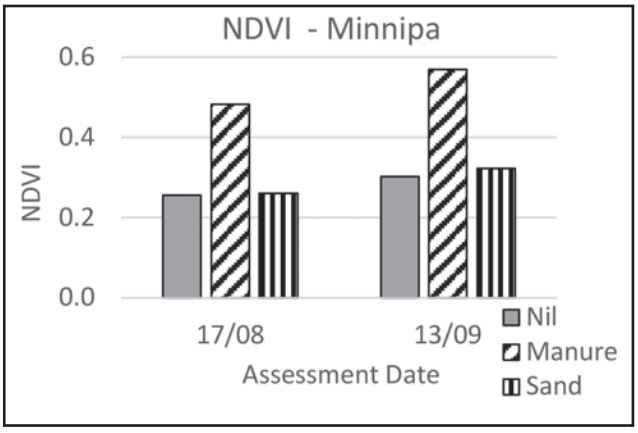


***Figure 5. Minnipa NDVI on 17 August and 13 September 2022.***

Despite poorer establishment on the sand treatment at Minnipa, by mid-August there was no difference in growth between the control (with 0.9 t/ha of dry matter) and the sand treatment, but the manure treatment showed improved growth (P = 0.021) with more than double the biomass of the control (2.0 t/ha) (Figure 4). This improved growth carried through into the spring biomass cut with no difference (P = 0.015) in dry matter on the sand treatment and 92% more dry matter on the manure treatment (5.0 t/ha) compared to the control (2.4 t/ha). NDVI values on these two assessment dates also reflected these improvements in crop growth on the manure treatments compared to the control (P = 0.0124 and P = 0.0005 respectively) (Figure 5).

The Buckleboo site was sprayed out ('brown manured') by the landholder on 10 September. Dry matter cuts were taken on 29 September to assess peak biomass. Results showed much higher biomass on the treated areas compared to the paired controls (Figure 6), with the scalded areas of the control strips averaging between 2.8 and 4.4 t/ha and the adjacent areas of the sand treatments averaging 7.0 to 10.3 t/ha of dry matter. The amount of dry matter on the double sown sand spread treatments (low and high rates) when the site was desiccated in spring was at least as good as the best areas of the untreated control (which had 9.1 t/ha dry matter).

Although unreplicated biomass cuts at Tumby Bay suggested higher biomass on the barley+vetch+tillage radish the landholder cut the demonstration site for hay before a measure of peak biomass could be taken.

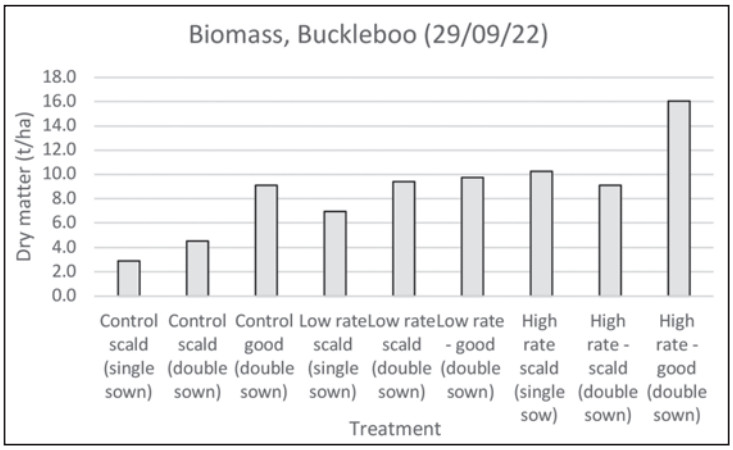


***Figure 6. Peak dry matter (t/ha) at desiccation, Buckleboo, 29 September 2022.***

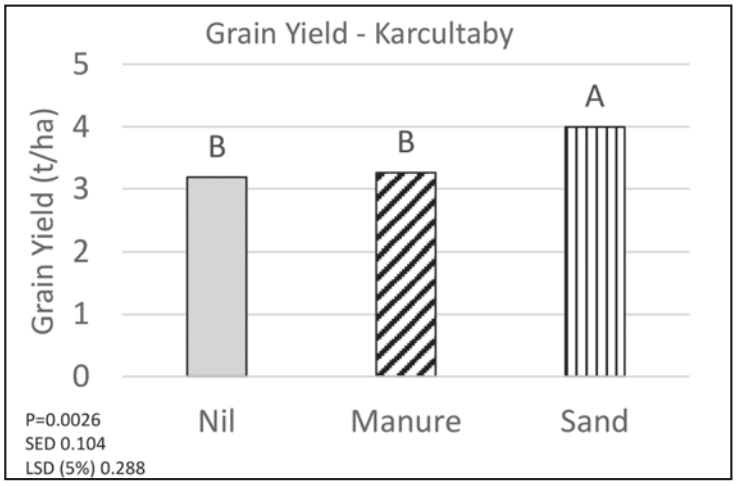


***Figure 7. Barley grain yield (t/ha) at Karcultaby, December 2022. A different letter indicates a significant difference at P < 0.05.***

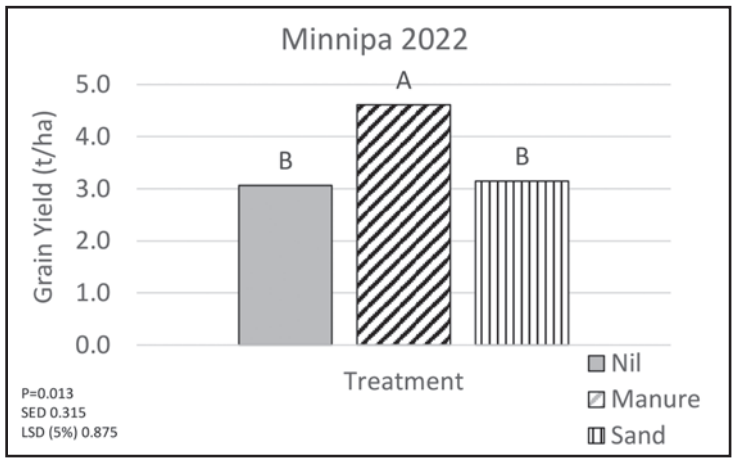


***Figure 8. Wheat grain yield (t/ha) at Minnipa, December 2022. A different letter indicates a significant difference at P < 0.05.***

***Grain yields***

The early growth improvements afforded by the manure treatment at Karcultaby compared to the nil control did not carry into improved grain yield, with the manure treatment yielding 3.3 t/ha and the control yielding 3.2 t/ha (Figure 7). However, the sand treatment continued to provide benefits and yielded 4.0 t/ha of grain.

The production trends observed in the crop establishment and biomass cuts at Minnipa carried through to grain yield with no difference in yield between the control (which yielded 3.1 t/ha) and sand treatment, whilst the manure treatment had a 50% yield improvement over the control (4.6 t/ha) (Figure 8).

## What does this mean?

Despite little difference in growing season (April - November) rainfall compared to the long-term averages, January rainfall started the season with a full soil moisture profile which is likely to have washed salts deeper into the soil profile, facilitating better crop establishment compared to years which have a dry start. Field observations saw generally good crop establishment across the sites. Early observations indicate that the application of ameliorants, including sand and manures, have provided some benefit for improved plant establishment and growth in 2022. This is consistent with reports from landholders who have trialled the practices on their properties in recent years as well as results coming from demonstrations in other regions, including Yorke Peninsula and the Murray Mallee. Grain yields were exceptional at Karcultaby and Minnipa with even the controls yielding more than 3.0 t/ha. Both the manure and sand treatments at Karcultaby resulted in improved crop growth and yield. The manure treatment at Minnipa provided similar production benefits. Dry conditions in June and July checked growth on the scalded areas at Buckleboo, with well-established plants dying off, however this did not occur on the sand spread treatments.

The improved surface cover, if maintained by limiting grazing and soil disturbance, could reduce evaporation and the capillary rise of salts to the surface, which could provide production benefits over multiple years.

The poor performance of the sand spread treatment at Minnipa in 2022 is likely the result of the salt content of the spread material. This highlights the importance of understanding both the nature of the constrained soil profile as well as the ameliorant material to maximise the benefits from applied treatments. Organic amendments (e.g., feedlot manures, spoiled hay, or residues from chaff carts) can contain weed seeds and it is worth considering the risk of introducing new or potentially herbicide resistant weeds onto a site when considering using such amendments.

Whilst these results have shown some promise, there is still some unanswered questions about the rate of sand required to achieve economic yield benefits. At Buckleboo the double sown areas seemed to have improved surface cover and biomass compared to the single sown area, whilst at Tumby Bay the mixture of barley and vetch seemed to provide higher levels of ground cover. Both of these treatments warrant further investigation. Positive results from demonstrations using alternative species/varieties (i.e. safflower, Mulgara oats) to manage the dry saline patches in other regions could also provide management options for these soils on Eyre Peninsula. The sites which had ameliorants applied in 2022 will continue to be monitored, in conjunction with the establishment of new sites in 2023.

## Acknowledgements

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