Office Use Only	
Project Code	
Project Type	

FINAL REPORT 2020

Applicants must read the *SAGIT Project Funding Guidelines 2020* prior to completing this form. These guidelines can be downloaded from www.sagit.com.au

Final reports must be submitted by email to admin@sagit.com.au as a Microsoft Word document in the format shown **within two months** after the completion of the Project Term.

PROJECT CODE	**IEA117**
PROJECT TITLE (10 words maximum)	
Spading Header Rows for Grass Control, Improved Yields and Soil Protection	

PROJECT DURATION *These dates **must** be the same as those stated in the Funding Agreement.*	
Project start date	**4/04/2017**
Project end date	**31/03/2020**

PROJECT SUPERVISOR CONTACT DETAILS *(responsible for the overall project)*		
Title:	**First Name:**	**Surname:**
Dr	Christopher	McDonough
Organisation:	Insight Extension for Agriculture	

PROJECT REPORT: *Please provide a clear description for each of the following:*

Executive Summary (200 words maximum)

A few paragraphs covering what was discovered, written in a manner that is easily understood and relevant to SA growers. A number of key dot points should be included which can be used in SAGIT communication programs.

The spading of header rows undertaken within this trial did not lead to a sustained reduction in ryegrass numbers by burying a high percentage of weed seed. However, some ryegrass suppression was achieved through increased crop competition associated with rootzone soil amelioration.

Soil improvements achieved through the spading in of header rows resulted in average yield advantages across the 6 trial sites with varying soil types with minimal erosion risk. Average income gains of $125/ha/year for the spaded treatments were achieved above the control treatments across both sands and flats, despite three well below average rainfall years. These gains would justify the purchase equipment by farmers and the costs of spading operations. These benefits are expected to increase in higher rainfall years.

Clear soil advantages were obtained from Spaded Header Row treatments, including breaking soil compaction, root access to deeper soil moisture and nutrients, increased available moisture storage in deep sandy soils, and increased subsoil nutrition.

More work is required to improve our understanding of effective spading strategies, equipment and application across more farming environments, to further the potential uptake of the findings within this trial.

Project objectives

A concise statement of the aims of the project in outcome terms should be provided.

This project aimed to assess whether spading header rows can provide a non-chemical, highly effective, practical and affordable method of ryegrass and brome grass control, while improving soil health and yield potential, and greatly reducing the risk of wind erosion currently associated with spading.

The research questions to be answered are:

- To what level can spading header rows reduce heavy ryegrass and brome grass populations within continuous cropping systems in the southern mallee, when compared to standard grass weed control practices.
- Can the resulting benefits of non–chemical grass weed reduction and deep soil amelioration be effective and significant enough to justify farmers changing to this innovative management strategy.

Overall Performance

A concise statement indicating the extent to which the project objectives were achieved, a list of personnel who participated in the Research Project including co-operators, and any difficulties encountered and the reasons for these difficulties.

The project clearly answered the research questions, by firstly showing that the technique used did not achieving lasting ryegrass reduction through weed seed burial, and secondly by clearly showing strong average yield and gross margin increases through soil improvements created that would justify machinery purchase and management within 3 years over 1500 ha. This was achieved despite 3 very poor years, while creating long lasting benefits to both sandy rises and heavy flats. Brome grass surprisingly did not feature highly in any of the grass counts, despite being strongly present at sites prior to this trial's commencement and has therefore not been featured in analysis.

The Hayward family, on whose farm the trial was conducted, were key colaborators in the trial in both initiating the innovations that developed into this trial work, and for their use of machinery and co-operation that allowed this farmer machinery scale site preparation to operate over 2 soil types within each of 3 paddocks representing different phases within their farming system. The assistance of the

SARDI and NRM officer support, Elders staff and local work experience volunteers was greatly appreciated in assisting with soil testing, plot monitoring, harvesting and statistical analysis of this trial. The mentoring and technical collaboration of the scientific community, including Dr Chris Preston, Dr Jack Desbiolles, Dr Rick Llewellyn, Dr Nigel Wilhelm, Dr Lynne Macdonald, Dr Alan McKay and Dr Allan Mayfield provided significant input into this trial work.

Being a farmer scale trial using farming equipment for all spading, seeding, weed control and stubble management for header row burning, within the farmer's paddock operations, meant that not all operations could be strictly controlled as with a small plot fenced off trial, and did present some challenges that needed to be accounted for within the analysis (particularly in regard to a rotation change with high weed pressure consequences on one paddock). The large scale of plots and replications meant there were some inherent paddock variations which may have impacted some results (ie there were some sections with higher initial ryegrass seedbank pressure). However, this farmer applied trial work also had great advantage in keeping the activities and results very real and uncovered consequences that would not have been exposed by a smaller, more tightly controlled trial using research equipment, which also would have greatly increased the project costs.

KEY PERFORMANCE INDICATORS (KPI)

*Please indicate whether KPIs were achieved. The KPIs **must** be the same as those stated in the Application for Funding and a brief explanation provided as to how they were achieved or why they were not achieved.*

KPI	Achieved	If not achieved, please state reason.
1st season trial sites sown, soil tests, early and mid-season weed and plant counts completed. Report written and delivered to SAGIT. Sept 30th 2017	Yes ☒ No ☐	
Late site plant and weed counts completed, site field day, plots harvested with grain analysis. 1st season analysis and report completed and delivered to SAGIT with progress statement. Feb 1st 2018	Yes ☒ No ☐	
Results delivered to mallee farmer group harvest reports. 2nd season trial sites sown, soil tests, early and mid-season weed and plant counts completed. Report written and delivered to SAGIT. Sept 30th 2018	Yes ☒ No ☐	
Late site plant and weed counts completed, site field day, plots harvested with grain analysis. 2nd season analysis and report completed and delivered to SAGIT with progress statement. Feb 1st 2019	Yes ☒ No ☐	
Results delivered to mallee farmer group harvest reports. 2nd season trial sites sown, soil tests, early and mid-season weed and plant counts completed. Report written and delivered to SAGIT. Sept 30th 2019	Yes ☒ No ☐	
Results delivered to mallee group harvest reports. 2nd season trial sites sown, soil tests, early and mid-season weed and plant counts completed. Final report written and delivered to SAGIT with progress statement. Feb 1st 2020	Yes ☒ No ☐	
Results delivered to mallee farmer group harvest reports. Final summary of group delivery and final expenditure report delivered to SAGIT as required. March 31st 2020	Yes ☒ No ☐	

TECHNICAL INFORMATION (Not to exceed **three** pages)

Provide sufficient data and short clear statements of outcomes.

Three paddocks representing different rotation phases were each set up with a Sand and a Flat trial site. There were 4 treatments, being Control (normal farmer practice), Burnt Header Row (each season where possible), Spaded Header Row (Spaded HR) and Spaded Header Row with High Nutrition (100kg/ha MAP + 200kg/ha Urea spread on 4.5m header row prior to spading). Both spading treatments were carried out once in the autumn of 2017, prior to seeding. There were 3 replicated in each trial site, with each treatment area being 12 m wide (the width of the farmers header to allow for the creation of appropriate header row widths), with each site 50m in length, within which all monitoring and harvest activities have taken place over the 3 seasons of the trial. Each paddock was managed (sown, fertilised and sprayed) by the farmer according to his normal paddock practices.

Grass control summary

This trial concluded that in its current form, spading of header rows was not an effective tool for reducing ryegrass populations through deep burial of weed seeds. There were some reductions in ryegrass evident due to increased weed competition through improved crop growth in the spaded treatments. At other sites with very high ryegrass populations, the ryegrass levels carried through to unacceptable levels in the 3rd year, even after 2 years of break crops, attributable to the high seed bank still remaining.

The best methods for effectively burying grass weed seed needs further development, and having one only set treatment at the start of the trial did not allow for improvements to be made to the techniques and be monitored over time.

The team at the University of South Australia's Agricultural Machinery Research and Design Centre are also testing and using computer simulation to test the dynamic interaction of various forms of spading technologies, and their abilities to bury surface materials. This may well lead to new machine designs and strategies that will greatly improve the benefits of spading techniques in achieving improved weed seed burial and crop competitiveness.

Soil Improvements

In June 2019 surface and deep soil tests were taken, 2 years after the initial site treatments were established in April 2017. The initial Spaded HR and Spaded Nutrition treatments changed the subsoil to the spading depth (40cm in the Sand plots and 30cm in the Flat plots) incorporating stubble loads varying from 14 to 31 t/ha, and stubble nitrogen contributions of between 12-53kg/ha. The Spaded Nutrition plots had approximately 100kg/ha of MAP and 200kg/ha Urea (22kg/ha of phosphorus and 102kg/ha of nitrogen) applied to the stubble strips prior to spading to assist with the straw breakdown and to increase nutrition to help match future increased yield potential.

Soil testing results revealed a clear trend of the dilution of the surface organic carbon levels due to spading, but an increase at depth, over the non-spaded plots. Raising subsoil carbon by 0.1-0.2% in low fertility sands, was aligned to increasing these soils ability to retain and exchange moisture and nutrients with plant roots, and slightly increase N mineralisation.

The nitrogen dynamics comparisons were impacted by soils, crops, seasons, application and grain exports. The extra N supplied on loamy Flat Spaded Nutrition sites were maintained, contributing to higher crop growth. This was measured at over 35kg/ha average N above the Control N levels across the sites. However, these high N levels were not sustained in the Sand sites, possibly due to N leaching after the 40mm of rainfall in Nov 2017.

There was significantly higher surface soil P levels recorded at some non-spaded sites due to the dilution effect of the spading. Although there was higher average P measured at depth at all sites in to the spaded plots, there was no significant difference recorded.

Root function can be severely restricted in sands once the pressure exceeds 2500 kPa, which is often reached at 17-25 cm in the non-spaded plots. Penetrometer readings in Aug 2018 show that the spaded plots have greatly reduced soil compaction on the Sand within

the top 30-50cm of soil. While it is understandable that there has been less spading effects to the subsoil penetration pressures in the Flats, it is clear that mixing some topsoil into the heavy sodic clay flats has been beneficial for root access. This was reflected in the higher yields obtained at the sites where heavy sodic clay was closer to the surface.

Soil moisture probes placed within Spaded and Control plots on 2 of the Sand sites showed clearly that more soil moisture from rainfall was held within the crop rootzone and used late in the season where the stubbles and topsoil spaded into the top 40cm had occurred. In the corresponding control plots rainfall events of 40mm penetrated to the 30cm depth sensors, but was all lost within 6 weeks.

There was no evidence of soil erosion occurring at any of the 3 sandy trial sites as a result of the initial spading operations. Wind erosion was also not evident in other areas outside of the trials, where the Spading Header Rows option was moved across one third of the header width to spade the whole paddock over a 3 year period.

Yield Improvements

Yield improvements achieved by spading header rows over 3 very challenging years of the trial was shown to be more frequent and higher than expected, as shown in Table 1. While some sites produced poor results for various reasons, the most substantial yield increases were obtained from the Steers Paddock Sand and Flats in 2018 & 2019. The Ewe paddock consistently showed stronger crop growth each season, but very poor season finishes meant this was unable to be sustained on both the sand and the flats. In 2019 there was superior lupin podding in the spaded plots, and while the rest of the paddock was windrowed, the standing trial sites suffered substantial grain loss from a hot windy day prior to harvest. Yields in the continuous cereal Dary Paddock proved significantly responsive to the spading treatments in 2019, while but not so in 2018. The Sand site in 2019 had very poor yields mainly due to the very high ryegrass competition for moisture in a very poor season. All of these yield results suggest that this soil amelioration technique can be used to gain substantial yield increases in most soils, and that its' potential was not fully realised within the various circumstances occurring within this project trial.

Economics

Despite the 3 years of well below average rainfall at the site, and the failure to demonstrate any clear advantage to ryegrass reduction through spading treatments, this trial has demonstrated economic reasons to justify the pursuit of these Spaded Hear Row strategies, based on the extra income achievable through higher yields on both Sand and loamy Flats. Table 1 details the increased average yield obtained over the Control treatments by both the Spaded Header Row and the Spaded Header Row Nutrition treatments, for every site and every crop. It then converts these yield results into the extra income received based on the 5 year commodity price averages from PIRSA's 2019 Gross Margin and Enterprise Planning Guide. This reveals that despite the Ewe Flat site consistently showing a negative income (due to the higher growth than yield potential crashing on this soil type with the lack of spring rainfall) and the first lupin crop after spading on Steers (suffering with sodic clay being brought to the surface upsetting germination), the extra income gained from all other sites and years far outweigh these negatives. Extra income on Steers paddock (despite 2017 losses) averaged between $207 and $256/ha/year.

Across all sites the Spading Header Rows alone produced the best financial outcomes on the sand, particularly when the extra $180/ha cost of the Spaded Nutrition treatment is taken into account (Table 2). However, it should be considered that these nutrition treatments on these highly infertile sands did result in superior crop potential that may well be realised and more profitable in more favourable years.

The current cost of a new 4.5m wide Farmax Spading machine is $160,000 and approximately $120,000 second hand. For a farmer to apply a spading operation for subsoil amelioration over their entire farm over 3 years by moving over header rows by 4m each year to profile increased organic matter and nutrition, it makes sense to purchase their own

spading machine. Using local spading contract rates of $300/hr, and an estimate of 3ha/hr, the spading costs come to approximately $100/ha. In the dry soils (particularly with heavier textured soils, it is beneficial to deep rip the strips prior to spading, estimated at $50/ha. Where high nutrition was applied to assist with stubble breakdown and feed the increased yield potential, this added an extra $180/ha (100kg/ha MAP + 200kg/ha Urea). Table 2 summarises the costs of different combinations of operations, depending on the circumstances in which this strategy may be applied.

Table 1. Yield and Grain Income Increases of Spading Header Row Treatments over Control

Site	Extra Yield t/ha over Control			Extra income $/ha over Control			3 Yr Total	Ave
Ewe Sand	**2017 Wheat**	**2018 Barley**	**2019 Lupins**	**2017 Wheat**	**2018 Barley**	**2019 Lupins**	**$/ha**	**$/ha/yr**
Spaded	0.39	0.01	0.09	108	1	32	**142**	**47**
Spaded Nutritio	0.05	0.24	0.10	14	64	34	**112**	**37**
Ewe Flat	**2017 Wheat**	**2018 Barley**	**2019 Lupins**	**2017 Wheat**	**2018 Barley**	**2019 Lupins**		
Spaded	-0.08	-0.27	-0.08	-22	-70	-26	**-119**	**-40**
Spaded Nutritio	-0.07	-0.34	-0.08	-19	-91	-29	**-140**	**-47**
Steers Sand	**2017 Lupins**	**2018 Canola**	**2019 Wheat**	**2017 Lupins**	**2018 Canola**	**2019 Wheat**		
Spaded	-0.13	0.82	1.41	-46	420	393	**767**	**256**
Spaded Nutritio	-0.08	0.68	1.48	-28	348	412	**732**	**244**
Steer Flat	**2017 Lupins**	**2018 Canola**	**2019 Wheat**	**2017 Lupins**	**2018 Canola**	**2019 Wheat**		
Spaded	-0.18	0.52	1.51	-64	266	419	**621**	**207**
Spaded Nutritio	0.11	0.39	1.44	37	200	399	**636**	**212**
Dary Sand	**2017 Barley**	**2018 Wheat**	**2019 Wheat**	**2017 Barley**	**2018 Wheat**	**2019 Wheat**		
Spaded	1.06	0.76	0.12	281	211	33	**525**	**175**
Spaded Nutritio	0.77	0.55	0.09	204	153	25	**382**	**127**
Dary Flat	**2017 Barley**	**2018 Wheat**	**2019 Wheat**	**2017 Barley**	**2018 Wheat**	**2019 Wheat**		
Spaded	0.22	0.09	0.90	58	26	251	**335**	**112**
Spaded Nutritio	0.86	0.13	0.97	228	37	271	**535**	**178**
5 Year Ave Grain Prices ($/t)		**Average increased income over Control across all sites from Spading Header Rows**					**Sand**	**159**
Wheat	278						**Flat**	**93**
Barley*	265						**Combined**	**126**
Lupins	353	**Average increased income across all sites over Control from Spading Header Rows with Nutrition**					**Sand**	**136**
Canola	512						**Flat**	**115**
* ave of Malt and Feed Price							**Combined**	**125**

Table 2. Estimated cost/ha of Spading Header Row operations

Operations	All operations $/ha	Spading alone $/ha	Ripping & Spading $/ha	High Nutrition & Spading $/ha
Spading	**100**	**100**	**100**	**100**
Ripping	**50**		**50**	
High Nurition	**180**			**180**
Total Costs	**330**	**100**	**150**	**280**
Cost/year/paddock (spading 4.5m strips, or 1/3 of paddock)	**110**	**33**	**50**	**93**

It is difficult to make a direct and clear final economic analysis of the exact $ benefits of applying this Spading Header Row treatments across a whole farming system basis involving so many variables in soil types, rotations, machinery ownership, farm business management and seasonal factors. However, by presenting a clear estimation of the costs involved (Table 2) and the analysis of the benefits achieved at this Lameroo farm despite three very low rainfall years in a row, it is clear that pursuing this strategy for subsoil amelioration is justifiable, even with the highest cost options being applied. With total cost of the Spaded Nutrition treatment being $330/ha, the average increased income over the 3 drought years was $375/ha. It is also expected that many of the benefits obtained to produce these higher yields will last far longer than the 3 years of this trial.

The benefits of Spading header rows without added nutrition, even including the cost of the preceding ripping operation, would see a potential $378/ha increase for a cost of $150/ha, according to the figures presented in Tables 1 and 2. This provides strong justification for farmers to be able to purchase their own Spading and Ripping equipment, so they can utilise it across their farm at optimal times at their own convenience.

A final year report has been attached with this document, providing a more complete and statistical analysis of all trial results, evaluations and recommendations.

CONCLUSIONS REACHED &/OR DISCOVERIES MADE (Not to exceed one page)

Please provide concise statement of any conclusions reached &/or discoveries made.

This large scale three year Spading Header Rows farming systems trial, utilizing the farmers equipment and fitting within the farmers actual practical operations over 6 sites across three paddock, has produced key outcomes that have answered the original aims of the project.

This work has shown that in its current form, the spading of header rows was not successful in burying enough weed seed to adequately reduce ryegrass populations over a three year period. However, some ryegrass suppression through improved crop growth was achieved.

Project results have revealed that the amelioration of subsoils through this practical and convenient spading header rows technique has led to significant yield increases across a range of sites (various soil types and rotation phases), despite the 3 extremely challenging rainfall years across the southern Mallee. While the most profitable technique was shown to be spading header rows without the extra addition of fertiliser, it is possible that the spading of header rows with additional fertiliser could be more beneficial in years with average rainfall and above. The increased income gained spading header rows was found to average approximately $125/ha across all sites and years of the trial, which was shown to be more than enough to justify farmers pursuing the potential equipment purchases and inputs required to achieve these outcomes across 1500ha of land.

INTELLECTUAL PROPERTY

Please provide concise statement of any intellectual property generated and potential for commercialisation.

There appears to be no intellectual property implications resulting from this work.

APPLICATION / COMMUNICATION OF RESULTS

A concise statement describing activities undertaken to communicate the results of the project to the grains industry. This should include:

- *Main findings of the project in a dot point form suitable for use in communications to farmers;*
- *A statement of potential industry impact*
- *Publications and extension articles delivered as part of the project; and,*
- *Suggested path to market for the results including barriers to adoption.*

Note that SAGIT may directly extend information from Final reports to growers. If applicable, attach a list of published material.

This trial has examined a unique method of achieving safe, practical and affordable ways that farmers can achieve effective subsoil amelioration across their paddocks. This method does not involve the operations of transporting and spreading of expensive animal manures or other forms of organic matter that may not be readily available to many farmers. It utilises the concentrated, readily available on-farm source of organic matter in the previous crops header row. Extra nutrition, if required, is supplied through spreading mineral fertiliser prior to spading, to help simulate the both the organic matter and nutrition applied in manures.

The main points be communicated to both the agricultural research and farming community are that:

- Spading header rows can improve soil health and increase yields
- This technique breaks soil compaction in sands and mixes high amounts of organic matter into crop rootzones in clays and sands to improve plant / water / nutrient dynamics.
- By moving header rows each year, a whole paddock surface can be spaded over a 3 year period, with minimal erosion risk.

Average yield increases of achieved across all sites during 3 low rainfall challenging seasons, produced average gross margin increases of $125/ha over non-spaded trial strips. Such increases achieved over 1500ha (or 500ha/yr over 3 years for a 1500ha total area) would increase cropping profits by $187,500 which is well in excess of the purchase price of a new spading implement. These ongoing benefits have the potential to bring many millions of dollars profits into farming business if widely adopted across rural communities.

A joint paper "Improving the adoptability of spading practices in constrained sandy soil environments" was submitted and presented by the project manager at the Australian Agronomy Conference in August 2019, focusing on innovative techniques for effective spading practices that improve soils while reducing wind erosion risks. http://www.agronomyaustraliaproceedings.org/images/sampledata/2019/2019ASA_Saunders_Chris_196.pdf This paper also features on the Mallee Sustainable Farming website at www.msfp.org.au.

Early trial results were also presented at the Karoonda GRDC Grains Research Update on Aug 7 2018 to approximately 60 participants., and the proceedings paper is on the GRDC Website at: https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2018/08/improving-crop-productivity-and-profits-on-sandy-soils

Project findings on improving water retention and use on deep sands were shown within a Mallee Seeps presentation by the project manager at the GRDC Advisors Update in Adelaide 2020, as this is a key strategy for seep management. Similar presentations have been made across 5 other Seep Workshop presentations across 3 States at Underbool, Manangatang, Robinvale, Rudall and Bow Hill involving approximately 100 farmers and industry representatives in total.

Many of the findings and applications of this technology has been communicated to farmer groups and forums across the SA and Victorian Mallee and Eyre Peninsula. In 2018 and 2019 project results were presented and discussed at SA Mallee harvest report meetings at Waikerie, Wunkar, Paruna, Pinnaroo and Karoonda, as well at MSF Field Days at Lameroo, along with other individual group Spring Crop Walks.

The project site was visited by local farmers at a field day in Sept 2017. The project was featured in the Stock Journal on Aug 17, 2017 in an article titled "Research Digs into Spading Benefits"

Unfortunately, in 2020, partly due to COVID19 restrictions there was no opportunity to present the final project results to Mallee farmer groups, including the critical economic advantages. These results are expected to be extended to these groups as opportunities arise over the coming 12 months. There is also an opportunity for a media release of final results through both local Mallee and Statewide media outlets.

Contribution to Knowledge on Sub-soil Amelioration

While the trial has shown that spading header rows is not a reliable tool for combatting ryegrass, it has also made a strong contribution to the farming and scientific community in areas of subsoil ameliorations though spading. This has been particularly evident in the way in which this trials findings were utilised within a joint paper and presentation at the Australian Agronomy Conference in Wagga Wagga 2019 (Desbiolles et al, 2019) providing a key source of longer term field data.

This trial has also contributed data that has been presented to farmers and agricultural industry representatives in at least 25 forums across the South Australian and Victorian Mallee and Eyre Peninsula, in relation to farmers attaining sandhill amelioration for management the growing issues of seeps and perched water tables. This is becoming a rapidly growing issue within modern farming systems.

POSSIBLE FUTURE WORK

Provide possible future directions for the research arising from the project including potential for further work and partnerships.

This research has shown that significant improvements to long term soil health and yield can be made on both light sandy rises and heavy loamy flats through the spading in of organic matter. This technique of only spading in header rows in strips across a paddock shows that this can be achieved with minimal soil erosion risk, which has been a major impediment to uptake previously. However, this still requires an initial high capital outlay in machinery purchase, as well as extra paddock operations in ripping and spading. While this technique has been shown to be cost effective at this trial, there is still need to prove its effectiveness in other regions and a wider set of conditions. It is also expected that even greater benefits would be experienced in for favorable seasons, which would greatly assist the promotion and uptake of this practice.

The principles of soil improvement shown within this work supports complimentary subsoil amelioration research being done through the University of South Australia's Agricultural Machinery Research and Design Centre, School of Engineering. This includes the one pass, narrow row spading and sowing techniques which also reduces erosion risks, as well as the development of deep ripping inclusion plate design to safely incorporate more surface residue organic matter into the deeper rootzone.

There has also been some limited trial work in the mallee (SARDI Agronomy, Crop Sciences) with the development of the "Subsoil Extruder" which essentially is a big hopper towed behind a tractor that pumps a manure slurry behind deep ripping tynes. The initial research has shown promising results from this very safe method of achieving subsoil amelioration of mallee sands, however, there are many practical application issues that still need development.

Further farmer scale work is required to test and improve the value and practicality of subsoil amelioration techniques, as mentioned above, as there are great gains to be made in improving the productivity of poorly performing soils (both heavy and light textured) across the cropping regions of South Australia.