# “Sand Improvement through manure profiling in low rainfall Northern Mallee”

## Lowbank Agricultural Bureau

## Final Project Report March 2016


**By Chris McDonough,**
**Farming Systems Consultant,**
**Insight Extension for Agriculture**


Insight Extension for Agriculture


**This project was funded through the South Australian Murray-Darling Basin Natural Resources Management Board and the Australian Government’s National Landcare Programme**


Australian Government | National Landcare Programme

Government of South Australia
South Australian Murray-Darling Basin Natural Resources Management Board

Prepared by:

**Chris McDonough**

**Farming Systems Consultant, Insight Extension for Agriculture**

**C/o Post Office, Loxton North, SA 5333**

**Ph   0408085393**

**cmcd.insight@gmail.com**

# Contents

# 1 Introduction

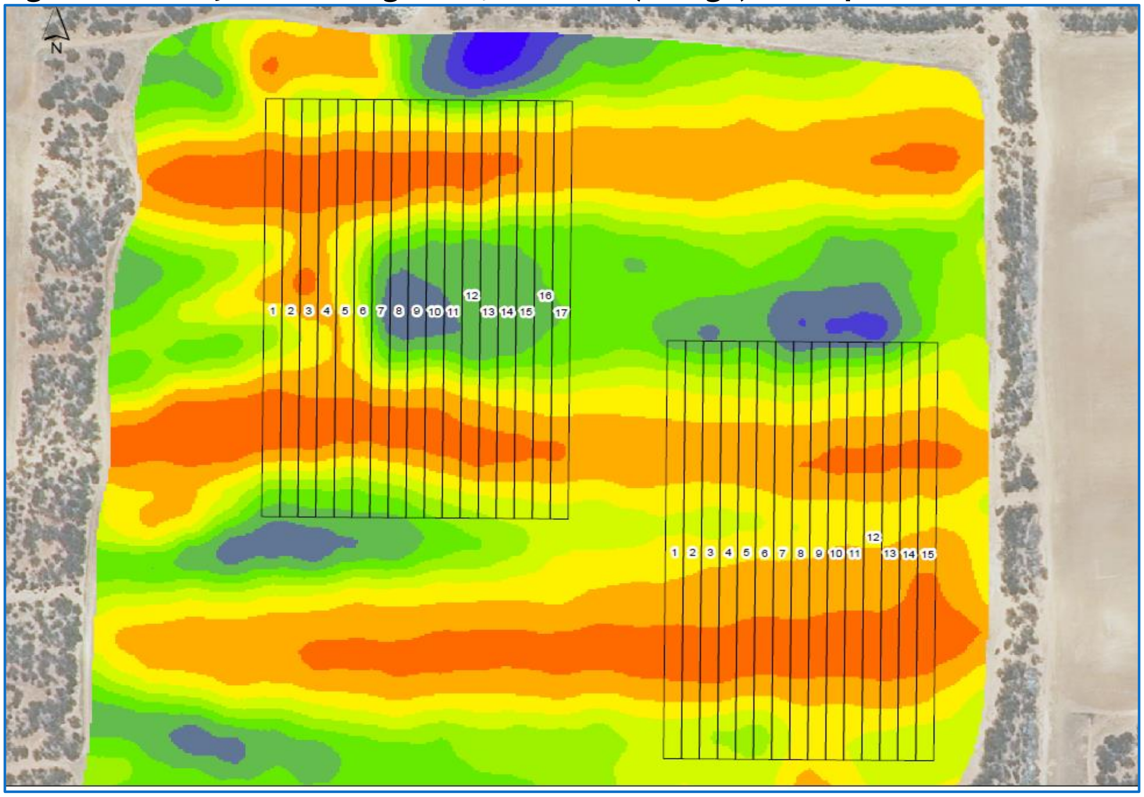
In Feb 2015, the Lowbank Agricultural Bureau successfully applied for project funds through the NRM Agricultural and Fishing Innovations Grants to improve the performance of poorly producing sands in the district. The project site was on the Schmidts property on Paschke Rd, not far from the Maggea road.

Spading highly nutritious organic matter was one of the most successful treatments for sand amelioration at the New Horizons trial site at Karoonda. Chicken manure has become readily available and affordable in the area due to major chicken farm developments near Swan Reach/Blanchetown, and farmers have begun spreading it on the surface of their sandy soils with some benefits evident.

The aims of this trial were to improve both the profitable production and protection of poorly performing sandy soils in the Waikerie District and across the northern Mallee. This was mainly to be done through the profiling (spading) of chicken manure, compared against other possible options such as clay spreading, biological treatments, winery waste products (through collaboration with the Bureaus Mallee Challenge initiative), commercial fertiliser application, deep ripping and surface applied treatments. These were tested at various rates comparing surface spreading (current farmer practice) with spading the manure to a depth of 35-40cm across various soil types to assess both the practicality and economic value of applying such treatments. The trial is now set up for long term evaluation of treatments.

# 2 Project Plan

**Figure 1. .Site layout showing main 3 sandhills (orange) and replicated site treatments**




| Plot | Treatments | Cost $/ha (est.) | Years to return on investment if 0.5t/ha increase |
|---|---|---|---|
| 1 | Kitchen Sink. Clay spreading, Chicken manure 5t/ha, spaded, high fert 100kg 19/13?, trace elements 4l/ha | 700 | 4 |
| 2 | Clay spread 80 t/ha spaded | 400 | 3 |
| 3 | 2.5t/ha Chicken Manure Spaded | 200 | 2 |
| 4 | 2.5t/ha Chicken Manure | 100 | 1 |
| 5 | 5t/ha Chicken Manure | 190 | 2 |
| 6 | 5t/ha Chicken Manure Spaded | 290 | 3 |
| 7 | Control | ? | ? |
| 8 | Bio Soil Conditioner Rate 1 | ? | ? |
| 9 | Bio Soil Conditioner Rate 2 | | |
| 10 | Deep Ripping+ 2.5t/ha Chicken Manure | 110 | 1 |
| 11 | Shane Phillips Fluid Winery Mix Surface | | |
| 12 | Shane Phillips Fluid Winery Mix Spaded | | |
| 13 | Shane Phillips Fluid Winery Mix + 3t/ha Grape Marc Spaded | | |
| 14 | High Fertiliser Spaded (100kg/ha 19:13 + Trace Element (Zn, Cu, Mn)mix | 190 | 2 |
| 15 | High Fertiliser Surface (100kg/ha 19:13 + Trace Element (Zn, Cu, Mn)mix | 90 | 1 |
| 16 | 12t/ha Chicken Manure Spaded | 470 | 3 |
| 17 | 2.5t/ha Chicken Manure + 3t/ha Grape Marc Spaded | 190 | 2 |
| 18 | 2.5t/ha Chicken Manure + 3t/ha Grape Marc Spaded | 190 | 2 |

Trial_Layout
em38 0-100cm
9.5 - 10
10.1 - 20
20.1 - 30
30.1 - 40
40.1 - 50
50.1 - 60
60.1 - 70
70.1 - 80
80.1 - 90
90.1 - 100
100.1 - 105

0 30 60 120 Meters

**Lowbank Ag Bureau Deep Sand Trial**


This project is jointly funded through The South Australian Murray-Darling Basin Natural Resources Management Board and the Australian Government's National Landcare Programme.

Australian Government | National Landcare Programme

Natural Resources SA Murray-Darling Basin

Government of South Australia
South Australian Murray-Darling Basin Natural Resources Management Board

RURAL SOLUTIONS SA

wisdom DATA & MAPPING

Printed 13th October 2015

The paddock was EM38 mapped and soil tested for both nutrition, soil qualities and root disease (see Fig 1.) Each trial replication spans across 2 sand hills, mid-slopes and flats. Each treatment plot is 15m wide and 400m long (0.6ha), so it could be sown and reapt using farmer equipment.

The site was established with the assistance of 10 Lowbank Agricultural Bureau members, who also contributed farm machinery for treatment application. It should also be noted that while the original site planning, rates of 2.5t/h and 5t/ha of chicken manure are written, the spreading process is not an exact science, and those applying the manure thought that it had been spread at rates closer to 3t/ha and 6t/ha, which is how these plots are referred to in the results and discussion.

There was some product remaining after the main site treatments were established, which resulted in a few extra strips, including 12t/ha chicken manure spaded, as well as a mix of chicken manure and grape marc on the end of the first trial replication.

**Figure 2. Lowbank Agricultural Bureau members discussing trial site establishment**

**Figure 3 Spreading the chicken manure**

**Figure 4. Multiple farm machines used to establish various treatment plots**

**Figure 5. Deep ripper used to a depth of approx. 40cm depth**

**Figure 6. Deep ripper in action showing maintenance of surface stubble cover**

**Figure 7. Fresh grape marc being loaded for spreading**


**Figure 8. Straw based chicken manure used for spreading**

**Figure 9. Chicken manure at approx. 6t/ha spread on surface prior to spading**

**Figure 10. Chicken manure at approx. 6t/ha spread on surface prior to spading**

**Figure 11. Spading machine in action**


**Figure 12. Spading various treatment plots to 35-40cm depth on the sand**

# 3 Results and Discussion

## 3.1 Soil Test Results

Four soil tests were undertaken across the trial area. Table 1 shows the deep sand to have reasonable phosphorous levels but extremely low organic carbon. This means that it has extremely limited ability to mineralize nitrogen, which is evidenced by the very low ammonium and nitrate levels down the profile. There is no subsoil constraints recorded to 80cm but the soil is very infertile.

The mid slope sand has low phosphorus (14ppm) and a low organic carbon. There are no subsoil constraints so root activity should be able to exceed 80cm depth.

The loamy soils and heavy flats have good levels of phosphorus in the surface, a reasonable organic carbon of around 1% but start to run into subsoil constraints (transient salinity and boron) in the 50-80cm zone. There are some stony fragments in these soils (up to 10%).

Root disease tests reveal high levels of Rhizoctonia on the sand and medium levels on the flat. There was also concerning levels of Bipolaris (common root rot) on the sand. This would suggest that treatments with lower nutrition (N, P, Zn) could be more susceptible to root disease attack.

### Table 1. Topsoil and Deep Soil Test Results

**Topsoil Results**

| Name | Code | Customer | Depth | Gravel | Texture | Ammonium | Nitrate Nitrogen | Phosphorus Colwe | Potassium Colwe | Sulphur | Organic Carbo | Conductivity | pH Level (CaCl2 | pH Level (H2O) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | % | | mg/K | mg/Kg | mg/Kg | mg/Kg | mg/Kg | % | dS/m | pH | pH |
| Sand | 02/04/15 | Schmi | 0-10 | 0 | 1.5 | 2 | 5 | 21 | 160 | 1.9 | 0.23 | 0.06 | 7.8 | 8.6 |
| Mid Slope | 02/04/15 | Schmi | 0-10 | 0 | 1.5 | 2 | 12 | 14 | 258 | 2.5 | 0.52 | 0.076 | 7.8 | 8.5 |
| Loam | 02/04/15 | Schmi | 0-10 | 5 | 2 | < 1 | 17 | 25 | 492 | 4.6 | 0.98 | 0.132 | 7.8 | 8.6 |
| Heavy Flat | 02/04/15 | Schmi | 0-10 | 5 | 2 | 2 | 18 | 29 | 561 | 6.4 | 1.05 | 0.139 | 7.8 | 8.5 |

**Subsoil Results**

| Customer | Name | Code | Depth | Ammonium Nitroge | Nitrate Nitrogen | Sulphur | Conductivity | pH Level (CaCl2 | pH Level (H2O) | Exc. Aluminium | Exc. Calcium | Exc. Magnesium | Exc. Potassium | Exc. Sodium | Boron Hot CaCl2 | Chloride | MCP Sulfur | Moisture % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | mg/Kg | mg/Kg | mg/K | dS/m | pH | pH | meq/1 | meq/1 | meq/1 | meq/1 | meq/1 | mg/Kg | mg/Kg | mg/Kg | % |
| Schmidt | Sand | 02/04/ | 10-30 | < 1 | 3 | 1.6 | 0.073 | 8.1 | 8.8 | 0.13 | 6.44 | 0.62 | 0.38 | 0.05 | 0.47 | < 1.0 | 3.5 | 1.34 |
| Schmidt | Sand | 02/04/ | 30-50 | < 1 | 3 | 2.1 | 0.073 | 8.1 | 8.9 | 0.104 | 9.24 | 0.9 | 0.29 | 0.04 | 0.6 | 1.6 | 6 | 4.09 |
| Schmidt | Sand | 02/04/ | 50-80 | < 1 | 2 | 2.4 | 0.077 | 8.1 | 8.9 | 0.106 | 9.05 | 1.38 | 0.19 | 0.03 | 0.64 | < 1.0 | 5.5 | 3.82 |
| Schmidt | Mid Slope | 02/04/ | 10-30 | < 1 | 2 | 3.1 | 0.084 | 7.9 | 8.9 | 0.101 | 12.24 | 1.09 | 0.66 | 0.06 | 0.76 | 1.6 | 5.8 | 4.97 |
| Schmidt | Mid Slope | 02/04/ | 30-50 | 2 | 2 | 3.5 | 0.088 | 8 | 8.9 | 0.088 | 10.13 | 2.56 | 0.45 | 0.08 | 0.83 | 2.8 | 4.9 | 6.29 |
| Schmidt | Mid Slope | 02/04/ | 50-80 | < 1 | < 1 | 3.9 | 0.132 | 8 | 9.3 | 0.059 | 9.24 | 3.77 | 0.69 | 0.95 | 1.7 | 1.1 | 4.9 | 7.65 |
| Schmidt | Loam | 02/04/ | 10-30 | 1 | 4 | 5.8 | 0.098 | 8 | 9 | 0.039 | 14.68 | 2.77 | 0.89 | 0.56 | 2.14 | 7.6 | 9.3 | 5.9 |
| Schmidt | Loam | 02/04/ | 30-50 | 2 | 5 | 16.4 | 0.3 | 8.3 | 9.5 | 0.058 | 7.71 | 4.17 | 0.81 | 4.07 | 11.07 | 60.3 | 17.8 | 7.23 |
| Schmidt | Loam | 02/04/ | 50-80 | < 1 | 11 | 30.7 | 0.51 | 8.3 | 9.6 | 0.092 | 6.38 | 2.73 | 1 | 5.71 | 17.49 | 124.9 | 31.3 | 7.65 |
| Schmidt | HF | 02/04/ | 10-30 | 2 | 7 | 4.1 | 0.136 | 8 | 9.1 | 0.063 | 14.69 | 3.73 | 1.3 | 0.68 | 2.56 | 13 | 8.8 | 4.94 |
| Schmidt | HF | 02/04/ | 30-50 | < 1 | 7 | 24 | 0.549 | 8.2 | 9.7 | 0.076 | 8.46 | 6.25 | 0.98 | 4.4 | 11.86 | 266.3 | 30.9 | 8.89 |
| Schmidt | HF | 02/04/ | 50-80 | 1 | 25 | 92.6 | 0.82 | 8.3 | 9.7 | 0.074 | 8.39 | 5.66 | 1.04 | 7.09 | 17.93 | 618.5 | 111 | 9.48 |

**Texture Results**

| Name | Site | Soil de | Texture | Course Fragment % |
|---|---|---|---|---|
| Schmidt | Sand | 0-10 | CS | 0 |
| Schmidt | Sand | 10-30 | LS | 0 |
| Schmidt | Sand | 30-50 | LS | 0 |
| Schmidt | Sand | 50-80 | LS | 0 |
| Schmidt | Mid Slope | 0-10 | LS | 0 |
| Schmidt | Mid Slope | 10-030 | SL | 0 |
| Schmidt | Mid Slope | 30-50 | SL | 0 |
| Schmidt | Mid Slope | 50-80 | SL | 20 |

| Name | Site | Soil depth | Texture | Course Fragment % |
|---|---|---|---|---|
| Schmidt | Loam | 0-10 | SL | 10 |
| Schmidt | Loam | 10-030 | SCL | 10 |
| Schmidt | Loam | 30-50 | SCL | 10 |
| Schmidt | Loam | 50-80 | SCL | 10 |
| Schmidt | Heavy F | 0-10 | L | 0 |
| Schmidt | Heavy F | 10-030 | L | 0 |
| Schmidt | Heavy F | 30-50 | CL | 10 |
| Schmidt | Heavy F | 50-80 | CLS | 10 |

**Table 2. Root disease test results for flat and sand at site, prior to treatment application**

| Paddock | CCN eggs /g soil | Take-all (wheat + oat strains) pgDNA/g Sample* | Gga pgDNA/g Sample* | R. solani AG8 pgDNA/g Sample* | Pyrenophora tritici-repentis (YLS) Copies / g sample | Bipolaris pgDNA/g Sample* | Pythium clade f pgDNA/g Sample* | Botryosphaeria clade 1 Copies / g sample | Eyespot Copies / g sample | Pratylenchus neglectus nematodes /g soil | Pratylenchus thornei nematodes/g soil | Pratylenchus quasiterioides nematodes /g soil | Stem nematode nematodes/ 100 g soil |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DS Flat | 0 | 1 | 0 | 92 | 38904 | 51 | 7 | 853278 | 0 | 5 | 0 | 0 | 0 |
| DS Sand | 0 | 1 | 0 | 184 | 56328 | 229 | 0 | 6277 | 0 | 3 | 0 | 0 | 0 |

## 3.2 Crop Monitoring Results

**Table 3. Crop monitoring counts on top of sandhill, Rep 1, 27/8/2015**

| Plot | Treatment | Ave plants/m row | Ave tillers/m row | Ave tillers/pl | Visual Crop growth rating (0-10) | Comments |
|---|---|---|---|---|---|---|
| 0 | Control | 29 | 60 | 2.1 | 4 | Poor growth, lighter green, not thick, tillers and heads not strong |
| 1 | Kitchen Sink Spaded (most treatments) | 27 | 108 | 4.0 | 8 | Excellent crop, deep green, strong growth, even heads, old leaves slight septoria? |
| 2 | Clay spread 80 t/ha Spaded | 22 | 59 | 2.7 | 5 | Not as thick or green, some patchiness due to old blowout or unmixed clay |
| 3 | Chicken Manure 2.5t/ha Spaded | 31 | 103 | 3.3 | 6.5 | Looking fairly thick and green but not as good as kitchen sink |
| 4 | Chicken Manure 2.5t/ha Surface | 34 | 69 | 2.0 | 5.5 | Thinner than spaded, but ok. Good colour but tillers and heads not as strong |
| 5 | Chicken Manure 5t/ha Surface | 26 | 67 | 2.6 | 6 | as dark green as the Trt 1 or 6. Big diff with this and Trt 6 down midslope until you get to loamy |
| 6 | Chicken Manure 5t/ha Spaded | 29 | 100 | 3.5 | 8.5 | Crop much taller, thicker and deeper green. Nearly all very strong stems and heads. |
| 7 | Control | 22 | 50 | 2.3 | 4 | Thin, light green, fewer heads, yellow older leaves, inconsistent maturity |
| 8 | Bio Soil Conditioner Post 1 | 24 | 59 | 2.5 | 4.5 | Much like control, maybe slightly more out in head but hard to pick |
| 9 | Bio Soil Conditioner Post 2 | 26 | 60 | 2.4 | 4.5 | Much like control, maybe slightly more out in head but hard to pick |
| 10 | Deep Rip 2.5t/ha Chicken Manure | 35 | 70 | 2.0 | 6 | Better growth, crop evenly out in head, not as thick as spaded but ok. |
| 11 | Shane Winery Mix Surface | 26 | 55 | 2.1 | 4.5 | Ok, seems slightly better than control, but still poor tillering. Sand slightly improving. |
| 12 | Shane Winery Mix Spaded | 35 | 79 | 2.3 | 5.5 | Clear improvement over non-spaded, but still patchy and poor growth |
| 13 | Shane Winery Mix + Grapemark Spaded | 23 | 76 | 3.3 | 5.5-6 | OK, slightly better than previous, but thin in patches, possibly due to old blowout. |
| 14 | High Fert with Trace Elements Spaded | 23 | 94 | 4.1 | 7 | Rich green, has good strong tillers and heads, some patchiness but excellent growth |
| 15 | High Fert with Trace Elements Surface | 22 | 64 | 3.0 | 5.5-6 | Good colour, but not as thick or tall as spaded |
| 16 | 12t/ha Chicken Maure Spaded | 26 | 100 | 3.8 | 8.5 | Good strong stems and heads. Deep green, high yield potential. Excellent. |
| 17 | 6t/ha Chick Man + 3t/ha Grapemarc Spaded | 23 | 68 | 3.0 | 7.5 | Good stems, heads and colour. Some patchiness but excellent growth. |
| 18 | Control | 24 | 53 | 2.2 | 5.5 | Sand appears slightly better than controls at middle and other end of the trial. |

Table 3 shows significant differences in crop yield potential, with the spaded chicken manure treatments often having twice the number of tillers/m row than the control areas. The visual crop growth rating was also much higher as the plants were greener with stronger tillers and larger head formation. Figures 13 and 14 show clear visual differences between crops which were evident throughout the year. It is felt that the yield differences between treatments could have been higher if not for the poor finish to the season, based on these differences in crop growth.

**<u>Figure 13.</u> Comparative crop growth of treatment plots on sand hill, rep 1. Sept 2015**


**<u>Figure 14.</u> Comparative crop growth of treatment plots on sand hill, rep 1. Sept 2015**

## 3.3 Soil Moisture Comparisons

The spading of chicken manure has resulted in much improved soil moisture retention and deep root growth to extract this moisture as is evidenced in Figures 16 to 18. Figure 16 shows a 10mm rain in July penetrated past the 30cm sensor whereas Figures 17 and 18 show a spike only in the surface. Figure 16 also shows the crop roots using deep moisture to 70-90cm far earlier than the other sites. Figure 18 shows the control had very little moisture extraction in the 30-50cm soil zone. Soil pits dug at the end of the growing season showed the control area still had wet sand below 30cm whereas the "kitchen sink" plot had healthy root growth and a dry soil profile to 150cm depth (see Figure 15).

Figure 24 shows the difference in soil moisture extraction between these treatments was approximately 15mm, which does not seem very high, but is a reflection of the fact that these non-wetting sands have an inability to hold much water at all. However, an extra 15-20mm of plant available water in September will make a very large difference to yield potential. Figure 25 reveals one of the key reasons for the improved yields in the spaded treatments. The sand penetration resistance graph taken from a CSIRO sand trial at Loxton in 2015 reveals sand compaction between 20cm and 40cm depth which is too strong for roots to penetrate. It is only spading or deep ripping that will break this compaction and allow crop roots to explore the deeper layers. It also explains why so many of our mallee sands remain wet at depth after crop senescence in October.

**Figure 15. Root growth pit comparisons between treatments**

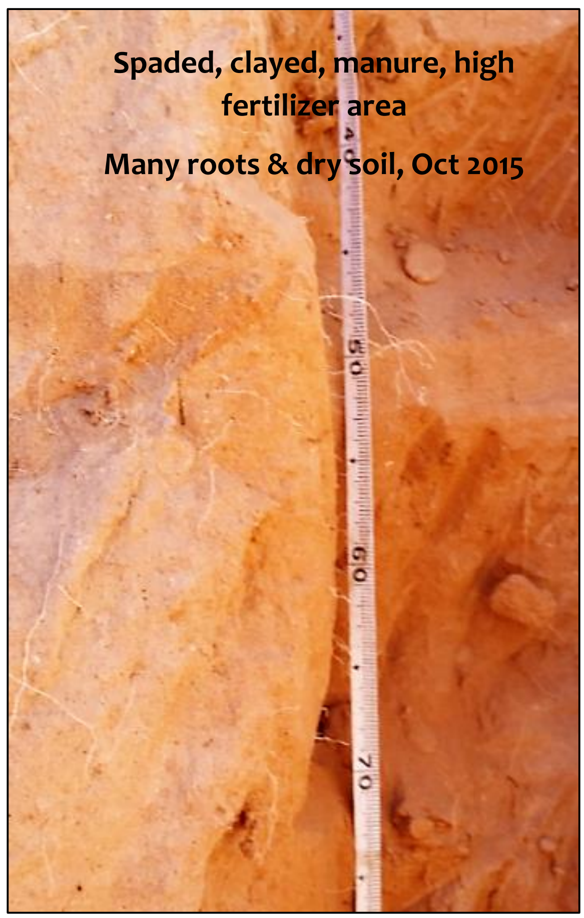



Figure 16. Moisture probe stacked, Sand hill, 6t/ha Chicken manure spaded, May-Nov 2015

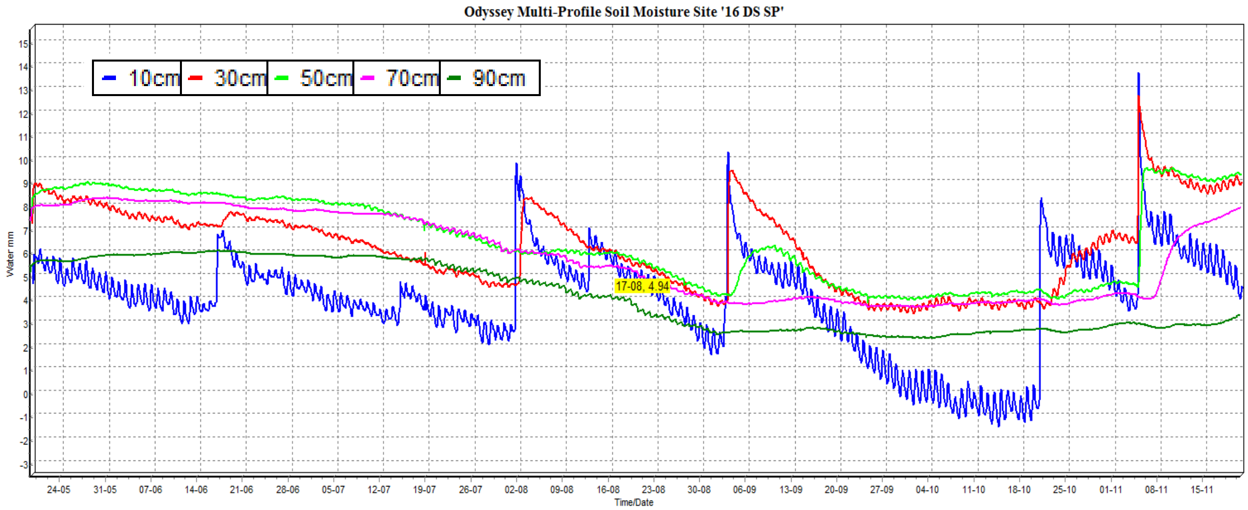



Figure 17. Moisture probe stacked, Sand hill, 3t/ha Chicken manure Deep ripped, May-Nov 2015

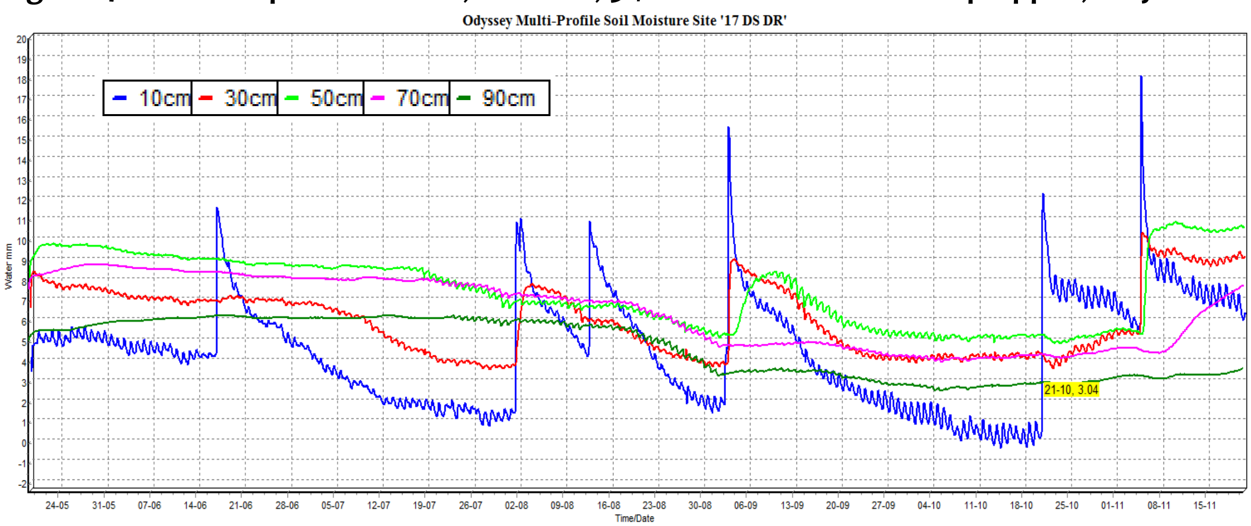



Figure 18. Moisture probe stacked, Sand hill, Control, May-Nov 2015

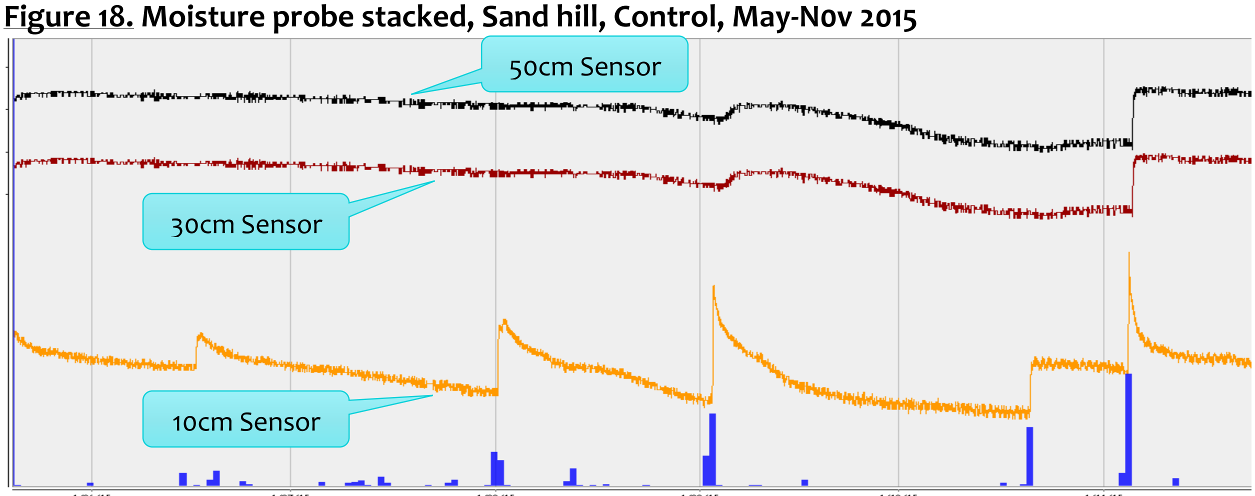


Figure 19. Moisture probe summed, Sand hill, 6t/ha Chicken manure spaded, May-Nov 2015

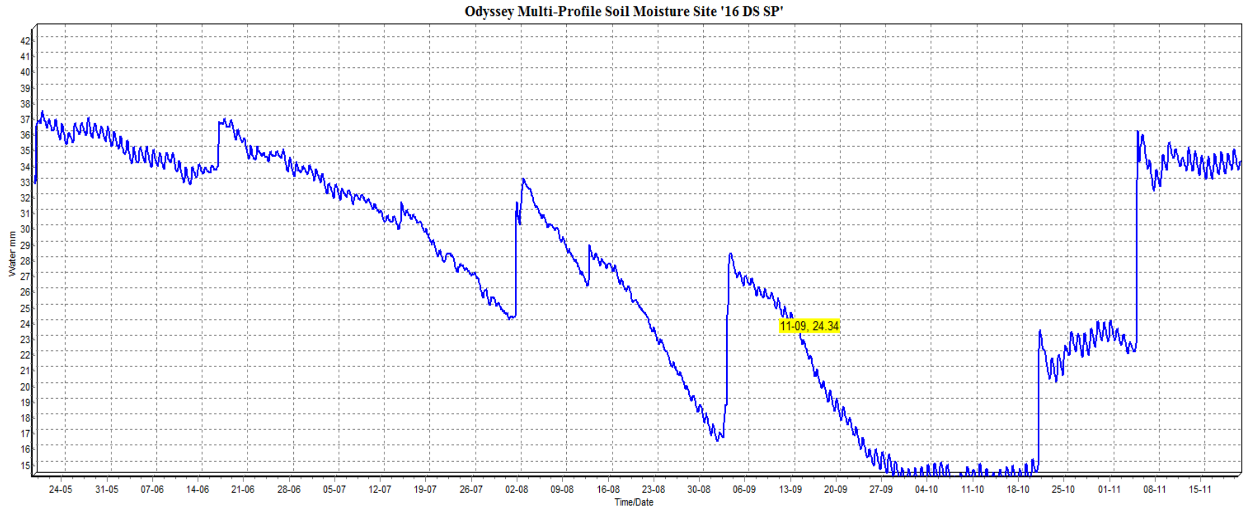



Figure 20. Moisture probe summed, Sand hill, 3t/ha Chicken manure deep rip, May-Nov 2015

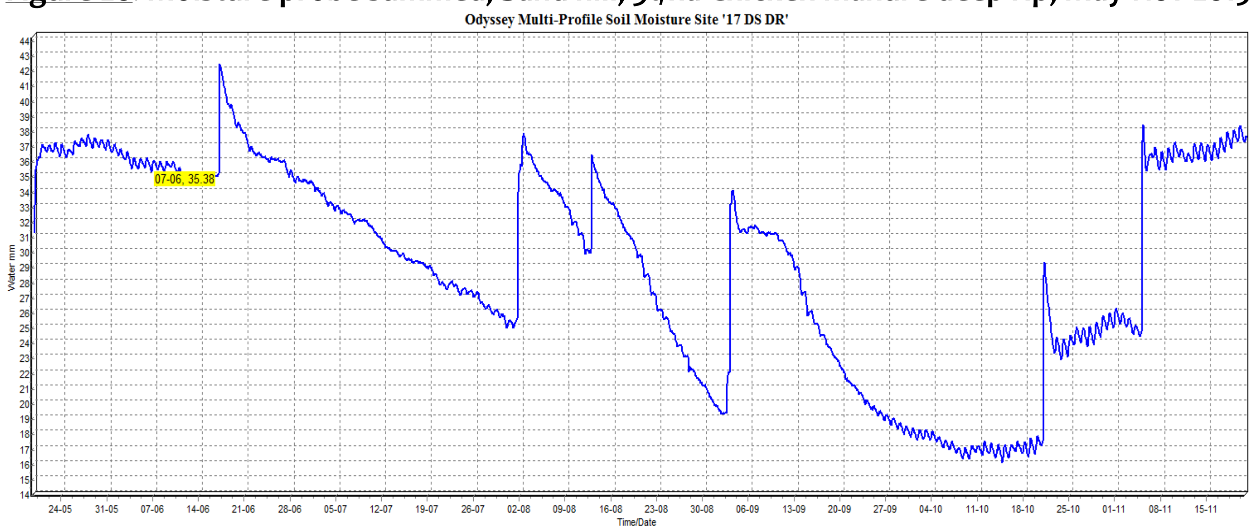
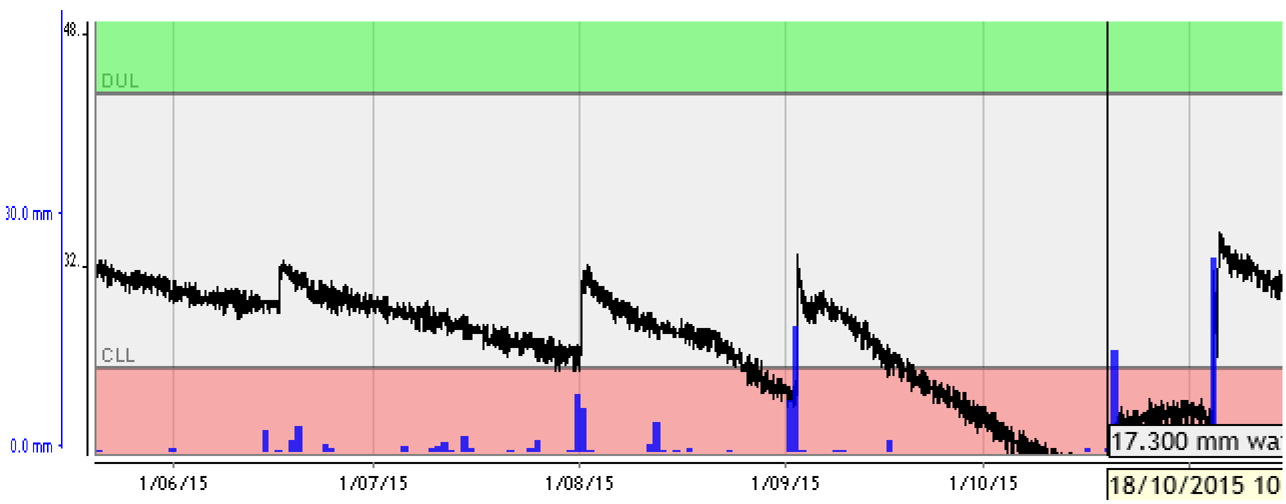



Figure 21. Moisture probe summed, Sand hill, Control, May-Nov 2015



Figures 19 and 20 compare soil moisture extraction between the spaded chicken manure and chicken manure deep ripped (60cm tine spacing to 40cm depth). This reveals that the deep ripping led to almost the same final moisture extraction. With less organic matter profiled through the top 40cm it did not show the same ability to hold moisture in the top 40cm and also lacked the same fertility through this zone.  Figure 21 used the NRM moisture probes only to 50cm depth, so is not directly comparable with the previous 2 graphs. It is worth noting that both the spaded and deep ripped plots had extracted 10mm more moisture from the top 50cm than the control.

Figures 22 and 23 show moisture extraction on the mid slope sands using the NRM moisture probes. While there is reasonable moisture extraction at the 30cm sensor there is still poor moisture extraction from the 50cm zone similar to that of the deep sand control (Figure 18).

**Figure 22. Moisture probe results, Midslope, Control, Stacked, May-Nov 2015**

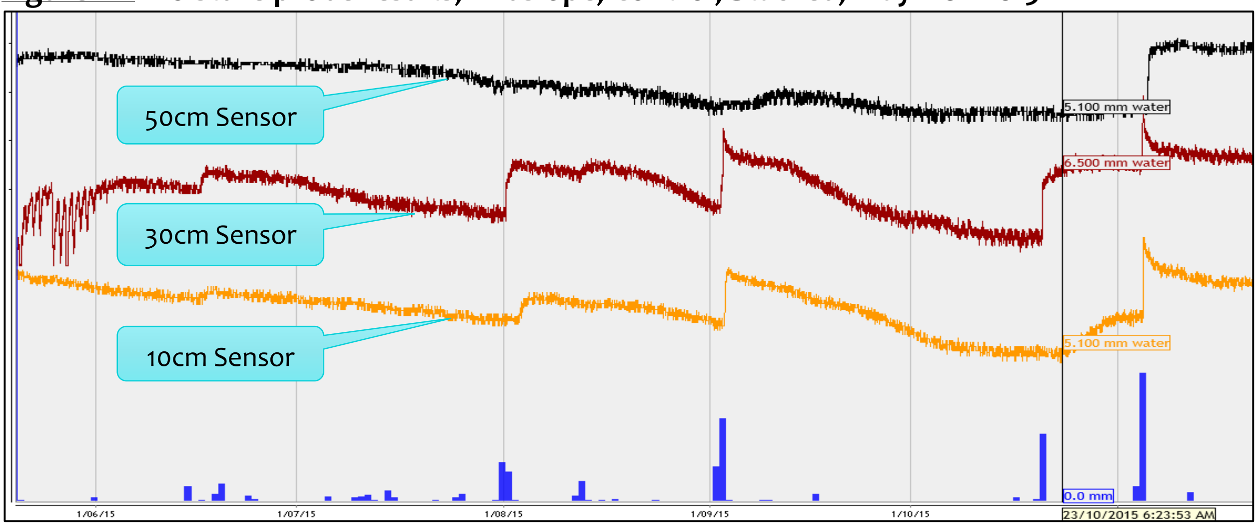



**Figure 23. Moisture probe results, Midslope, Control, Summed, May-Nov 2015**

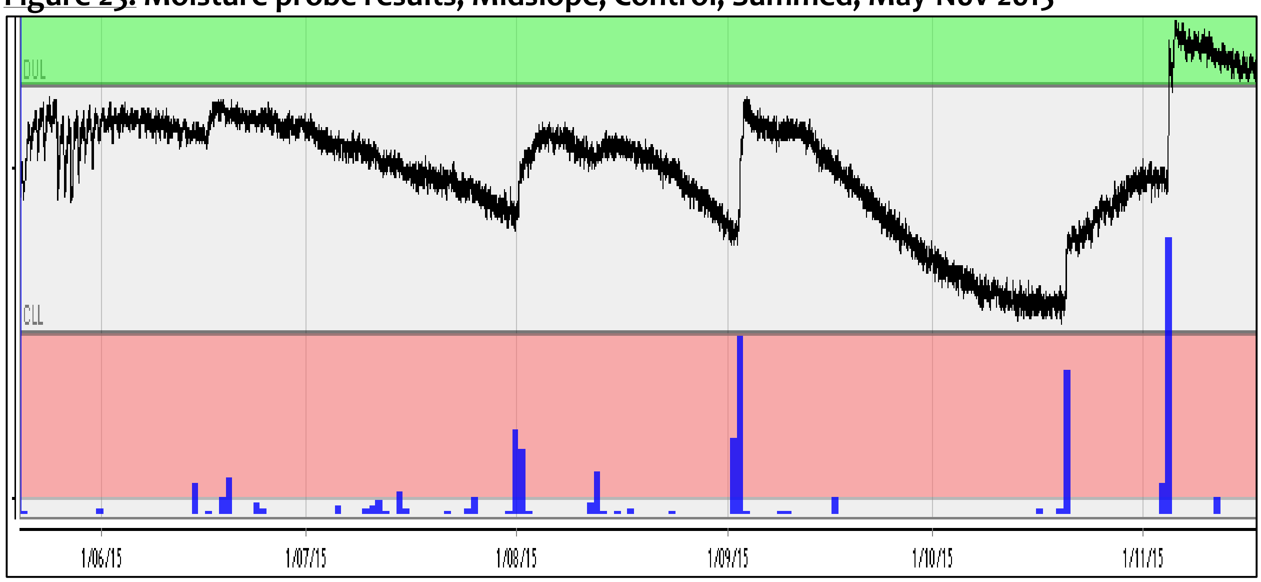
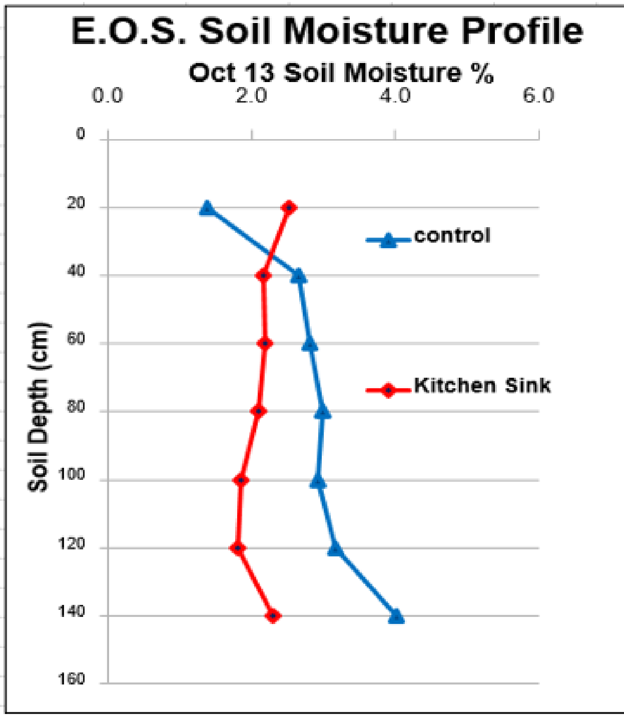


**Figure 24.** End of season soil moisture measurement comparison taken from soil pits

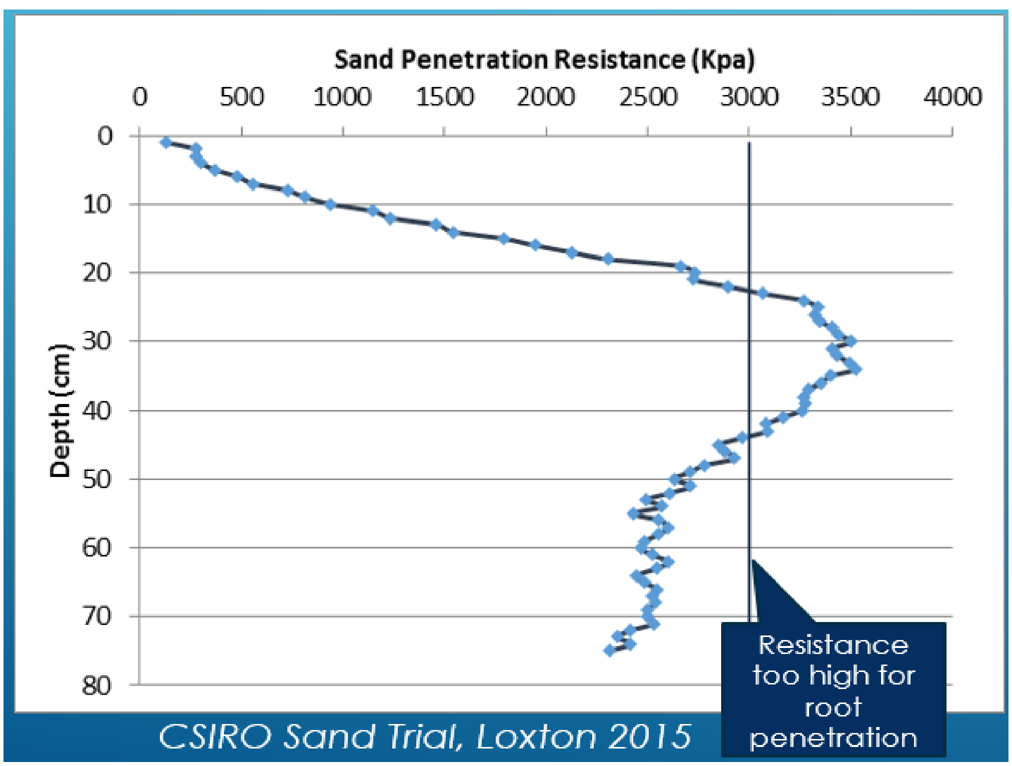



It appears form the pit that the spading has clearly broken the deep compacted layer form 20-40cm, allowing for excellent root growth to penetrate to 150cm, aided by the extra nutrition, allowing moisture access and soil drying throughout the profile. The control area feel quite wet, with few roots below 40cm.

Initial measurements of soil moisture profile suggest that the kitchen sink has extracted an extra 15mm moisture from the sandy soil profile. This alone would account for approximately 300kg/ha yield benefit.

Other yield increases could be attributed to increased nutrition, cation exchange capacity and water retention due to the clay spreading, chicken manure, high fertilizer and trace elements.

**Figure 25.** End of season soil moisture measurement comparison taken from soil pits



## 3.4 Yield, Grain Quality and Gross Margin Analysis

The yield data from each plot was obtained using the farmers' header with yield mapping technology. The yield maps were then analyzed over the EM38 soil zone maps so that a more accurate comparison of treatments to various soil types could be made. Grain samples were obtained from each plot and soil type.

Figures 26 and 27 show treatment yield results for the deep sands, midslope sands and loamy soils. Rep 1 shows very similar trends to Rep 2 results. There was some missing data from the Rep 1 harvest results and also some soil improvements from the western side to the eastern side. The full gross margin analysis has therefore been applied to Rep 2 results as this gave more consistent results between the control strips at either end and in the center of the plots (see Table 4).

These harvest results reveal the following:

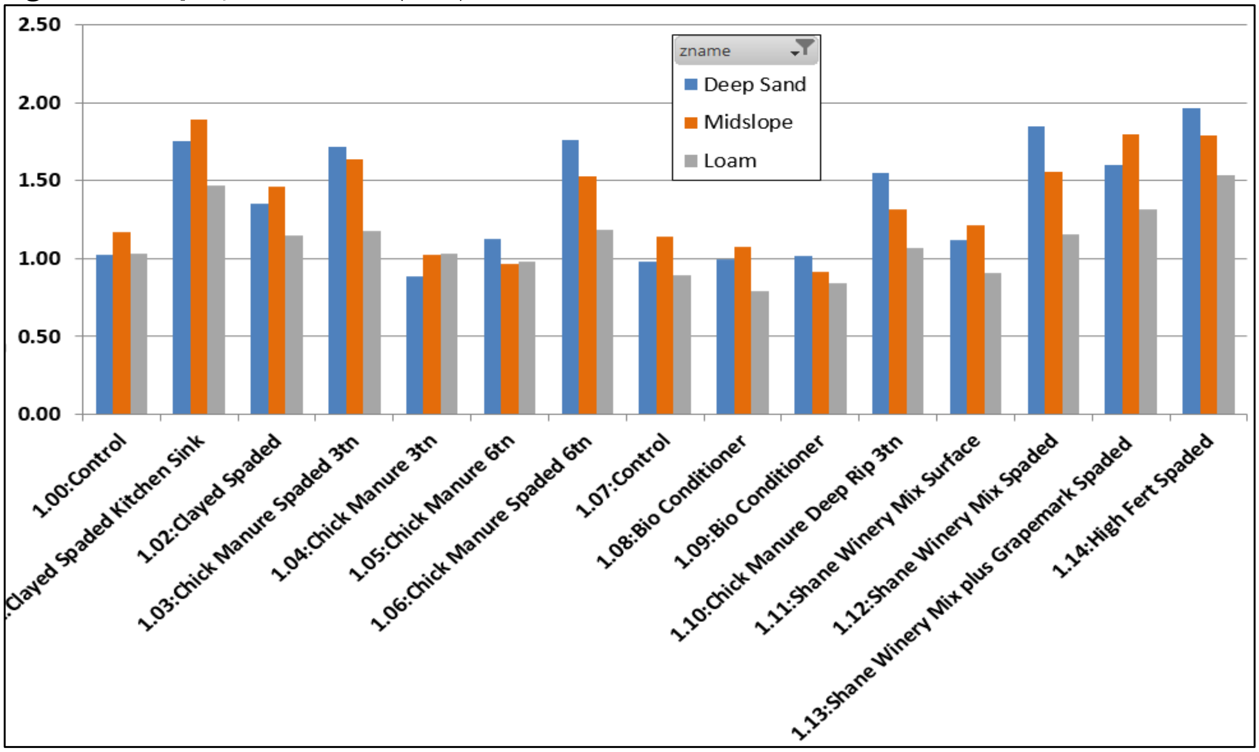
- The spading of 6t/ha of chicken manure lifted crop yields by 0.86t/ha (nearly double). If this same increase was realized next season this treatment would have recovered costs within 2 years.
- The difference between spading 3t/ha and 6t/ha of chicken manure was shown to be approximately 0.15t/ha suggesting that the lower rate may be the most economic. However, this will depend on how long the benefits of the extra 3t/ha will last, and emphasizes the need to continue monitoring this trial in future years.
- The common practice of spreading 3t/ha of chicken manure on the surface improved yields by 0.2t/ha over the control.
- On each occasion where the same treatment was applied on the surface next to being spaded the spading significantly increased the yields by 0.4-0.5t/ha. This suggests that the advantages gained were due to both breaking soil compaction and increasing soil nutrition and water holding capacity within the top 40cm.
- While the trial was aimed at improving grain production on the sandy soils it was clear that there were strong benefits obtained from most treatments on the loamy soils.
- The deep ripped 3t/ha chicken manure plots gave some yield advantage over the surface spread chicken manure. In rep 2 loamy soils responded strongly to deep ripping, but this was not the case in rep 1.
- Deep ripping provides an easier, cheaper and safer option for treating these mallee sands, but has not provided the same yield advantage as spading in the first year. This may be the best option for many farmers until more spading machinery becomes locally available and is better modified to reduce wind erosion (see Figure 29).

- Spading in high levels of commercial fertilizer (including trace elements) gave an excellent yield response while still breaking even in the first year. However, other trials suggest that the benefits of these treatments may not be long lasting.
- The bio-conditioning plots were applied late (post sowing) and appeared to show very little difference against the control plots.
- The winery waste mix (essentially flush water from liquid fertilizer manufacturing containing base level trace elements including Zn, Mn, Fe, Mg, Seasol and formbic acid) may have provided a small benefit, but was not consistent.
- The grape mark application with the winery mix appeared to show more benefits in the mid-slope to loamy soils than the sand.
- Spading clay spread at 80 t/ha produced a 0.5t/ha yield increase over the control. Its higher treatment costs mean that it may take 4 years or more to break even at this rate, which suggests it may be too risky as a strategy for the northern mallee. However, as it changes the soil texture, it may provide the longest lasting benefits.

**Table 4. Rep 2 yield results with gross margin comparisons**

| | Ave Yld Sand & Midslope t/ha | Yield increase t/ha | $/ha Value @ $250/t | Est Cost $/ha | $ GM 1st Yr | Years to pay off |
|---|---|---|---|---|---|---|
| Clay Spaded Kitchen Sink | 2.17 | 0.90 | 226 | 650 | -424 | 2.9 |
| Clayed Spaded | 1.76 | 0.49 | 123 | 400 | -277 | 3.3 |
| Chick Manure Spaded 3tn | 1.98 | 0.71 | 178 | 200 | -22 | 1.1 |
| Chick Manure 3tn | 1.47 | 0.20 | 49 | 100 | -51 | 2.1 |
| Chick Manure 6tn | 1.41 | 0.14 | 34 | 190 | -156 | 5.6 |
| Chick Manure Spaded 6tn | 2.13 | 0.86 | 215 | 290 | -75 | 1.4 |
| Control | 1.27 | | 0 | | 0 | |
| Deep ripped 3t/ha Chick Man | 1.59 | 0.32 | 80 | 110 | -30 | 1.4 |
| Winery Waste Mix Surface | 1.36 | 0.09 | 24 | 30 | -6 | 1.3 |
| Winery Waste Mix Spaded | 1.75 | 0.48 | 121 | 130 | -9 | 1.1 |
| Winery Mix/Grapemark Spaded | 1.63 | 0.36 | 90 | 150 | -60 | 1.7 |
| High Fert Spaded | 2.01 | 0.74 | 184 | 190 | -6 | 1.0 |
| High Fert | 1.61 | 0.34 | 85 | 90 | -5 | 1.1 |

**Figure 26. Rep 1 yield results (t/ha)***




*there was loss of yield data in Rep 1 that made the final plots unable to be represented in this graph.

**Figure 27. Rep 2 yield results (t/ha)**

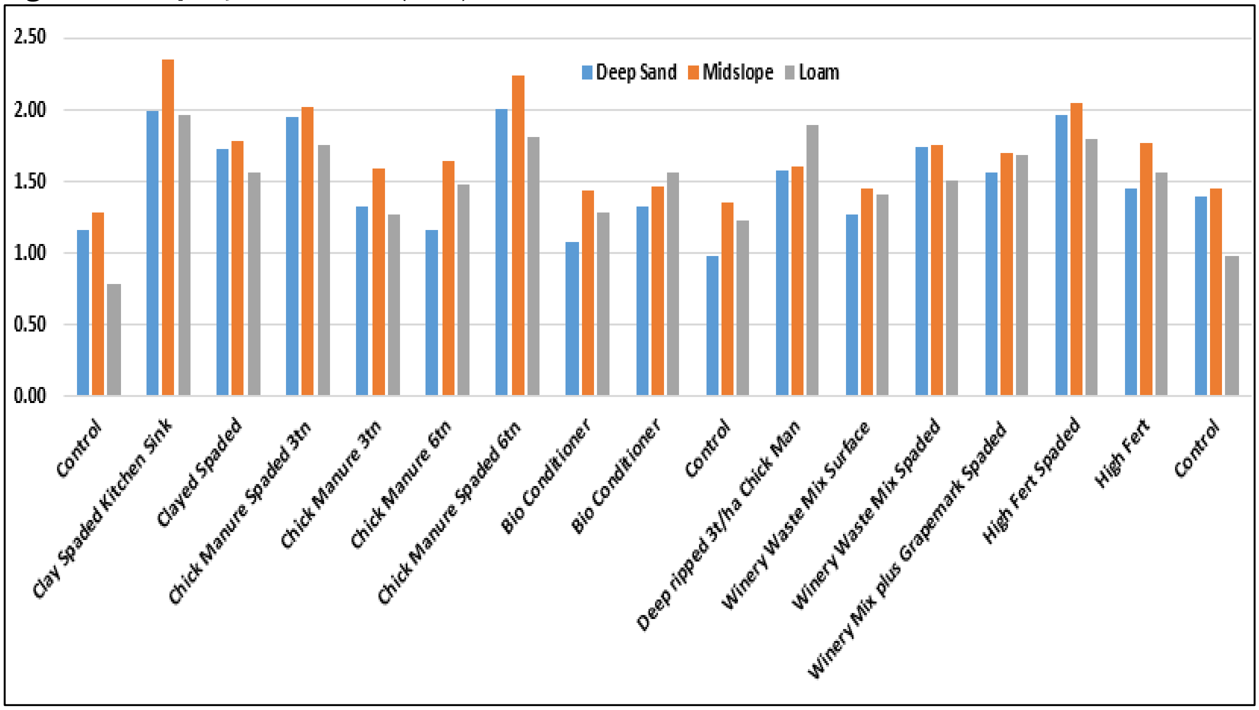


**Figure 28. Rep 2 yield results (t/ha) of 4 treatments by EM38 ranges**

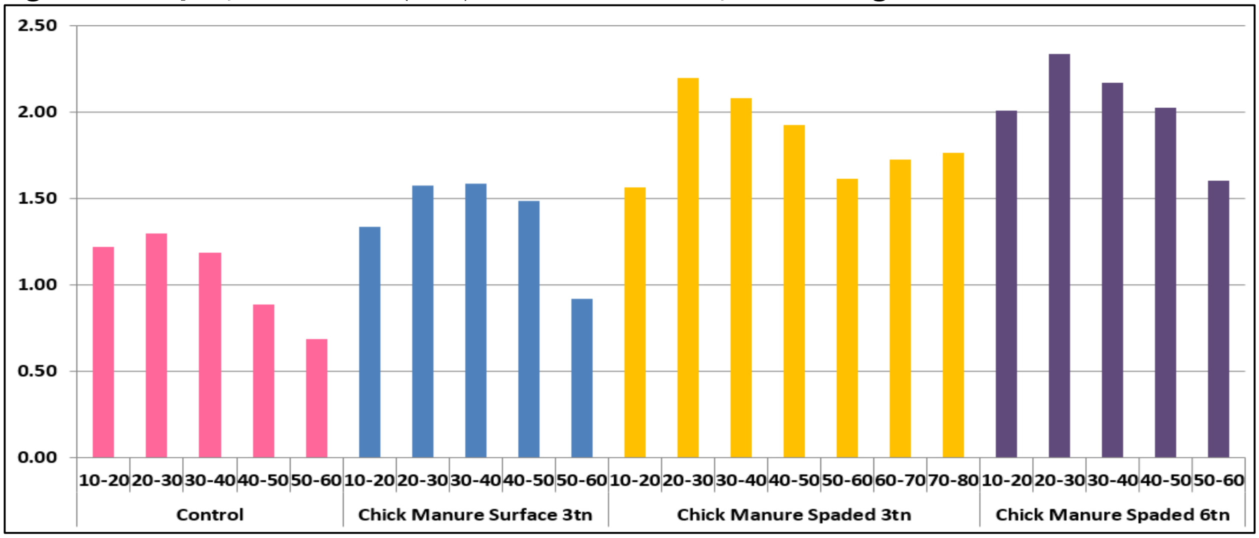



Figure 28 shows how various treatments performed against the incremental ranges of EM38, with 10-20 representing deep sand, while 50-70 indicates loams. It shows the larges benefits of spading chicken manure lie between EM38 20-50, the deep and midslope sands.

Tables 5 and 6 show the grain quality results of Reps 1 and 2. The majority of the wheat samples were of high quality with low screenings and high protein. Generally there were higher protein results from plots which supplied the higher chicken manure or fertiliser. Many of the winery waste sites resulted in low protein as this product did not supply high rates of nitrogen. Some of the control areas had reasonable protein but this was often associated with low yield, and therefore still a low "N use".

The "N use" is of particular relevance as it provides an estimation of how much nitrogen is removed due to the yield and protein levels of each plot. The control areas are often showing an N removal of 40-60kg/ha, which is in stark contrast to the higher input areas such as "kitchen sink" spaded, 6t/ha chicken manure spaded and high fertilizer treatments that are often shown to be removing 100-140kg/ha. **If the increased yields of different treatments is mainly N driven then it is feasible that the benefits may only last for a few years.**

For instance, each ton of chicken manure contains approximately 25kg/ha of N and 4.8kg/ha P. Applying 6t/ha is essentially 150kg/ha extra N. If this high yielding treatment is removing an extra 50kg/ha N per year over the control, then after 3 years the majority of the extra N may be used up. **However, it is expected that the benefits of improved soil health and breaking compaction through spading manure to 40cm, resulting in increased root growth and higher organic matter turn over should result in longer lasting benefits than just higher N availability. This is another reason why it is vitally important that this trial be monitored long term.**

## Table 5. Grain quality results, rep 1.

| Yield | Protein | % Screenings | N use | Plot | Rep | Teatment | Zone |
|---|---|---|---|---|---|---|---|
| 0.78 | 11.9 | 1.5% | 42 | 0 | 2 | Control 0 | Loam |
| 1.17 | 11 | 1.2% | 59 | | 2 | Control 0 | Sand |
| 1.29 | 9.7 | 0.6% | 57 | | 2 | Control 0 | Midslope |
| 2.36 | 12.9 | 0.7% | 138 | 1 | 2 | Kitchen Sink Spaded | Midslope |
| 1.99 | 11 | 0.6% | 100 | | 2 | Kitchen Sink Spaded | Sand |
| 1.97 | 12.9 | 1.1% | 116 | | 2 | Kitchen Sink Spaded | Loam |
| 1.57 | 12.9 | 1.5% | 92 | 2 | 2 | Clayed Spaded | Loam |
| 1.73 | 10.6 | 1.7% | 83 | | 2 | Clayed Spaded | Sand |
| 1.79 | 9.7 | 0.6% | 79 | | 2 | Clayed Spaded | Midslope |
| 2.02 | 10.4 | 0.5% | 95 | 3 | 2 | 3t/ha Ch Man Spaded | Midslope |
| 1.95 | 9.3 | 0.6% | 82 | | 2 | 3t/ha Ch Man Spaded | Sand |
| 1.76 | 10.3 | 0.7% | 82 | | 2 | 3t/ha Ch Man Spaded | Loam |
| 1.28 | 12.5 | 1.3% | 73 | 4 | 2 | 3t/ha Ch Man | Loam |
| 1.33 | 11.8 | 1.4% | 71 | | 2 | 3t/ha Ch Man | Sand |
| 1.6 | 10.4 | 1.0% | 76 | | 2 | 3t/ha Ch Man | Midslope |
| 1.65 | 11.9 | 1.4% | 89 | 5 | 2 | 6t/ha Ch Man | Midslope |
| 1.16 | 11.5 | 1.6% | 61 | | 2 | 6t/ha Ch Man | Sand |
| 1.48 | 11.8 | 1.8% | 79 | | 2 | 6t/ha Ch Man | Loam |
| 1.81 | 14 | 1.4% | 115 | 6 | 2 | 6t/ha Ch Man Spaded | Loam |
| 2.01 | 11.9 | 1.2% | 109 | | 2 | 6t/ha Ch Man Spaded | Sand |
| 2.25 | 10.2 | 0.7% | 104 | | 2 | 6t/ha Ch Man Spaded | Midslope |
| 1.44 | 10.5 | 1.2% | 69 | 7 | 2 | Bio treatment 1 | Midslope |
| 1.07 | 11.7 | 1.9% | 57 | | 2 | Bio treatment 1 | Sand |
| 1.29 | 11.4 | 1.0% | 67 | | 2 | Bio treatment 1 | Loam |
| 1.56 | 12 | 1.8% | 85 | 8 | 2 | Bio treatment 2 | Loam |
| 1.33 | 11.7 | 2.3% | 71 | | 2 | Bio treatment 2 | Sand |
| 1.47 | 10.7 | 1.5% | 71 | | 2 | Bio treatment 2 | Midslope |
| 1.35 | 11.7 | 1.9% | 72 | 9 | 2 | Control 7 | Midslope |
| 0.98 | 10.3 | 1.5% | 46 | | 2 | Control 7 | Sand |
| 1.23 | 10.8 | 1.0% | 60 | | 2 | Control 7 | Loam |
| 1.61 | 11 | 1.0% | 81 | 10 | 2 | 3t/ha Ch Man Deep Rip | Loam |
| 1.58 | 11 | 1.1% | 79 | | 2 | 3t/ha Ch Man Deep Rip | Sand |
| 1.9 | 11.1 | 1.2% | 96 | | 2 | 3t/ha Ch Man Deep Rip | Midslope |
| 1.46 | 12.1 | 1.9% | 80 | 11 | 2 | Winery Waste | Midslope |
| 1.27 | 9.6 | 1.1% | 55 | | 2 | Winery Waste | Sand |
| 1.41 | 11 | 0.9% | 71 | | 2 | Winery Waste | Loam |
| 1.5 | 13.8 | 1.5% | 94 | 12 | 2 | Winery Waste Spaded | Loam |
| 1.75 | 10.1 | 1.0% | 80 | | 2 | Winery Waste Spaded | Sand |
| 1.76 | 9.1 | 0.6% | 73 | | 2 | Winery Waste Spaded | Midslope |
| 1.7 | 9.9 | 0.6% | 77 | 13 | 2 | Win Wste+3t/ha Grp Mk Spaded | Midslope |
| 1.56 | 8.7 | 0.6% | 62 | | 2 | Win Wste+3t/ha Grp Mk Spaded | Sand |
| 1.69 | 10.4 | 1.1% | 80 | | 2 | Win Wste+3t/ha Grp Mk Spaded | Loam |
| 1.8 | 10.7 | 0.6% | 88 | 14 | 2 | High Fert+Tr Elements Spaded | Loam |
| 1.97 | 9.7 | 0.6% | 87 | | 2 | High Fert+Tr Elements Spaded | Sand |
| 2.04 | 9.4 | 0.4% | 87 | | 2 | High Fert+Tr Elements Spaded | Midslope |
| 1.77 | | #DIV/0! | | 15 | 2 | High Fert+Tr Elements | Midslope |
| 1.45 | 10.7 | 1.0% | 71 | | 2 | High Fert+Tr Elements | Sand |
| 1.56 | 11.4 | 1.2% | 81 | | 2 | High Fert+Tr Elements | Loam |
| 0.98 | 13.2 | 1.6% | 59 | 16 | 2 | Control | Loam |
| 1.4 | 10.9 | 1.7% | 69 | | 2 | Control | Sand |
| 1.45 | 9.5 | 0.9% | 63 | | 2 | Control | Midslope |

**Table 6. Grain quality results, rep 2.**

| Yield | Protein | % Screenings | N use | Plot | Rep | Teatment | Zone |
|---|---|---|---|---|---|---|---|
| 1.03 | 9.8 | 2.9% | 46 | 0 | 1 | Control 0 | Sand |
| 1.03 | 12.2 | 3.3% | 57 | | 1 | Control 0 | Loam |
| 1.17 | 12.6 | 2.6% | 67 | | 1 | Control 0 | Sand/Midslope |
| 1.89 | 13.9 | 1.7% | 119 | 1 | 1 | Kitchen Sink Spaded | Sand/Midslope |
| 1.47 | 13.4 | 0.8% | 90 | | 1 | Kitchen Sink Spaded | Loam |
| 1.75 | 12.1 | 1.0% | 96 | | 1 | Kitchen Sink Spaded | Sand |
| 1.35 | 11.4 | 1.5% | 70 | 2 | 1 | Clayed Spaded | Sand |
| 1.15 | 10.7 | 1.3% | 56 | | 1 | Clayed Spaded | Loam |
| 1.46 | 11.6 | 0.9% | 77 | | 1 | Clayed Spaded | Sand/Midslope |
| 1.64 | 11.4 | 1.5% | 85 | 3 | 1 | 3t/ha Ch Man Spaded | Sand/Midslope |
| 1.18 | 13.5 | 2.6% | 72 | | 1 | 3t/ha Ch Man Spaded | Loam |
| 1.71 | 11.1 | 1.0% | 86 | | 1 | 3t/ha Ch Man Spaded | Sand |
| 0.89 | 12.7 | 2.3% | 51 | 4 | 1 | 3t/ha Ch Man | Sand |
| 1.04 | 14.3 | 4.7% | 68 | | 1 | 3t/ha Ch Man | Loam |
| 1.02 | 13.3 | 0.0% | 62 | | 1 | 3t/ha Ch Man | Sand/Midslope |
| 0.97 | 12.6 | 1.9% | 56 | 5 | 1 | 6t/ha Ch Man | Sand/Midslope |
| 0.98 | 14.7 | 4.4% | 65 | | 1 | 6t/ha Ch Man | Loam |
| 1.13 | 12.8 | 3.3% | 66 | | 1 | 6t/ha Ch Man | Sand |
| 1.76 | 11.6 | 0.9% | 93 | 6 | 1 | 6t/ha Ch Man Spaded | Sand |
| 1.19 | 13.9 | 2.1% | 75 | | 1 | 6t/ha Ch Man Spaded | Loam |
| 1.53 | 12.2 | 0.8% | 85 | | 1 | 6t/ha Ch Man Spaded | Sand/Midslope |
| 1.14 | 11.3 | 1.6% | 59 | 7 | 1 | Control 7 | Sand/Midslope |
| 0.89 | 14.4 | 3.0% | 58 | | 1 | Control 7 | Loam |
| 0.98 | 11.6 | 2.0% | 52 | | 1 | Control 7 | Sand |
| 1 | 12.3 | 2.4% | 56 | 8 | 1 | Bio treatment 1 | Sand |
| 0.79 | 14.3 | 3.9% | 51 | | 1 | Bio treatment 1 | Loam |
| 1.08 | 12.4 | 2.1% | 61 | | 1 | Bio treatment 1 | Sand/Midslope |
| 0.91 | 11.4 | 1.4% | 47 | 9 | 1 | Bio treatment 2 | Sand/Midslope |
| 0.84 | 14.4 | 2.9% | 55 | | 1 | Bio treatment 2 | Loam |
| 1.02 | 12.4 | 3.3% | 57 | | 1 | Bio treatment 2 | Sand |
| 1.55 | 11.1 | 2.3% | 78 | 10 | 1 | 3t/ha Ch Man Deep Rip | Sand |
| 1.07 | 12.5 | 2.1% | 61 | | 1 | 3t/ha Ch Man Deep Rip | Loam |
| 1.32 | 11.1 | 1.4% | 67 | | 1 | 3t/ha Ch Man Deep Rip | Sand/Midslope |
| 1.21 | 10.5 | 1.3% | 58 | 11 | 1 | Winery Waste | Sand/Midslope |
| 0.91 | 14.3 | 2.1% | 59 | | 1 | Winery Waste | Loam |
| 1.12 | 13 | 2.1% | 66 | | 1 | Winery Waste | Sand |
| 1.85 | 10.2 | 1.4% | 86 | 12 | 1 | Winery Waste Spaded | Sand |
| 1.15 | 14.4 | 2.3% | 75 | | 1 | Winery Waste Spaded | Loam |
| 1.56 | 11.1 | 0.6% | 79 | | 1 | Winery Waste Spaded | Sand/Midslope |
| 1.8 | 9.9 | 1.3% | 81 | 13 | 1 | Win Wste+3t/ha Grp Mk Spaded | Sand/Midslope |
| 1.32 | 13.5 | 1.3% | 81 | | 1 | Win Wste+3t/ha Grp Mk Spaded | Loam |
| 1.6 | 10.3 | 1.2% | 75 | | 1 | Win Wste+3t/ha Grp Mk Spaded | Sand |
| 1.97 | 10.9 | 1.1% | 98 | 14 | 1 | High Fert+Tr Elements Spaded | Sand |
| 1.54 | 10.4 | 1.0% | 73 | | 1 | High Fert+Tr Elements Spaded | Loam |
| 1.79 | 11.3 | 0.9% | 92 | | 1 | High Fert+Tr Elements Spaded | Sand/Midslope |
| 2.39 | 11.8 | 2.3% | 128 | 15 | 1 | High Fert+Tr Elements | Sand/Midslope |
| 1.63 | 14.3 | 1.4% | 106 | | 1 | High Fert+Tr Elements | Loam |
| | 12 | 3.2% | | | 1 | High Fert+Tr Elements | Sand |
| | 13.5 | 1.7% | | 16 | 1 | 12t/ha Ch Man Spaded | Sand |
| 1.42 | 15.8 | 2.8% | 102 | | 1 | 12t/ha Ch Man Spaded | Loam |
| 2.26 | 12.6 | 2.5% | 129 | | 1 | 12t/ha Ch Man Spaded | Sand/Midslope |
| 1.76 | 10.8 | 0.9% | 86 | 17 | 1 | 3t/ha Ch Man 3t/ha Grp Mk Spaded | Sand/Midslope |
| 1.32 | 14 | 0.6% | 84 | | 1 | 3t/ha Ch Man 3t/ha Grp Mk Spaded | Loam |
| 1.17 | 10.4 | 1.0% | 55 | | 1 | 3t/ha Ch Man 3t/ha Grp Mk Spaded | Sand |
| | 10.2 | 1.5% | | 18 | 1 | Control 18 | Sand |
| 1.68 | 13.4 | 1.4% | 102 | | 1 | Control 18 | Loam |
| 2.09 | 10.4 | 0.7% | 99 | | 1 | Control 18 | Sand/Midslope |

**Figure 29. Spading machine with large presswheels to leave ground ridged and firm**


## 4 Summary

Spading Chicken Manure at rates of 3t/ha and 6t/ha has almost doubled yields at a farmer scale sand trial south of Waikerie. This is due to a combination of breaking deep soil compaction, increasing soil fertility and improving soil moisture holding capacity, leading to increased rooting depth and moisture extraction through spring.

There has been a great deal of farmer interest in the trial that is practical for local farmers to implement given the increasing numbers of chicken farms in the area. There is some concern over the erosion risk of spading large areas of these sandy soils. It is advised that spading is done as close as possible to seeding time, and that the spading machine has large presswheels trailing to ridge and firm soil, to help minimise this risk.

Initial economic analysis suggests these treatments are affordable with costs recoverable in short term. It is intended that this site will be monitored over coming years to assess the long term effects of various treatments.

# 5 Acknowledgements

This project would not have been possible without the commitment of the Lowbank Agricultural Bureau members. In particular, the Schmidt family, whose property, time and equipment were used to host this trial, as well as Bureau chairman Brenton Kroehn.

Viterra Loxton provided support for grain analysis.

**This project was funded through the South Australian Murray-Darling Basin Natural Resources Management Board and the Australian Government's National Landcare Programme.**