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	LDA217
PROJECT TITLE (10 words maximum)	
Copper management for the future	

PROJECT DURATION *These dates **must** be the same as those stated in the Funding Agreement.*	
Project start date	1/07/2017
Project end date	30/06/2020

PROJECT SUPERVISOR CONTACT DETAILS *(responsible for the overall project)*		
Title:	**First Name:**	**Surname:**
Mr	George	Pedler
Organisation:	Lower Eyre Ag Development Association (LEADA) now AIR EP	

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.

Field trials to test management strategies to overcome copper deficiency at six Lower Eyre Peninsula sites were conducted over the three growing seasons of 2017, 2018 and 2019 (two sites per year).

Yield loss caused by copper deficiency can be devastating to wheat yield, with significant losses of up to 48.5% in 2018 recorded at Edillilie.

Soil and tissue testing can be useful in helping to detect low levels, but are not always definitive. Copper response appears to be dependent on other complex interactions such as soil moisture, yield potential and other constraints (N fertility etc.) and thus soil/tissue tests alone are not a definitive guide to future responses.

Chelate and sulphate formulations performed equally well.

Foliar applications performed better than in-furrow liquids at Edillilie in 2018.

Foliar application timings between mid-tiller and head emergence were not significantly different in yield response.

In-furrow applications at seeding were not as effective as foliar applications.

Project objectives

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

This project aimed to explore different management strategies to overcome copper deficiency in cereals. The project compared the effectiveness of copper sulfate and copper chelate applied either as liquids banded at seeding or as a foliar spray. The project also evaluated the effect of different timings of application of the foliar sprays and their efficiency.

This project aimed to benefit local and South Australian farmers by establishing an independent best practice management guide for copper applications for the future.

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.

Extent to which project objectives were reached

The project was able to demonstrate the differences in the efficacy of copper applications.

Personnel who participated in the project

LEADA contracted SARDI Port Lincoln to deliver field trials for this project. Staff included but not specifically assigned to the project: Andrew Ware, Blake Gontar, Jacob Giles, Ashley Flint and David Holmes.

In 2019 SARDI sub-contracted field work to EPAG Research (Andrew Ware).

George Pedler convened the LEADA Trials sub-committee that provided direction and methodology for the project.

Megan Low, former LEADA executive officer, oversaw project administration.

Co-operating farmers who participated in the project
Shane Nelligan – Strawberry Hill (2017)
Jim Holman – Cockaleechie (2017)
Jed Siegert – Edillilie (2018 & 2019)
John and Stuart Richardson – Stokes (2018)
Tim Roediger – Stokes (2019)

Difficulties encountered
Over the three seasons, the project conducted trials at six field sites. Only one season x site demonstrated a response to copper.

Reasons for the difficulties
Seasonal conditions, particularly soil moisture in critical parts of the soil profile at critical times of plant growth, likely limited copper response.

Soil test values proved to be a reasonable guide in helping to detect copper deficiency, but low soil copper levels didn't always lead to copper deficiency in wheat plants.

During the first year of the project LEADA recognized that it needed to provide clearer direction on project methodology to its sub-contractors such as nitrogen rates etc. This was addressed as soon as it was identified as an issue in-season and for following experiments.

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.
Research protocols developed and site selected. A research protocol for field trials which supported use of liquid streaming and foliar spray applications was developed. Trial sites were chosen based on site access, field homogeneity and likelihood of response to copper based on historical visual symptoms confirmed with a soil copper test. In 2017, sites were sown at Edillilie and Cockaleechie. In 2018 & 2019, sites were sown at Stokes and Edillilie.	Yes ☒ No ☐	
2017 trial harvested with results compiled.	Yes ☒ No ☐	
Analyse 2017 trial data and publish in LEADA and EPARF results booklets as well as presenting at LEADA Expo and upper EP post-harvest grower meetings. "Copper Management for the Future" LEADA Ag Expo booklet 2018, 2019, 2020. EPFSS booklet 2018 & 2019.	Yes ☒ No ☐	

Extended research protocols developed.	Yes ☒ No ☐	
2018-year trial harvested with results compiled.	Yes ☒ No ☐	
Analyse 2018 trial data and publish in LEADA and EPARF results booklets as well as presenting at LEADA Expo and upper EP post-harvest grower meetings.	Yes ☒ No ☐	
Extended research protocols developed.	Yes ☒ No ☐	
2019 trial harvested with results compiled.	Yes ☒ No ☐	
Collate, analyse & publish 2019 trial data and final report and publish in LEADA and EPARF results booklets as well as at LEADA Expo and Upper EP post-harvest grower meetings.	Yes ☒ No ☐	
Develop best management packages for copper management and make available to the farming public.	Yes ☐ No ☒	We did not believe that we had enough significant data to produce the management guideline with only one of the six trials giving us significant results. We have been able to extend general messages as a result of the project, but do not have the full story to develop a definitive management package.

TECHNICAL INFORMATION (Not to exceed **three** pages)
Provide sufficient data and short clear statements of outcomes.

Field trials at six Lower Eyre Peninsula sites were conducted over the three growing seasons the project was conducted (two sites per year).

Year	Site	Soil Copper 0-10cm (mg/kg)	Soil Colwell P 0-10cm	Sowing Date	Copper Responsive
2017	Wanilla	1.21	24	18 May*	No
	Cockaleechie	0.76	46	18 May*	No
2018	Edillilie	0.55	58	10 May	Yes
	Stokes	0.93	30	15 May	No
2019	Edillilie	0.72	41	15 May	No
	Stokes	0.50	73	21 May	No

**Site sown dry prior to opening rain due to late break with emergence around 11 July*

Field trials 2017

In 2017 field trials were conducted at Strawberry Hill (North-east of Wanilla) and Cockaleechie (North-east of Cummins). Due to the short period between funding being awarded and the potential break in the season, sites were selected based on a history of copper deficiency-like symptoms.

Opening rains for the 2017 growing season did not occur until early July. Trials were sown dry, emerging on the opening rain.

The field trials consisted of 44 treatments in a randomized block design (replicated four times). The treatments included six application times (at seeding, GS21, GS31, GS41, GS 49 and flowering + combinations of two applications at different timings), two different products were evaluated (copper sulphate and copper amino-acid chelate), each product was applied at 2-3 different rates.

Soil tests taken prior to sowing showed DPTA copper levels to be 1.21mg/kg at Strawberry Hill and 0.76mg/kg at Cockaleechie. Literature shows soil test critical values of less than 0.2 to 0.4mg/kg are deficient.

Tissue samples collected at GS41 (Zadok) showed copper levels were @ 3.4mg/kg at Cockaleechie, with no significant difference between treatments. At the Strawberry Hill site the untreated treatment had copper plant tissue levels of 6.0mg/kg, whereas the treatment that received 2kg/ha Copper Sulphate at in-furrow at seeding had a significantly higher plant tissue levels of 7.4mg/kg. Literature shows that plant tissue levels need to be below 1.3mg/kg to be deficient.

A site mean yield of 2.25t/ha was achieved at the Strawberry Hill site. The Cockaleechie trial achieved a site mean yield of 2.70t/ha. Through ANOVA analysis both sites did record treatments that were significantly different from each other, however there was no clear pattern in response.

Field trials 2018

In 2018 field trials were conducted at Edillilie (approximately 25km south-west of Cummins) and Stokes (approximately 10km west of Tumby Bay). At each site trials were broken up into three separate trials.

Trial 1: 17 treatments: four times of application (in-furrow @ seeding, GS22, GS31, G49), a sulphate and chelated product, each applied at two different rates + a nil control.

Trial 2: 6 treatments: all different times of application of a chelated product.

Trial 3: 10 treatments: two different chelated products, each applied at three rates. Copper Sulphate applied at three different rates and a nil control.

The Stokes site had pre-seeding soil copper levels of 0.93mg/kg, 5.2 pH and 30 Colwell P, whilst the Edillilie site had pre-seeding soil copper of 0.55mg/kg, 5.7pH and 58 Colwell P.

Plant tissue tests collected at flowering found samples contained 3.81mg/kg copper from untreated plots at the Edillilie site and ranged up to 8.7mg/kg where copper sulphate was applied at a high rate (300g/ha). Plant tissue tests collected at flowering found samples contained 1.55mg/kg copper in untreated control plots and 2.59mg/kg where copper sulphate was applied at a high rate (300g/ha).

The Stokes site achieved a site mean grain yield of 5.16t/ha. In trials 1 and 3 there were no significant differences between any of the treatments. In Trial 2, the application of a 2L/ha chelated copper achieved a significantly higher yield than the nil treatment.

The Edillilie site achieved a site mean grain yield of 2.82t/ha. This trial site showed very strong visual symptoms traditionally associated with copper deficiency around flowering time. In trial 1 all treatments, with the exception, of a low rate (1L/ha) of copper chelate applied in furrow, yielded significantly more than the untreated control. Treatments where copper was applied in furrow generally yielded lower than foliar applications. As can be seen in the attached yield results, the foliar applications at times earlier than traditional copper application (prior to head emergence) yielded as well, if not better than the traditional timing

Trial 2 demonstrated that the time of application did not have any effect on grain yield.

In trial 3 all treatments (applied at GS49) yielded higher than the untreated control, with the exception of copper sulphate, applied at half the recommended rate. However beyond this here was no product or rate that was able to demonstrate a yield benefit higher than any other.

Field trials 2019

In 2019 field trials were conducted at Edillilie (approximately 25km south-west of Cummins) and Stokes (approximately 15km west-northwest of Tumby Bay). At each site trials were broken up into three separate trials.

Trial 1: 17 treatments: four times of application (in-furrow @ seeding, GS22, GS31, G49), a sulphate and chelated product, each applied at two different rates + a nil control.
Trial 2: 13 treatments: application of three chelated products and one sulphate product, each applied at three rates.
Trial 3: 10 treatments: applicated of a chelated product at four timings and combinations of timings.

The Stokes site had pre-seeding soil copper levels of 0.5mg/kg and the Edillilie site was 0.72mg/kg.

Plant tissue tests collected at flowering found samples contained 1.55mg/kg copper in untreated control plots at the Stokes site and 2.59mg/kg where copper sulphate was applied at GS31 timing at a high rate (300g/ha). Plant tissue tests collected at flowering found samples contained 3.81mg/kg copper from untreated plots at the Edillilie site and ranged up to 8.72mg/kg where copper sulphate was applied at GS31 timing at a high rate (300g/ha).

None of the trials at Stokes and Edillilie showed a response to copper application in 2019.

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

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

Yield loss caused by copper deficiency can be devastating to wheat yield, with significant losses of up to 48.5% in 2018 at Edillilie.

Soil and tissue testing can be useful in helping to detect low levels, but are not always definitive. Copper response appears to be dependent on other complex interactions such as soil moisture, yield potential and other constraints (N fertility etc.) and thus soil/tissue tests alone are not a definitive guide to future responses.

Chelate and sulphate formulations performed equally well.

Foliar applications performed better than in-furrow liquids at Edillilie in 2018.

Foliar application timing between mid-tiller and head emergence were not significantly different in yield response.

In furrow applications at seeding were not as effective as foliar applications.

INTELLECTUAL PROPERTY

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

N/A

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.

Copper management in wheat remains a concern for many lower EP growers. SAGIT funded a three-year program to evaluate copper application timings, product types and rates to underpin future management recommendations.

The program demonstrated that:

- At some sites where copper deficiency was historically assumed, no response to any form of copper application was observed. Copper response is likely to vary by site and season.
- Yield loss caused by copper deficiency can be devastating to wheat yield.
- Soil and tissue testing can be useful in helping to detect low levels, but are not always definitive. Copper response appears to be dependent on other complex interactions such as soil moisture, yield potential and other constraints (N fertility etc.) and thus soil/tissue tests alone are not a definitive guide to future responses.
- Foliar applications performed better than in-furrow liquids.
- Chelate and sulphate products performed equally well when applied as foliar applications.
- Timing did not appear to be critical, with a wide band of opportunity from mid-tiller to early head emergence providing similar results.

Industry Impact

Publications and Extension

2017/2018

A presentation at LEADA's Expo held on Tuesday 13 March conveyed the results of the trial to the farming community on Lower Eyre Peninsula. Results of the trials were also included in the Expo booklet and posted on the LEADA Website.

2018/2019

Field visit by SAGIT in August that was also attended by members of the LEADA committee, which included growers, researchers, retail agronomists and independent ag consultants.

LEADA Spring Field Walk on 9 September 2018 – was initially planned to attend one of the sites, however with a tight schedule and no visual responses present at the time we did not visit. The project still had a timeslot where the trials were discussed on the day explaining to the 82 attendees what we were looking at and some of the early visual responses we had observed at the two sites up to that point in the season.

Friday 12 October 2018 - LEADA held an open day for the copper management sites, with some excellent visual responses evident. All LEADA members and other contacts were invited to visit both the Stokes and Edillilie Copper Management sites. A total of 21 primary producers and 7 Agribusiness related people attended.

A presentation of the 2018 results were made at the annual LEADA Expo on 15 March at Ungarra, conveying the results of the trial to the farming and agribusiness community on Lower Eyre Peninsula. 75 people were present to hear this report. These trial results were also printed in the Expo booklet and emailed out in the LEADA newsletter.

2019/2020

George Pedler Ag Consultancy growers visited the Siegert site on their annual Farmcrawl on 27 September 2019.

A presentation at LEADA's Expo held in March 2020 conveyed the 2019 results of the trial to the farming and agribusiness community on Lower Eyre Peninsula. The 2018 results were also revisited to remind growers of the findings from previous seasons. These results were included in the Expo booklet, emailed out in the next member newsletter and also posted onto the LEADA Website.

There has also been numerous agronomists and growers from across the state contact us to enquire about the project and source updated results throughout its term. The 2018 season has been especially of interest in a lot of the contact that has been made.

All trial results are provided as an attachment, Attachment 1.

POSSIBLE FUTURE WORK

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

Better identification of areas with copper deficiency - Are current soil test critical values representative of identifying deficiencies?

More understanding is needed on drivers of seasonal response. Does reasonable plant available moisture in the lead-up to flowering keep enough copper in solution or stored in plant tissue to help alleviate copper deficiency?

Are other crops – canola and pulses as susceptible to yield loss through copper deficiency as wheat (literature suggests that they should be less susceptible)?