SA Seep Site 2: Lachie Singh, Alawoona

“Fixing a waterlogged zone growing twice the crop, before it becomes a degraded seep scald, using the Subsoil Extruder to repair sandhill”

Dr Chris McDonough, Insight Extension for Agriculture

Purpose

This demonstration site aims to rehabilitate an emerging seep area while it is still at the soil saturation stage (growing a substantially better crop) before it becomes a degraded saline scald. This site has applied an innovative deep dipping machine that pumped a slurry of manure through the soil profile to 3ha of deep compacted non-wetting sand above the seep area. If successful it could represent a way of ameliorating the recharge zone to achieve far greater water use, in a practical, affordable and efficient way that improves production on sandhills without exposing them to high erosion risk. It will encourage farmers to start to address seep issues before they become a permanent land degradation issue.

Trial/Demonstration Design

The site has been established with 5 treatments, including:

- the deep ripping with slurry injection of chicken manure at both 50cm and 1m row spacings
- deep ripping pig manure at 1m row spacings (40-60cn depth
- deep ripping alone (40-60cm depth),

over 3ha of sandhill, direct above the crop area becoming waterlogged (see Figures 1 & 2, Photo 1).

As this is an innovative use of a prototype machine in its early stages of development, it proved to be a challenging exercise, and difficult to achieve consistency in ripping depth and slurry flow rates. It was often difficult to mix the manure, and while the aim was to use about 6-8t/ha of manure, there would have been some strips that want out at least twice this rate. The flow rate was generally controlled by speed of the tractor and the density of the slurry which tended to vary throughout each load. Unfortunately the PTO shaft broke on the machine, meaning that only 1 side of the sandhill was treated, rather than the whole rise. Despite these difficulties, the treatments and trial was set up sufficiently to adequately test the validity of this innovative strategy. (This trial was done in conjunction with a small plot replicated trial at Loxton by SARDI were a more even distribution of higher manure rates were obtained).

There were some modifications made to the manure distribution pipe for this trial. The original had a sausage of manure being extruded at 40cm depth. By cutting a slit in the back of pipe, (Photo 2) an improved profiling of the slurry from 20-40cm appeared to be obtained. This should be better for crop roots to follow the fertile organic band, and decrease the likelihood of soil re-compaction.

A soil moisture probe in both the Deep Ripped Chicken Manure Slurry section and the Control section, to measure the treatment's effect on rainfall infiltration, retention and crop water use to 1m depth. This is critical in understanding what differences the soil ameliorating treatment has made to the water dynamics of the sandhill. Unfortunately there was a machinery incident at seeding time that caused a loss of data from the Control probe for a 5 week period.

A piezometer has been placed at the middle of the seep concern area, which is presently growing vastly improved crops due to roots accessing the developing perched water table below. A rain gauge has been located on a nearby fenceline. At the time of establishment the perched water table level was sitting at 60cm below the soil surface. The soil was sampled and tested at this time at different depths, as well as the water that accumulated in the piezometer. Each of these monitoring items use data loggers to allow for a more accurate assessment of the dynamics of the site over time. Initial soil and water samples have been taken and analysed.

The treatments were visually monitored throughout the season, and dry matter cuts were taken in September. Yield samples were taken with the farmers header from the treatment plots but this proved to be extremely challenging as a result of extremely low yields due to the drought.

Figure 1. NDVI Image of trial paddock showing blue areas of seep concern

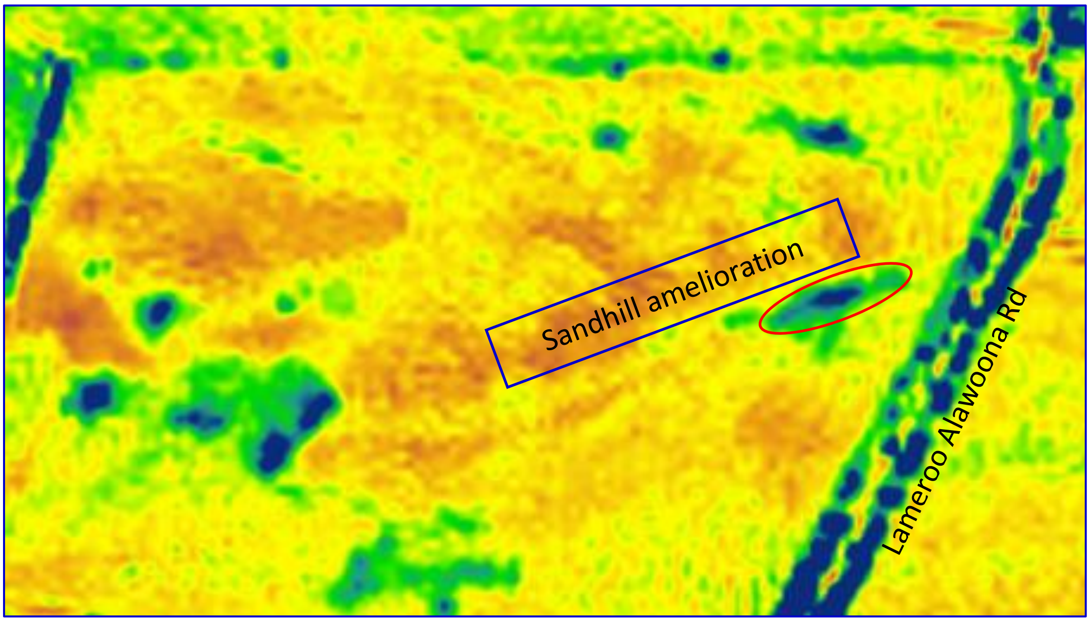


Figure 2. Google earth Image of paddock showing treatment areas

Photo 1. Singh catchment at seeding time showing demonstration site features

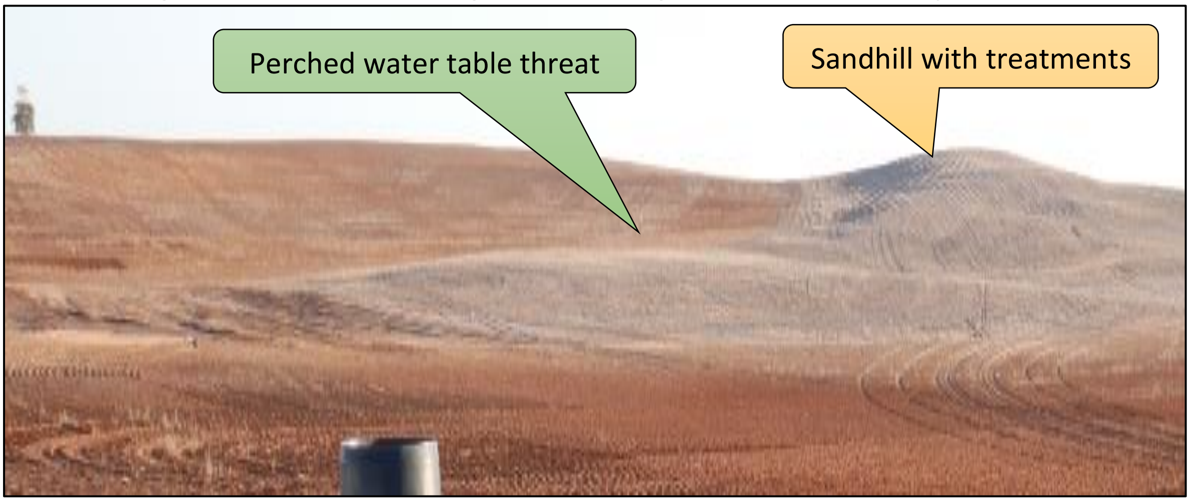


Photo 2. Treated sandhill with moisture probe above developing seep area

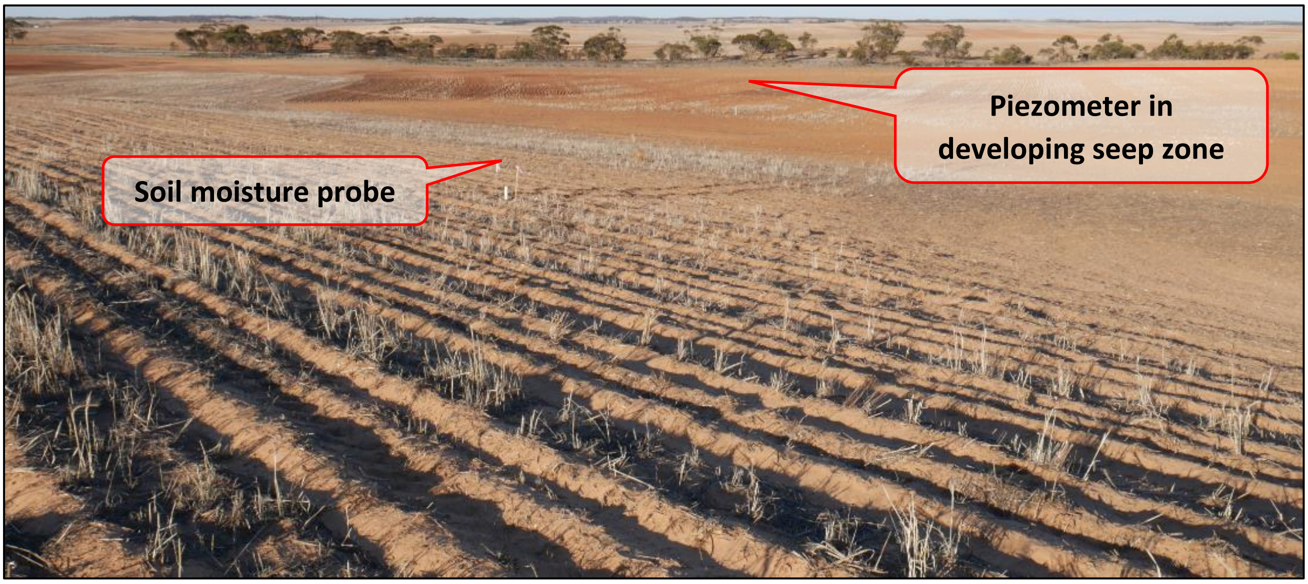


Photo 3. Piezometer with perched water table originally at 60cm (June 2019).

Photo 4. Modifying slurry pipe from original tube to soil profiling distribution

Photo 5. Subsoil extruder operations, filling with manure and mixing ready for use

Photo 6. Composted chicken manure and pig manure used

Results and Discussion

Sandhill Amelioration in the Recharge Zone

The Effectiveness of the Subsoil Extruder

The basic operational intention of the subsoil extruder is very sound in that it can:

1. break subsoil compaction, allowing crop roots to penetrate deep moisture & nutrients below 20cm;
2. deposit a column of fertile organic matter through the deep soil profile to greatly improve the soil health productive potential of these very poor soils;
3. achieve this with minimal topsoil disturbance, overcoming considerable wind erosion risk issues.

This was demonstrated at both this site and the SARDI Loxton trial site. However, this process did reveal many areas of improvement which should be addressed with the next prototype. The farmers and researchers involved believe it would be better as a tow behind machine, rather than a 3 point linkage. The mixing of water and manure to create the slurry is extremely time consuming, and needs to be improved, and may be more efficiently achieved as a separate operation. A wider machine with more tines would make the operations more efficient. A new improved Subsoil Extruder is presently under construction.

Photo 7. Testing the manure slurry flow through deep ripping tubes

Photo 8. Subsoil extruder in action

Photo 12 shows that the desired effect from the machine was achieved, with a clear example of a manure column created through the sand compaction zone (20-50cm depth). There is a clear proliferation of crop roots through this slot and directly below this into the wet soil below. It is unclear how consistently this effect was achieved, as not every soil pit showed as clear a result. This may have been the result of achieving the right combination of speed and slurry viscosity. I will be interesting to examine how crop roots follow these slots in the future, as they are very fertile and will not re-compact like the sand.

Table 1 shows the nutrient content of the manure when applied at the desired rate of the trial at 6t/ha. This equates to 180kg/ha N and 100kg/ha P for the chicken manure, with other nutrients, which is considerably high for a sandhill. The fact that these nutrient are very concentrated into the specific strips, will also affect the crop differently than when spread evenly across a paddock. It is hoped that the nutrient value supplied from this application will be long lasting, creating higher crop growth and yields and a higher turnover of organic matter and nutrients over time.

Photo 9. Successful manure profiling by the subsoil extruder showing strong root growth below

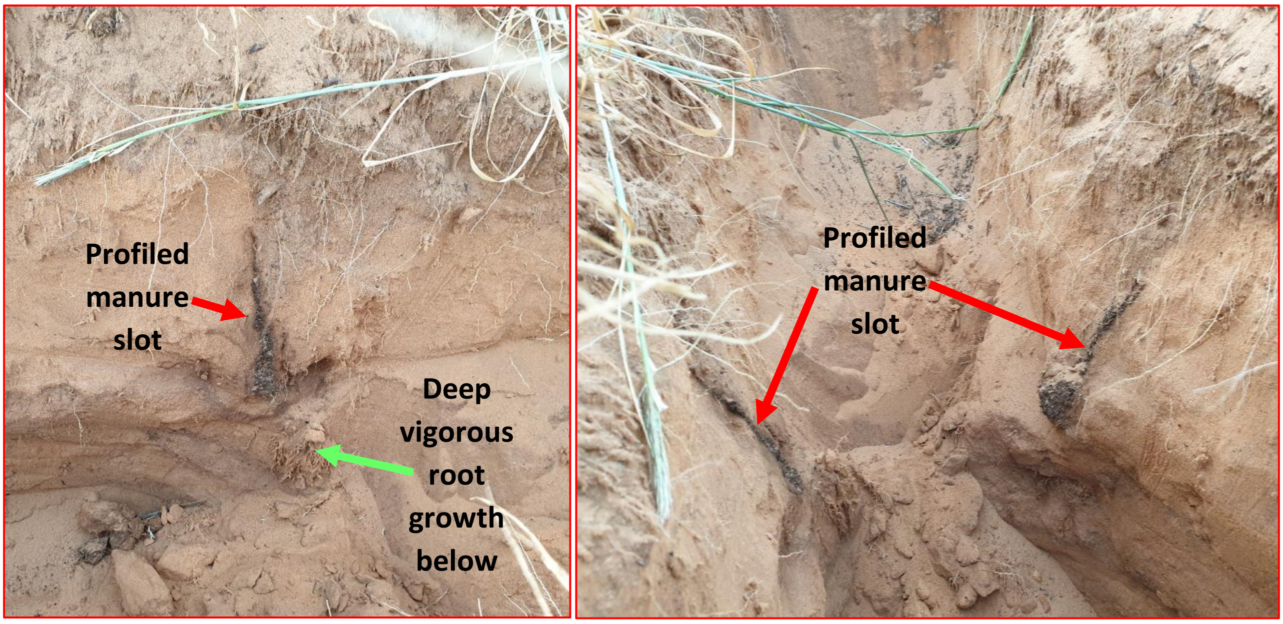


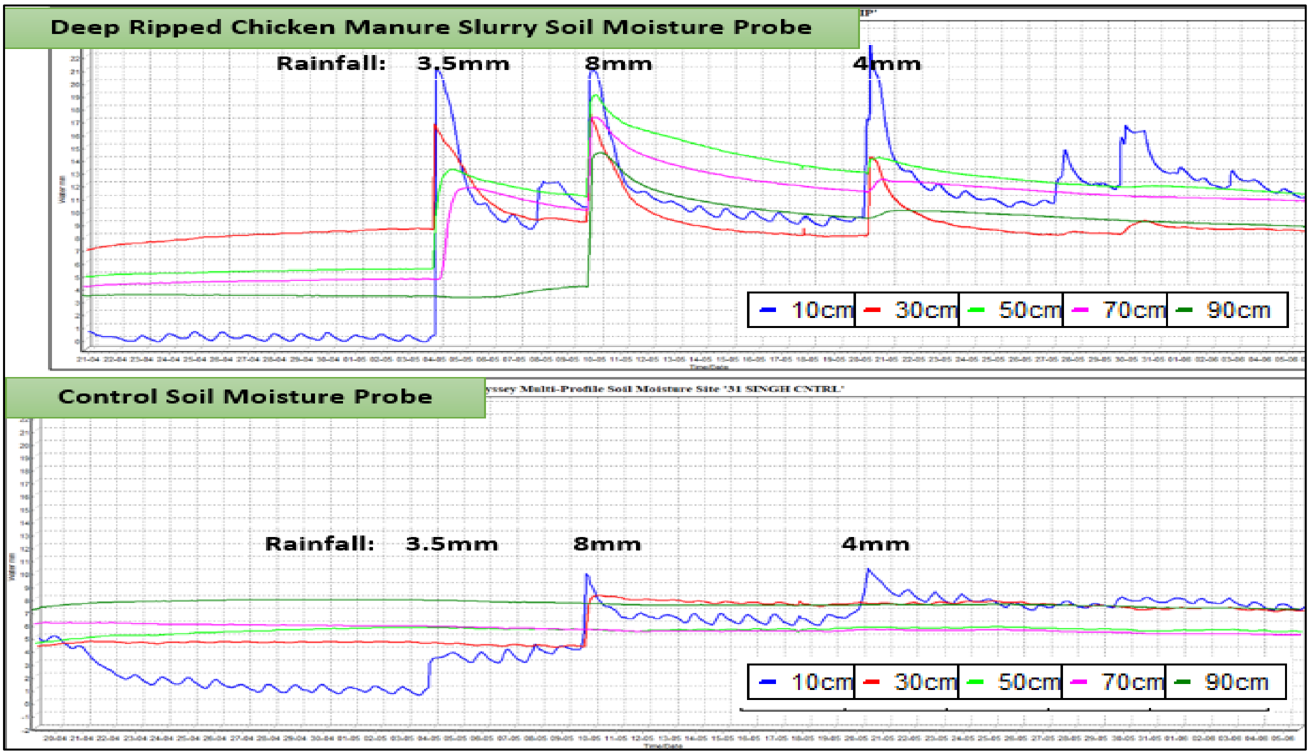
Table 1. Nutrient analysis results of manures used showing kg/ha applied if 6t/ha was applied

Analyte	Pig Manure	Chicken Manure
	Nutrients (kg/ha) if applied at 6t/ha	
Total Nitrogen	177	179
Aluminium	5	11
Boron	0.2	0.4
Calcium	142	180
Cobalt	0.01	0.002
Copper	5	1
Iron	7	12
Magnesium	35	47
Manganese	2	4
Molybdenum	0.03	0.07
Phosphorus	55	100
Potassium	163	160
Sodium	33	35
Sulphur	36	34
Zinc	3	3

Figure 3 shows a startling difference in soil moisture changes down to 1m after only the first few small rainfalls between the ripped and control areas. The lack of soil moisture penetration in the Control section is most likely due to the non-wetting nature of this soil, leaving it to evaporate in the surface. It showed minimal moisture increase at 10cm after 3.5mm, and without any build-up of moisture at 30cm until the 8mm rainfall, but no impact on soil moisture sensors below this. Even the 4mm rainfall after had very little impact on the 10cm sensor, which clearly shows that the non-wetting nature of this soil must be addressed for these soils to improve in crop establishmet.

This is in stark contrast to the soil moisture penetration to 70cm after the initial 3.5mm in the Deep Ripped Chicken Manure Slurry section. The following 8mm even made it to 90cm and likely deeper, given the peak and fall of this line with no root growth present. However, each subsoil layer has increased available moisture storage, which was then available to crop growth due to the breaking of the soil compaction layer. It is possible for cereal roots in these soils to penetrate to 150cm. The following 4mm rainfall event was clearly retained within the crop rootzone (Figure 3).

Figure 3. Soil moisture penetration differences between treatments (April 20th to June 5th)



The fact that such small rainfall events can penetrate so deep in the profile is a reflection of the very poor water holding capacity of this sand, and given that each sensor layer rises quickly and then gradually lowers, with no growing roots present, suggests that while moisture has been retained, a percentage has still passed through to lower layers. This result would suggest that from a seep prevention perspective, deep ripping these soils alone may only have limited impact on increasing water use and preventing recharge, if there is no soil amelioration work done with deep mixing of clay or organic matter to hold the moisture within the rootzone for crop use.

The full season moisture probe results (Figure 4) show the clear advantage of the subsoil extruder operation. Crop roots have clearly penetrated into the deeper layers and drawn moisture down close to their mid-autumn levels. By contrast, the Control soil moisture levels have mostly only fluctuated at the 10cm sensor, which may have been used by the crop or lost to evaporation, with some 30cm moisture utilised for a period beginning in late August. There was almost no evidence of any deep soil moisture being utilised by the crop throughout this drought season. While there is missing data for the 19mm rainfall in May, there was no evidence of any recharge occurring in this drought season form the control plots.

Figure 4. Moisture Probe and Piezometer Readings aligned with Rainfall (April- Dec 2019)

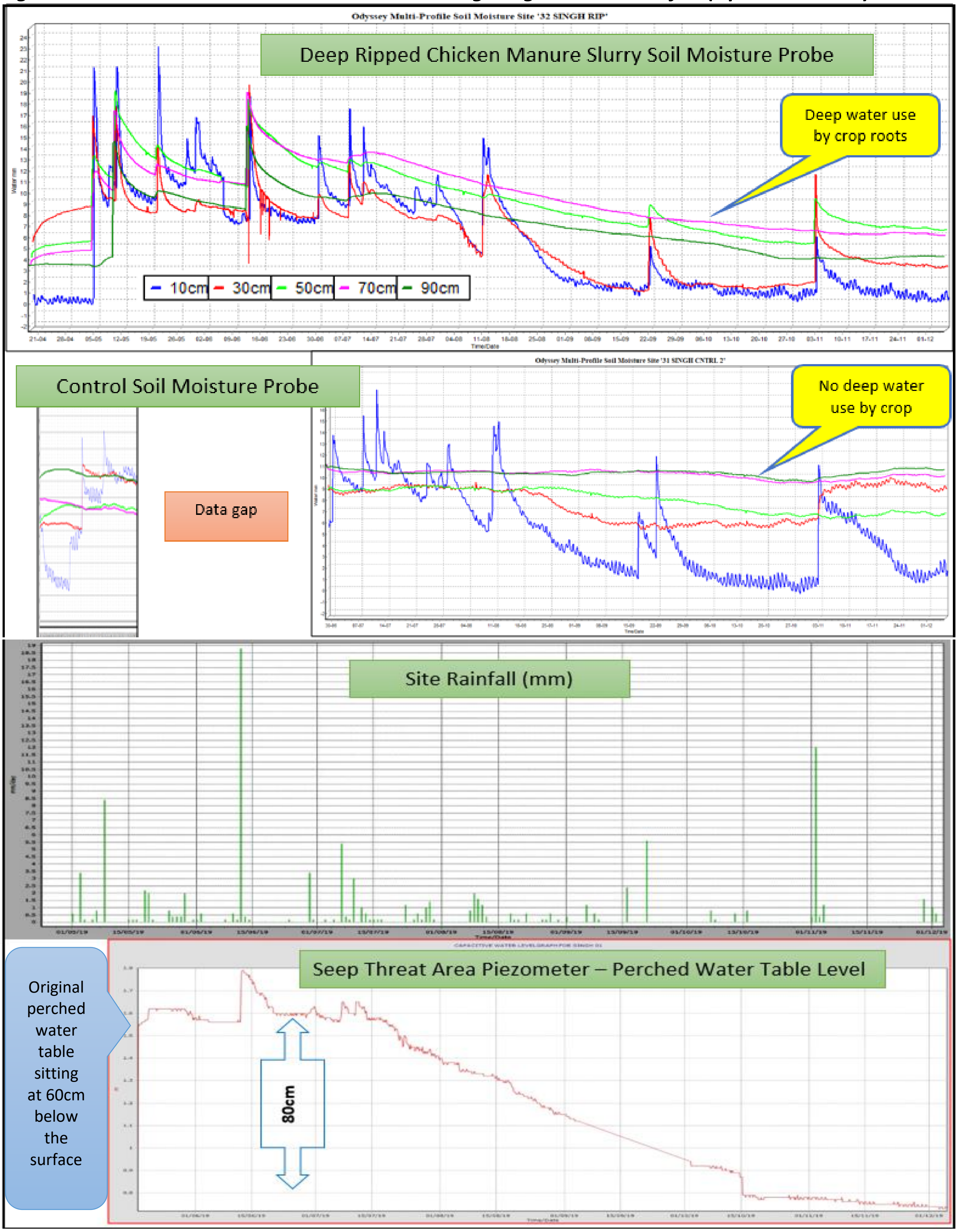
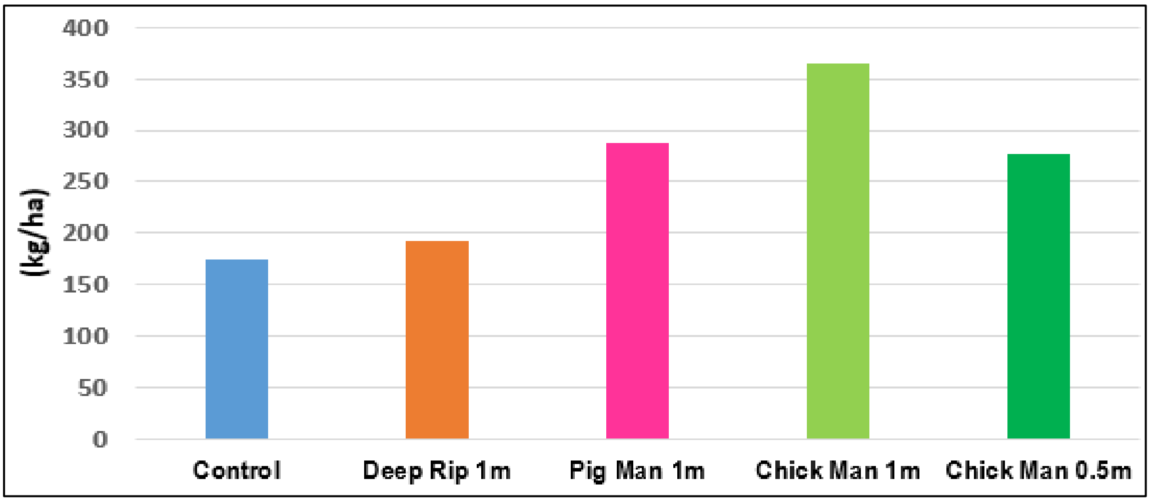


Figure 5. Cereal Rye Dry Matter Cuts, Sept 27, by Treatments and rip line spacings.



The dry matter cuts taken in late September show a clear trend towards improved crop growth in the deep ripped manure slurry treatments. The Chicken Manure at 0.5m rip line spacings may have been adversely affected by poorer crop establishment (seeding into a very soft uneven soil bed). It should also be noted that although each treatment strip is in a very deep non-wetting sand, the Control and Deep Rip strips are more on the crest of the hill, which appears slightly less fertile. The improved crop growth does follow the differences in the soil moisture use recording between the Control and Chicken Manure Extruded sites (Figure 3).

Harvest results from the site proved unreliable, as the drought conditions were to severe and yields too low to be meaningful and comparable results from the farmers header. The higher crop growth during the season in some plots could not be sustained through to yield in these deep sands. Similarly, in the SARDI trial at Loxton there was no meaningful results obtained from the deep sand, however, the subsoil extruder showed significant benefits in the midslope section of the trial.

It will be important to follow these trends through into the coming seasons, with possible yield results in more favorable years. The farmer is also considering establishing lucerne over the sandhill, which should provide the best long term and all year round high water use option to address the perched water table issue.

The Discharge Zone

Alawoona received less than half its annual average rainfall for 2019 with 137mm (ave 286). The late break and very poor growing season saw most of the heavier soil types produce very little crop yield, as evidenced in Photos 10, 11 & 12. However, in the area above the perched water table at the base of the sandhill, the barley was estimated to be producing at least a 3t/ha crop. While this may be viewed as a positive outcome, it is very clear from other areas in this paddock (Photo 12) and neighbouring paddocks that if no action is taken to address water flows from the Recharge Zone, then this are will quickly develop into an unproductive, bare saline scald.

Figure 4 reveals a drop in the perched water table of approximately 80cm over the year. This may be more attributable to the lack of high rainfall events, rather than the benefits of the sandhill amelioration at this stage. It is worth noting that there was no impact from the 12mm rainfall in November to the water table, whereas there were brief spikes recorded from much smaller rainfall events in May. This could suggest that the crop roots ability to dry out the subsoil to at least 1m (as evidenced in the Soil Moisture Probe readings) has provided a buffer to absorb this moisture and restrict recharge. This will be keenly monitored in the future.

Photo 10. Increased crop growth due to perched water table at the base of the sandhill.

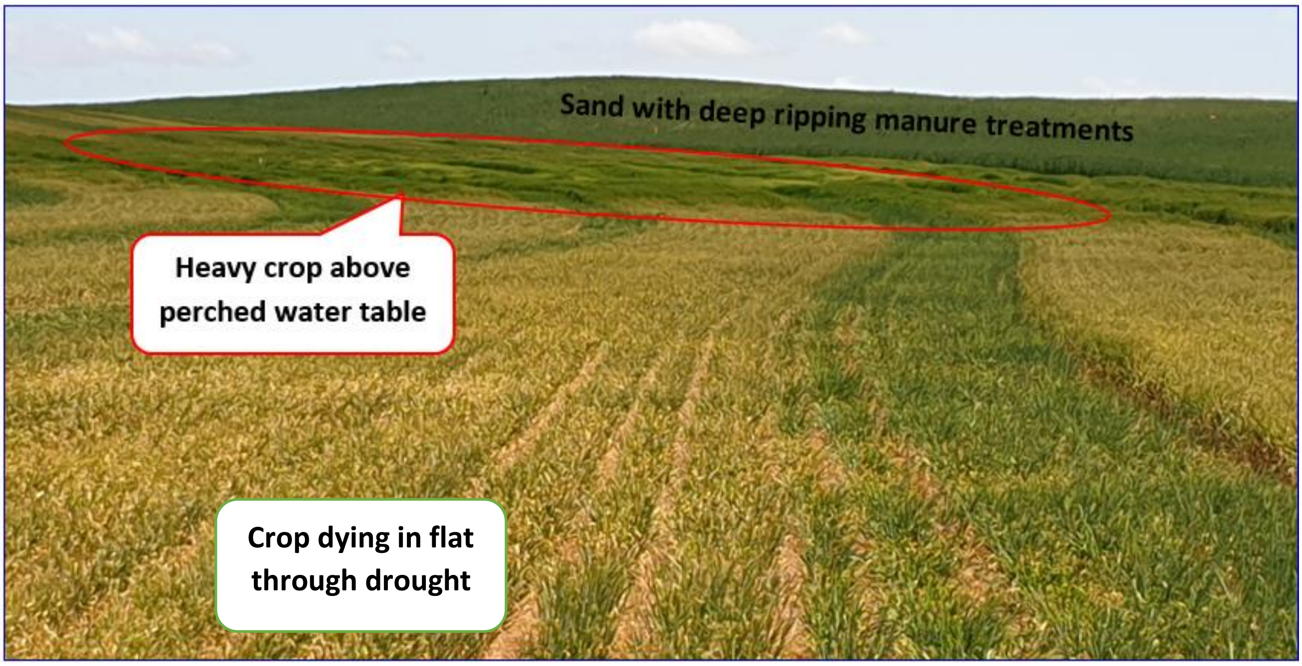


Photo 11. Huge crop growth above perched water, and poor crop growth in surrounding paddock

Photo 12. Bare saline seep scald forming in other part of same paddock (the next phase in process)

Conclusions

This demonstration trial has revealed important information about the water dynamics within these deep sands with very low water holding capacity. It has shown the lack of early moisture penetration due to the non-wetting nature of the soil, which can be corrected through aggressive soil disturbance. There has been a clear advantage of deep ripping to allow crop root penetration past 30cm depth to utilise soil moisture to at least 90cm. Allowing more water to penetrate and be used by the crop will lead to higher crop yields, as well as create a greater buffer to summer rainfalls contributing to recharge.

Soil moisture probe data has also indicated how little water these sands can hold, and even small rainfall events can contribute recharge. Subsoil amelioration with clay, manures or other organic matter may be important tools to help retain more water to be used within the crop root zones.

The innovative use of the Subsoil Extruder has appeared to work well in breaking soil compaction and creating a very fertile organic column to allow for crop roots to penetrate the deeper layers, and provide nutrition to match the increased yield potential of this sandhill in coming years. While there are many modifications that need to be made to this prototype to improve the efficiencies and effectiveness of operations, the Subsoil Extruder has been successful in providing a much safer way of ameliorating subsoils with nutrition organic matter, than alternatives such as spading which can lead to high soil erosion risks.

This site will continue to be monitored over coming years to see if the sandhill amelioration can lead to a sustained reduction of the perched water table below and protection from crop loss, surface scalding and permanent soil degradation, even after higher rainfall years.

Acknowledgements

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