Understanding and Farming Acid Soils on Eyre Peninsula

PROJECT SUMMARY 2019-2023

1. INTRODUCTION

Soil acidity is a significant issue on Lower Eyre Peninsula (LEP) and Eastern Eyre Peninsula (EEP) with more than 186,000 hectares of agricultural land in the region prone to acidification.

Previous projects on Eyre Peninsula (EP) have suggested that the rate of acidification is occurring faster on average than historical estimates. Average lime use since 1999 is about 77% of the estimated topsoil acidification rate (35,000 tonnes for all acid prone soils), so a lime deficit has accumulated. Increased lime sales in the region with estimated sales of more than 45,000 t per year since 2017 has started to reduce this deficit.

To keep the momentum and increase further remediation of acid soils, the Eyre Peninsula Landscapes Board (EPLB) developed the 'Farming Acid Soils Champions' project, supported by the EPLB Regenerative Agriculture Program and funded by the Australian Government's National Landcare Program.

The main components of the project were:

1. **Deliver the 'Farming Acid Soils Champions' program to landholders on Lower and Eastern Eyre Peninsula -** to develop and deliver an extension program called 'Farming Acid Soils Champions' with the objective of developing the knowledge and skills of 80 farmers on Lower Eyre Peninsula to champion the cause of managing acidic soils in the region.
2. **Facilitate pH mapping activities** - to provide those farmers involved with the knowledge and equipment to undertake pH mapping on their properties using aerial photos and pH field kits, and to offer them the opportunity to have a paddock mapped using a VERIS pH mapping machine.
3. **Assessment of pH levels at pre-existing and new sites** – to utilise the 35 pre-existing sites as baselines and monitor 20 new sites to assess change with various treatments.
4. **Lime sales** – monitoring of lime sales (through Department of Environment and Water (DEW)) annual soil acidity reporting.
5. Other acid soils workshops, events and case studies.

In summary, farmers in the program found it interesting and relevant to their business and found the information presented valuable for understanding the causes, and monitoring the impacts, of soil acidity. Farmers also gained skills to cost effectively treat soil acidity on their properties. Most farmers stated that they would make changes to the management of their property as a result of the program including:

- Increase regular pH testing/paddock scale pH mapping.
- Apply variable rates of lime to target areas.
- Incorporation of lime into the subsurface by deep ripping or spading.
- Utilise excel based tools/models for management of acidity.

2. BACKGROUND

Soil acidity describes the condition of the soil where there is an excess of hydrogen ions. Severe soil acidity is reflected by very low soil pH.

Strongly acid soils limit crop and pasture production by:

- Restricting root growth and reducing the efficiency of fertiliser uptake by plants
- Reducing the activity of micro-organisms
- Reducing the availability of many important nutrients
- Increasing the availability of toxic elements

Acidification is happening faster on acid-prone soils on Eyre Peninsula under current farming systems than historic estimates. Evidence collected through previous on-ground projects highlighted the growing concerns. Also, evidence-based estimates from the Department for Environment and Water indicate that around 7% (186,000 ha) of Eyre Peninsula's agricultural land, predominantly on lower EP and the Cleve Hills, is currently prone to surface soil acidification. A further 509,000 ha is at risk of acidifying over the next 20-50 years unless adequate ongoing treatment is implemented.

Soils can be naturally acidic, however more intensive, and productive farming systems can accelerate acidification. Crop and pasture plants take up alkaline cations as they grow, expelling acidic (hydrogen) ions to balance the soil charge. The alkaline cations are often then permanently removed from the systems as grain, hay, or livestock.

There are 3 main processes which contribute to accelerated acidification:

1. ***Crop and pasture growth*** – as plants grow, they take up alkaline cations and expel hydrogen ions to balance the soil charge.
2. ***Leaching of nitrates*** – when nitrates are leached alkaline cations (Ca++, Mg++, K+) are also removed to balance soil charge. This happens with high rates of applied nitrogen (N) but can also happen under legume systems if N produced is not used by following crops.
3. ***Application of mineral nitrogen fertilisers*** – conversion from fertiliser product into plant available forms of N results in a net concentration of H+ (acid ions) being left behind in soil. ***This is the biggest contributor to accelerated soil acidification.***

Modelling suggests that under high input canola/cereal production systems on lower Eyre Peninsula more than 90% of the total acidification can often be attributed to N fertiliser applications.

Soil acidification can be accelerated under high nitrogen input systems, particularly on soils with a low capacity to buffer pH change, i.e. sands. In recent years surveillance sampling is detecting acidification of such soils on Lower Eyre Peninsula, even in areas not traditionally thought of as being prone to soil acidity.

Paddocks with varying soil types may also have large variations in soil pH, creating a patchwork of areas to manage. Managing these areas as separate zones is the key to increasing the cost effectiveness and production benefits of liming operations.

3. OUTPUTS

3.1 FARMING ACID SOILS CHAMPIONS

To increase the knowledge and skills of farmers, workshops were delivered over 4 years of the project. Farmers were given an overview of the program and invited to participate as “champions”.

3.1.1 2019

Workshop 1 of the program was held in at Cummins on 28 February 2019 (4 participants) and at Cleve the following day (15 participants). Brett Masters (PIRSA) presented an overview of the causes of soil acidity and the impact of soil type and farming systems on acidification rates. Mary Crawford (NREP) led a mapping exercise to show participants how they could use an aerial photograph and soil pH kit to identify zones of varying soil pH within a paddock. Participants from the Cleve workshop were asked if they would like a paddock mapped with the Veris mapper; at this time 4 participants felt they would be interested in this (of the remaining participants 2 had already had some mapping done, 2 stated that they felt mapping with the field kit and aerial photo would give them a good idea of pH variation across the paddock, 2 said that they would get paddocks mapped using a commercial operator, because at a cheaper price per hectare, albeit at a lower resolution, they could cover more area).

3.1.2 2020

Representatives of 19 farm business attended the first workshops at Cleve and Cummins, February 2020 (follow up workshops were conducted in June 2020). Field pH mapping using an aerial photo and field pH kit were utilised to give farmers an idea of pH variation within paddocks. In addition, the results of some case study paddocks mapped using Veris machines adequately demonstrated some of the potential benefits of high-resolution pH mapping for cost effective management of soil acidity.

The second workshop in the program provided farmers with an opportunity to discuss their observations, what they had learnt about managing soil acidity, pH mapping results and what treatments they had implemented since the first workshop. 9 farm business were represented with 2 agronomists attending.

Key points from farmer discussions during the first workshops included:

- Some understanding that soils in the district are prone to acidification with some indicating that they are starting to see the impacts on crop growth, particularly in legumes such as lentils and vetch.
- Others were new to managing acid soils and keen to learn more.
- Some had done some liming in the past but wanted to update their knowledge regarding the causes, impacts and management of soil acidity,
- Some were observing production benefits following liming (either on their properties or neighbours’ properties), but that the effect of this seems to only last a few years.
- Interest in using yield maps or different crop types as indicators for soil acidity.
- Interest in learning more about subsurface acidity including the rate of lime movement through profile, and crop response from incorporating lime by deep ripping or spading.

- Most were generally unaware of the impact nitrogen fertiliser applications had on soil acidification.
- Most had ready access to lime spreaders (either owning or can easily hire one), and new models have improved capacity to spread the correct rates of lime more evenly.

Key points from the second workshops included:

- Address soil acidity now before it becomes more difficult and costly to treat.
- Liming is still cheaper than spreading urea.
- Keep monitoring soil pH, particularly where indicator plants, particularly where weeds or poor crop performance indicate a soil acidity issue.
- Need to keep surface pH above 5.5 to reduce the risk of subsurface acidity developing.
- Importance of soil testing to pick up spatial variation in pH, which can increase the cost effectiveness and reduce the overall cost of the liming operation.
- Importance of incorporation for addressing subsurface acidity
- Demonstration of lime models/calculators were interesting.
- Cost of lost production

The majority indicated that they would make changes to the way that they manage their property based on the information gained from the program, with the remaining farmers stating that they would make management changes as a result of the program. The most common management changes that farmers thought they will make as a result of the program are:

- Increase regular pH testing/paddock scale pH mapping.
- Apply variable rates of lime to target areas.
- Incorporation of lime into the subsurface by deep ripping or spading
- Utilise excel based tools/models for management of acidity.

3.1.3 2021

1 x workshop in priority soil acidification area (Cummins 24 Feb, 6 attended), 1 x workshop in emerging soil acidification area (Cleve 25 Feb, 9 attended). Follow up workshops: 1 x workshop in priority soil acidification area (Cummins 25 June, 4 attended), 1 x workshop in emerging soil acidification area (Cleve 28 June, 4 attended).

There were 16 farm business representatives that attend the workshops at Cummins and Cleve. Presentations provided an overview of the causes of soil acidity and farmers shared their experience of managing soil acidity. Farmers were shown how they could use an aerial photograph and field pH kit to undertake 'low tech' soil pH mapping and identify zones of varying soil pH within a paddock.

These were followed up with a second workshops where could discuss their observations, what they had learnt about managing soil acidity, pH mapping results and what treatments they had implemented since the initial workshop. Additional information was presented on case studies demonstrating the cost effectiveness of liming from pH mapping; a summary of the 2020 surveillance sampling results, pH stratification under no-till and lime movement through the soil profile. PIRSA demonstrated their Excel based soil acidity management tools including the 'Lime Maintenance Rate Model', 'Lime Comparison' and 'Cost of soil acidity' tools.

Feedback from farmers involved validated that the program was interesting and valuable; and that it had resulted in an improved understanding of soil acidity and acidification rates.

Farmers indicated that they would be implementing changes on their properties as a result of the program. The main changes they indicated they would implement were increased pH mapping and lime spreading, undertake lime incorporation and increased soil pH testing.

3.1.4 2023

Two workshops were held, at Cleve and Yallunda Flat in March 2023 with 39 farm business representatives participating.

Discussion across all the content was wide-ranging with all farmers showing interest. The farmers were interested in data which was specific to the long-term monitoring sites and major contributors to the development of acidic soils in their district. There was high interest in the emerging technological aspects. Overall interest was high as practical applications and real-life local results were discussed in detail.

Feedback included:

- Learning to trial ways to get lime to depth while dealing with high pH topsoil.
- Good insights into liming and effects on various depths of soil.
- Learned that the best time to start liming is now not later.
- Will continue to test more manually with a pH kit top and at 20cm.
- Learned that too much lime on subsurface affects it going into the subsoil.
- Great conclusions and take-home messages.
- Justified what they have done with ideas for ongoing management.
- Keep an eye on subsurface pH.
- Excellent information - local data and new cutting-edge research.

3.2 FACILITATED pH MAPPING EXERCISES

Participating farmers were asked to select one paddock to use as a case study, with each participant being provided a laminated aerial photograph of their paddock and a field pH kit. Farmers were asked to use the knowledge gained about soil type influences on pH and indictor plants to determine areas of low pH in the paddock. They were then asked to map the paddock using the field pH kit to ground truth their expected pH variation.

Nineteen of the 29 farm businesses involved in the program undertook mapping using their field kit prior to end of the project. The farmers who completed this said that it was a useful exercise, with a number commenting that some areas of the paddock were more acid or more alkaline that what they had thought.

Examples of case study paddocks with production zones and field pH results marked.

Several farmers also commented that they did not realise they had such large areas of acid soils and that they intend to map a portion of the property each year. Presentation of the results of some case study paddocks mapped using Veris machines at Workshop 2 demonstrated some of the

potential benefits of high-resolution pH mapping for cost effective management of soil acidity. Some had subsequently engaged commercial pH mapping contractors to map their case study paddocks.

Farmers were also asked to provide five years of paddock management information (nitrogen fertiliser inputs and crop/pasture production) to use PIRSA's lime maintenance rate model for estimating acidification rates on their case study paddock. Although not widely seen as useful, the most likely explanation for this is that the farmers rely on pulse crops to supply some nitrogen for following crops, and that drier seasons reduced crop nitrogen requirements, and hence acidification.

In general, much higher nitrogen rates are used in the higher rainfall areas of LEP compared to EEP. The acidification rate is therefore much higher. Discussion with workshop participants noted, as in 2020, that grain legumes in LEP rotations have generally increased compared to previous years (where a 3-year rotation of canola followed by two cereals was common). Under the more intensive canola and cereal rotation higher mineral nitrogen inputs resulted in very high mean acidification rates for the district.

3.3 OTHER ACID SOILS EXTENSION

3.3.1 Acid soils webinar 20 June 2023

Dr Ruby Hume and Josh Telfer presented an online update on the current liming and soil pH status of the long-term monitoring soil pH sites on Eyre Peninsula. This was a condensed version of the acid soil forum held in May 2023.

They covered aspects of soil acidity including:

- Liming to manage soil acidity and the process and outcomes of the practice
- Emerging areas of soil acidity on Eyre Peninsula
- Monitoring/surveillance site program
- Summary of results
- Insights on how to do your own monitoring

Ruby also presented new research into where the lime being applied is going including some Eyre Peninsula examples and how then this can inform liming programs on the EP going forward.

The attendees were encouraged to ask questions some of which included:

"Josh any sites on LEP that have had 10t/Ha over last few years that you guys monitored?"

"Take home message for LEP gravels particularly where deep ripping or deep incorporation is difficult, is to add 2-3T/ha lime every 3-4 years in hope of attempting to increase subsoil Ph?"

Registrations for the event totalled fourteen, three attended live. The webinar was recorded and is now accessible to the wider agricultural community via the AIR EP website link and YouTube. The recording link was also included in the AIR EP weekly e-newsletter to 340 subscribers.

An evaluation was emailed to live participants, with no responses received to date.

3.3.2 Soil pit at Kielpa demonstration day 24 March 2023

Brett Masters, PIRSA Soils Consultant held a soil pit workshop looking at identifying, assessing the severity of, and addressing soil constraints. The results of pH sampling at the site were discussed, as well as how to identify soil acidity, the increased acidification rates under current farming practices, and how to treat it. Liming and lime rates for different soil textures were discussed as well as the option of using tillage to include alkaline subsoil material into acidic soil layers, whilst addressing multiple soil constraints.

Collaborating with Tuckey Ag Bureau, 50 participants attended, including 15 Cleve Area School agriculture students. An initial discussion prior to the soil pit session showed a general lack of confidence around identifying soil acidity, with some comments from participants including:

- "I think the site might be acidic but I'm not sure."
- "I've tried using pH field kits but had trouble interpreting results, the green colours all look the same to me."
- "Soil acidity seems to be an issue on both my best and my worst soils, so I'm confused."

Feedback from participants following the soil pit session included:

- "That was spot on. Hit the nail on the head with identifying soils constraints information."
- "The soil pit session was good, and I learned a lot."
- "Soil acidification is definitely becoming more of an issue and I'm glad the school students were here as it's an issue they'll have to deal with down the track."
- "We never thought we'd have a problem with soil acidity in the past but can see why current farming practices are increasing this issue."

3.3.3 Case studies

Two farmer based case studies addressing acid soils were generated throughout the RAP, which are housed on both the EP Landscape Board and AIR EP websites.

- Turvey, Greenpatch: addressing sub-surface acidity with incorporation of lime.
- Macdonald, Whites Flat/Koppio: addressing surface and sub-surface acidity.

3.4 ASSESSMENT OF pH LEVELS AT PRE-EXISTING AND NEW SITES

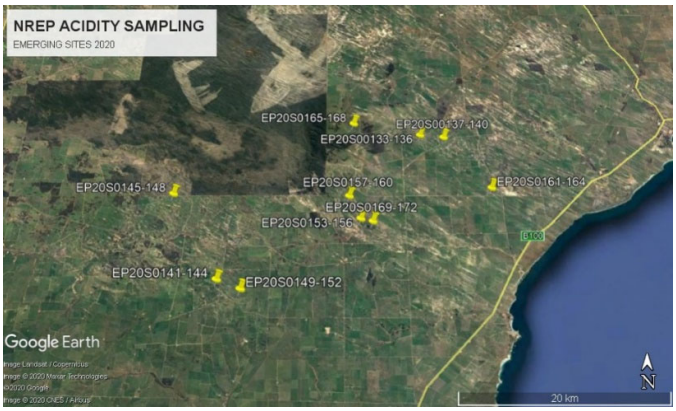
Several projects have been delivered on Lower Eyre Peninsula since 2010 looking to quantify acidification rates on Eyre Peninsula. Results from these projects indicate that under current farming practices and recent seasonal conditions acidification is happening faster than was historically estimated.

There were 65 surveillance sites established on Lower and Eastern Eyre Peninsula in 2010, 40 of which were resampled by PIRSA between December 2013 and February 2015 to monitor pH change under agricultural production. Under the Natural Resources Eyre Peninsula 'Restoring soil pH' project 20 of these 40 sites were resampled by PIRSA in March 2019.

In 2019-20 the project aimed to revisit at least 15 more of these sites to measure pH changes since the previous sampling, and 16 'existing' surveillance sites (13 in Lower EP and 3 in the Cleve Hills) were sampled by PIRSA and NREP staff in March 2020. Sites were sampled by taking 10 soil cores at random within this area to a depth of 20 cm.

In 2019 PIRSA sampled ten new monitoring sites in districts where soil acidity is considered to be an 'emerging' or potential issue and these sites were added to the database of soil acidity surveillance sites in the region.

An additional 10 new 'emerging' acidity surveillance sites were sampled in March 2020. Soil samples were taken to a depth of 20 cm.

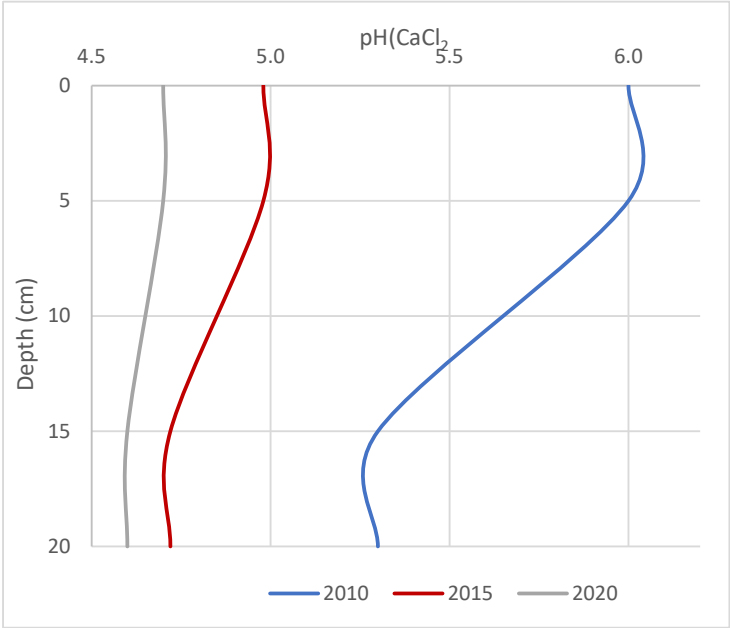


Map of new surveillance sampling sites, 2020.

Of the 16 existing surveillance sites sampled 9 had surface soils (0-10 cm) below the target value of pH 5.5 and 7 sites were below pH 5.0 at the surface. These results show an overall reduction in the proportion of sites with surface soils below pH 5.5 (from 69% of sites when surveillance sampling was last undertaken) and were similar to the results from the 20 sites sampled in 2019. There was however a slight increase in the proportion of sites with surface soils below pH 5.0, increasing from 38% when the sites were last sampled to 44% in 2020. The proportion of sites with subsurface layers below the critical value of pH 5.0 has slightly reduced since sites were last sampled, however half of the sites sampled still have subsurface layers with pH below this value.

When these results were compared with those from the last sampling event, there was no mean pH change in the 0-10 cm layer. Across all sites there was an average pH decline in the 10-20 cm layer by 0.2 pH units since the sites were last sampled. Whilst on-site spatial variation might account for some variability in the results, half of the sites had been limed at rates of between 1.5 and 5.0 t/ha since they were last sampled.

Soil analysis showed a reduction in the proportion of surveillance sites with surface soils below the target pH of 5.5 since last sampled in 2013-2015. However, there was a slight increase in the proportion of sites with surface pH below 5.0. This is likely to reflect the high proportion of sites (around 50%) where lime has been applied since they were last sampled, with pH increasing above 5.5 on limed sites and further acidifying below 5.0 on sites where lime had not been applied.



Example of pH change over time

In summary, there have been some gains in the management of soil acidity in known acid prone areas in the region since 2015. This is supported by increased lime sales in the region in recent years.

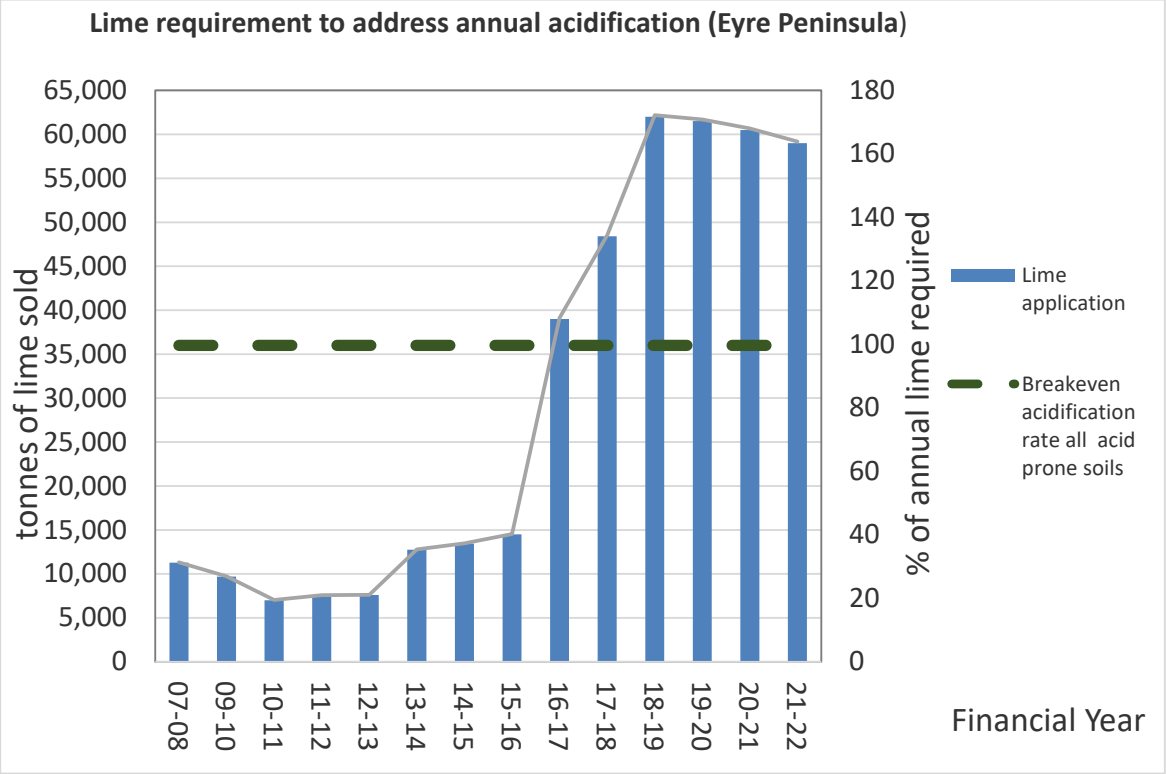
Despite a slight reduction since 2015, there is still a relatively high proportion of sites with subsurface layers below pH 5, with surface lime applications not necessarily addressing this issue at depth.

In line with the 2019 results, soil analysis from sites in the 'emerging' soil acidity areas confirm the potential for the target soils in these districts to acidify, particularly in the 5-10 cm subsurface layers where lower organic carbon levels restrict the soil's ability to buffer pH change. Combined with a lack of soil mixing given current farming practices, some soil stratification of acidity is being identified which should be considered when sampling for soil pH in long term no-till paddocks.

3.5 LIME SALES

Lime sales have been recorded since 2007 (see figure below). Changes in sales in recent years, have occurred due to a range of competing priorities as a lot of land finally got lime spread for the very first time, also through recent and ongoing labour shortages.

There is some competition with gypsum spreading as both are time intensive and use the same equipment. As farmers move from initial liming to re-liming strategies, it is expected that the tonnages sold will level out. There are still a number of unknowns in regard to re-liming, i.e. how often, and how much.



EP Regional Lime Sales, 2007-2022 [Source: DEW]

FURTHER READING

Forward, G. and Hughes, B (2019) '*Soil acidity status report for the Eyre Peninsula Natural Resources Management Region*' DEW, September 2019.

Masters, B (2016) '*FASC Managing Soil Acidity on Eyre Peninsula 2015/16* 'Final Project Report. PIRSA, July 2016

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Masters, B (2018) '*Restoring pH Balance in Lower and Eastern Eyre: Report on Component I: Farming Acid Soil Champions Round 2*'. Final Project Report, PIRSA July 2018.

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Masters, B (2020) *'Natural Resources Eyre Peninsula 'Farming Acid Soils Champions on Eyre Peninsula, 2019-2023'* Report on 2019/20 Project Activities, PIRSA, June 2020