Office Use Only

Project Code	
Project Type	

FINAL REPORT 2021

Applicants must read the *SAGIT Project Funding Guidelines 2021* prior to completing this form. These guidelines can be downloaded from www.sagit.com.au

Final reports must be emailed to admin@sagit.com.au as a Microsoft Word document in the format shown ***within 2 months*** after the completion of the Project Term.

PROJECT CODE :	**TC219**

PROJECT TITLE (10 words maximum)
Improved Phosphorus prescription maps - beyond replacement P

PROJECT DURATION

*These dates **must** be the same as those stated in the Funding Agreement*

Project Start date	**1/4/2019**					
Project End date	30/6/21					
SAGIT Funding Request	19/20	$49650	20/21	$47650	(year)	$

PROJECT SUPERVISOR CONTACT DETAILS

The project supervisor is the person responsible for the overall project

Title:	**First Name:**	**Surname:**
Mr	Sam	Trengove
Organisation:		
Trengove Consulting		

ADMINISTRATION CONTACT DETAILS

The Administration Contact is the person responsible for all administrative matters relating to the project

Title:	First Name:	Surname:
	AS ABOVE	

PROJECT REPORT

Provide clear description 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

This project has shown that the phosphorous rates required to optimise partial gross margin (PGM), vary widely across paddocks according to soil type and production zones for five trial paddocks located in the Mid North and northern Yorke Peninsula (YP) region. Within a paddock it was shown that optimal P rate can range from 0 kg P/ha up to more than 40 kg P/ha, depending on location within the paddock. It was also shown that several spatial data layers can be used to predict the variable P response in advance of seeding. In particular, combining soil pH and historical satellite imagery into a single index provided good prediction of spatial P response. A methodology for using these data layers to create variable rate P prescriptions has been developed. Economic analysis indicates application of optimal P rates at P responsive sites increased PGM by up to $79/ha compared with returns from replacement P rates through increased yield, with an average improvement in PGM of $41/ha. At the same time, investment in P at non-responsive sites was minimised, improving fertilizer use efficiency.

Project Objectives

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

The aim of this project is to increase the profitability derived from P fertiliser application. This will be achieved through increasing P fertiliser use efficiency by better understanding the spatial variability in P availability, demand and P response.

Map data layers that can infer spatial information on P uptake, soil tie up and response are becoming increasingly available, such as grain yield, soil pH, soil EC and NDVI. However, the best methodology for integrating these data for improving P rate calculations is unknown. The aim of this project is to better understand how these data layers can be integrated to produce variable rate P prescription maps that optimise P rates across variable paddocks.

This will be achieved by analysing data layers (yield, soil pH, soil EC, NDVI) to identify the range in likely P response. This information will be used to locate a series of P rate trials, in two paddocks per year in 2019 and 2020 in the Mid North and YP regions. The yield responses observed in these trials will be used to determine the relative importance or weighting that each data layer has on the rate calculation and inform the best method for integrating these data layers for calculating optimal P rates.

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.

All project objectives were achieved.

The aim of this project is to increase the profitability derived from P fertiliser application.

This project demonstrated that profitability can be increased by targeting P fertiliser to where it is required rather than applying blanket rates across paddocks. An average increase in partial gross margin of $41/ha was demonstrated for P responsive soils by using higher optimal P rates than recommended by P replacement strategies. In addition, on non-responsive soils, a saving in fertiliser could be achieved where lower fertiliser rates could be used without incurring any yield loss.

The aim of this project is to better understand how spatial data layers can be integrated to produce variable rate P prescription maps that optimise P rates across variable paddocks.

It has been shown that the combined use of soil pH maps with historical satellite imagery provides good prediction of likely P response within investigated paddocks in the Mid North and northern YP region. The basic premise is that zones with higher soil pH and poor historical cereal crop growth (defined from satellite imagery) are likely to be responsive to higher P rates, whereas zones with lower soil pH and high historical cereal crop growth are more likely to require lower P rates. A methodology has been developed for combining these data layers and generating P prescription maps for use in variable rate seeders and spreaders.

This will be achieved by analysing data layers (yield, soil pH, soil EC, NDVI) to identify the range in likely P response. This information will be used to locate a series of P rate trials, in two paddocks per year in 2019 and 2020 in the Mid North and YP regions.

Paddock trials were carried out in five paddocks, rather than the planned four, over the two seasons. This provided a total of 21 P response trials targeted across these paddocks to sites with a range of predicted P responses. All trials had P rates 0, 5, 10, 20, 30 and 50kg P/ha applied as MAP to determine rate response at each site. In addition, 16 trials included a treatment with the application of chicken litter or biosolids to determine the P response from these products.

The yield responses observed in these trials will be used to determine the relative importance or weighting that each data layer has on the rate calculation and inform the best method for integrating these data layers for calculating optimal P rates.

P responses from 21 trials were analysed in context of the predictive value of the spatial data layers available. These relationships between observed P response and data layers has been used to develop an algorithm utilizing these data layers to calculate optimal P rates and P prescription maps.

Personnel who participated in the project
Trengove Consulting: Sam Trengove, Stuart Sherriff and Jordan Bruce
Agronomy Solutions: Sean Mason
Cooperating growers: Leigh Fuller, Bill Trengove, James Venning and Kenton Angel

Key Performance Indicators (KPI)
*Please indicate whether KPI's were achieved. The KPI's **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 (Y/N)***	***If not achieved, please state reason.***
Analyse soil pH, soil EC, grain yield and NDVI data for two paddocks in 2019. Data layers including historical grain yield, historical satellite NDVI and Veris pH were collated for a paddock near Bute and a paddock near Koolunga. Data layers were combined using computer software, areas of high and low yield, pH and NDVI were identified for potential sites.	Y	
Identify, peg and sow four trial sites within each paddock, with sites representing a range in predicted P response. 4 sites within each paddock were identified during the analysis process with varying predicted P responses. Paddock inspection confirmed suitability of trial sites. Trials with 3 replicates were sown using knife point and press wheel seeding system. Treatments included P rates of 0, 5, 10, 20, 30 and 50 kg P/ha. Fertiliser was applied using MAP and nitrogen rates were matched between treatments using adjusted rates of urea. An additional treatment of 2.5t/ha Chicken litter was also included at each site.	Y	
Submit 100 soil samples for analysis of soil pH, PBI and carbonate testing.	Y	

109 0 – 10 cm soil samples were submitted to APAL for analysis of pH, PBI and carbonate and relationships investigations		
Assess 2019 treatment responses • *In season through tissue testing of select treatments and NDVI measurement* • *Grain yield* • *Grain P content of select treatments* In season assessments of plot NDVI were made in July and August/September. At both dates' biomass samples were taken to assess the relationship with crop biomass and NDVI. Youngest emerged blade (YEB) tissue analysis were conducted on the treatments 0, 10, 20 and 50kg P/ha for three replicates. Samples taken for crop biomass assessments were also submitted for whole shoot nutrient concentration for one rep only for comparison of the two methods. Grain yield data was collected using a plot harvester. Grain quality assessments of test weight, retention, screenings and protein were made. Grain samples were sent for grain nutrient concentration. A selection of treatment samples (treatments 0, 10, 20 and 50 kg P/ha were sent for grain nutrient concentration. Post-harvest Crop Lower Limit (CLL) soil samples were taken from treatments 0 and 50kg P/ha at site 4 and 6 and treatments 0, 10 and 50kg P/ha at responsive sites 1, 2, 7 and 8	Y	
Analyse 2019 trial results Analysis of the first year of trial results was completed for initial reporting. The results have been included in a data set with the 2020 results for further analysis	Y	
Analyse soil pH, soil EC, grain yield and NDVI data for two paddocks in 2020.	Y	

Data layers including historical grain yield, historical satellite NDVI and Veris pH were collated for two paddocks, one near Bute and one near Brinkworth. Data layers were combined using computer software, areas of high and low yield, pH and NDVI were identified for potential sites. In addition to the two paddocks already selected, an additional paddock at Kybunga was selected. Five sites were selected in this paddock to cover the range of pH and satellite imagery.		
Identify, peg and sow four trial sites within each 2020 paddock, with sites representing a range in predicted P response. 4 sites within the Bute and Brinkworth paddocks for 2020 were identified during the analysis process with varying predicted P responses. Paddock inspection confirmed suitability of trial sites. Trials with 3 replicates were sown using knife point and press wheel seeding system. Treatments included P rates of 0, 5, 10, 20, 30 and 50 kg P/ha. Fertiliser was applied using MAP and nitrogen rates were matched between treatments using adjusted rates of urea. An additional treatment of 5t/ha Biosolids was also included at each site. In the Kybunga paddock five sites were selected, P rates of 0, 5, 10, 20, 30 and 50 kg/ha were implemented, no biosolids or chicken litter were applied at this site.	Y	
Assess 2020 treatment responses • *In season through tissue testing of select treatments and NDVI measurement* • *Grain yield* • *Grain P content of select treatments* In season assessments of plot NDVI were made at all sites in 2020 to assess crop biomass responses. Youngest emerged blade (YEB) tissue analysis were conducted on the treatments 0, 10, 20 and 50kg P/ha for three replicates at the Bute and Kybunga sites. Brinkworth was not sampled for testing as it was	Y, Grain P concentration levels were not tested in 2020 as the data was not deemed useful and budget was reallocated to additional 5 sites at Kybunga	

beyond budget given there were five additional trials in 2020. Grain yield data was collected at all sites using a plot harvester. Grain quality assessments of test weight, retention, screenings and protein were made. Greenseeker NDVI and grain yield data was also collected from one 2019 responsive site at Koolunga and two 2019 responsive sites at Bute to assess the longer-term effect of high rates of P fertiliser on responsive soil types.		
Analyse trial results Trial results have been analysed and results reported in newsletters. Results have also been included in Sean Mason's GRDC update paper.	Y	
Prepare and submit final report	Y	

Technical Information (Not to exceed **three** pages)

Provide sufficient data and short clear statements of outcomes.

Predicted P response (low – very high) was estimated through analysis of historical satellite imagery and Veris pH data for five paddocks. In the work to date, only satellite imagery from cereal crops has been used in this analysis. Based on these estimates, eight sites were selected in 2019 and a further 13 sites were selected in 2020 to cover a range of expected P response. Four sites were chosen in each of the paddocks near Bute in 2019 and 2020, Koolunga (2019) and Brinkworth (2020), and the paddock near Kybunga (2020) had five sites.

An example of the map data layers used is shown in figure 1A and 1B for the 2019 Bute paddock. These data layers have been combined into a P sufficiency index (Figure 2), also being termed pHnNDVI in this report and is simply calculated by dividing soil pH by the normalised NDVI.

- pHnNDVI = soil pH/normalised NDVI

Based on this calculation, paddock zones with high soil pH and low NDVI have a high pHnNDVI value. These areas are predicted to have a higher P response than areas with low soil pH and high NDVI (low pHnNDVI).

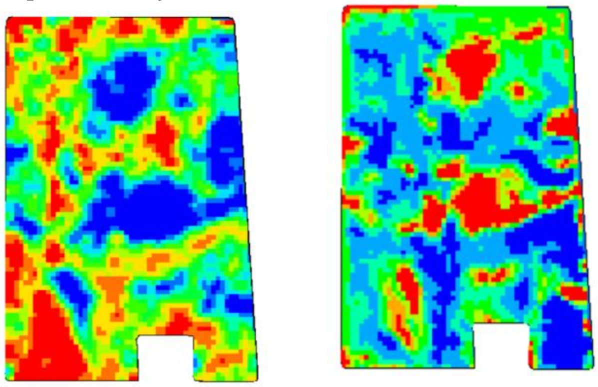

Figure 1. A) (left) Soil pH $CaCl_2$ and B) (right) satellite NDVI (Barley) for the trial paddock at Bute in 2019, warm colours represent low pH and NDVI values and cool colours represent high values.

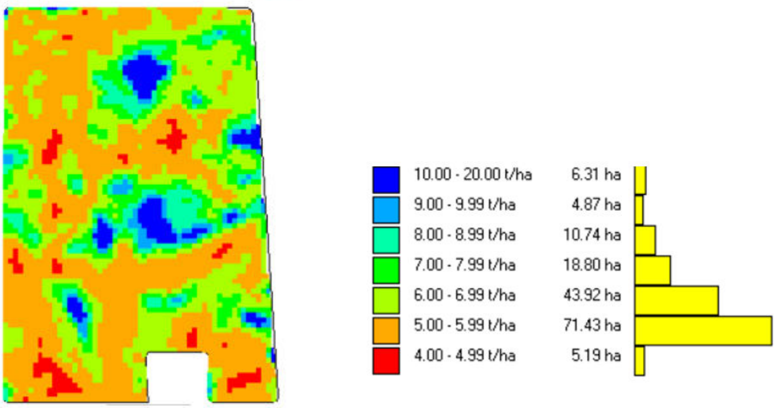

Figure 2. pHnNDVI derived from soil pH and satellite NDVI (shown in figure 2) for the 2019 Bute trial paddock.

At each of the 21 sites selected a P response trial was established using knife points and press wheels as a randomised complete block design with three replicates. Treatments included P rates of 0, 5, 10, 20, 30 and 50 kg P/ha. P Fertiliser was applied using MAP and nitrogen rates were matched between treatments using adjusted rates of urea.

Measurements throughout the season included soil tests for P levels (0-10cm) (Table 1), Greenseeker NDVI, tissue tests on selected treatments and grain yield and quality.

P rate for optimum grain yield for each site was calculated by generating a mitscherlich response curve (Exponential Rise to Max which generates the equation y = y0+a(1-exp(-b*x))) based on yield data for each site and then predicting the P rate that would achieve 90% of the overall response. Partial gross margins were then calculated from this data by calculating return from grain yield minus the fertilizer cost associated with P rates.

Table 1. *Site descriptions and soil test results for 21 trial sites in five paddocks across NYP and Mid North. Where descriptions of low-high are used, it is a relative reference compared to the paddock average.*

Paddock	Site	Historical NDVI	Veris pH	Expected P response	DGT P (ug/L)	Colwell P (mg/kg)	PBI	pH $CaCl_2$
Koolunga 2019	**1**	Moderate	Alkaline	**High**	12	24	121	7.55
	2	Low	Alkaline	**High**	21	35	131	7.58
	3	High	Acidic	**Moderate**	56	33	51	6.19
	4	Moderate	Neutral	**Low**	62	62	77	5.87
Bute 2019	**5**	Mod-High	Acidic	**Low**	103	27	20	4.94
	6	Moderate	Neutral	**Moderate**	106	63	50	5.96
	7	Low	Alkaline	**High**	22	20	71	7.67
	8	Low	Alkaline	**High**	38	19	51	7.67
Brinkworth 2020	**9**	Low-med	Alkaline	**Moderate-high**	211	75	62	7.63
	10	Med-high	Neutral	**Low-moderate**	110	53	103	6.65
	11	Low	Alkaline	**High**	65	45	115	7.69
	12	High	Acidic	**Low**	186	94	63	6.22
Bute 2020	**13**	High cereal, medium break crop	Acidic	**Low**	180	33	23	5.75
	14	Low	Alkaline	**High**	46	38	68	7.82
	15	Medium/Low	Neutral	**Moderate**	107	67	92	6.11
	16	Low	Alkaline	**High**	68	37	105	7.63
Kybunga 2020	**17**	High	Neutral	**Moderate**	86	32	62	7.15
	18	Low	Alkaline	**High**	26	25	110	7.78
	19	Medium	Acidic	**Low**	142	23	28	6.99
	20	Medium	Alkaline	**High**	47	15	58	7.75
	21	Low	Strongly Alkaline	**Very high**	21	37	120	7.85

At 10 of the 21 trial sites there was no significant yield gain from the application of any P fertiliser (Table 2). In contrast at some sites the calculated optimum P level (to achieve 90% maximum grain yield) was up to 55 kg P/ha. Table 2 also shows expected P response, pHnNDVI value and the site mean grain yields to demonstrate the production levels at each site. Site mean yields ranged from 1.02 to 5.09 t/ha. It should be noted that there is no correlation between historical grain yield and P response for these 21 sites indicating that past crop yield is a poor indicator of P requirement and simple replacement P strategies will not factor in other more significant controlling factors to a P rate decision.

The relationships derived from the 21 P response trials conducted in 2019 and 2020 show that there is a useful correlation between the derived pHnNDVI and soil P availability measured with DGT (Figure 3). It also shows that in this dataset the pHnNDVI provides an improved correlation with optimum P rate compared to the DGT P soil test value, indicating the methodology developed during this project performed better than industry standard soil testing methodology. Both pHnNDVI and DGT P were far superior to Colwell P alone at these 21 sites (data not shown). Collecting the soil pH data and satellite imagery data and generating the pHnNDVI is estimated to cost $15-20/ha, whereas DGT P tests are $20/test, therefore testing DGT P on a 1ha grid basis is estimated to cost more than $25/ha with sampling costs included. In addition, the pHnNDVI derived from Veris pH (8-10 samples/ha) and Sentinel 2 satellite imagery (10m pixel resolution) provides much higher resolution data than can be derived from a 1ha grid. Therefore, the methodology described here has several advantages over alternative methods for generating P prescription maps.

Table 2. *Expected P response, pHnNDVI, site mean yield, P rate for optimum grain yield and youngest emerge blade tissue P concentration (mg/kg) for P rate trials 2019 and 2020.* The significance of grain yield response to P applications of each site is indicated by ** ($p < 0.01$), * ($p < 0.05$) and non-significant response (NS).

Site	Expected P response	pH/ nNDVIi	Site mean yield (t/ha)	Calculated optimum P rate for 90% grain yield (kg/ha)	Critical concentration of leaf tissue P met at P rate (kg P/ha)	Grain response to P
Site 1	High	7.9	2.07	44	50	**
Site 2	High	9.8	2.55	33	Not achieved	**
Site 3	Low	5.0	3.11	0	20	NS
Site 4	Moderate	5.6	2.65	*	10	NS
Site 5	Low	5.4	5.09	0	10	NS
Site 6	Moderate	6.3	4.64	0	0	NS
Site 7	High	10.0	4.08	45	50	**
Site 8	High	8.7	4.92	22	50	**
Site 9	Mod-high	8.4	2.16	50	#	NS
Site 10	Low-mod	6.1	3.27	0*	#	NS
Site 11	High	10.0	2.08	27	#	**
Site 12	Low	4.1	2.57	10	#	*
Site 13	Low	5.0	2.53	*	0	NS
Site 14	High	8.8	2.51	50	Not achieved	**
Site 15	Moderate	6.0	1.14	24	10	*
Site 16	High	10.0	1.02	50	50	**
Site 17	Moderate	6.2	2.34	0	50	NS
Site 18	High	9.3	2.16	55	Not achieved	**
Site 19	Low	5.3	3.80	0	20	NS
Site 20	Mod-high	8.1	3.02	0	Not achieved	NS
Site 21	Very high	10.0	2.09	55	Not achieved	**

*unable to predict optimum P rate for 90% yield for low level and non-significant responses, #leaf tissue samples not taken at these sites

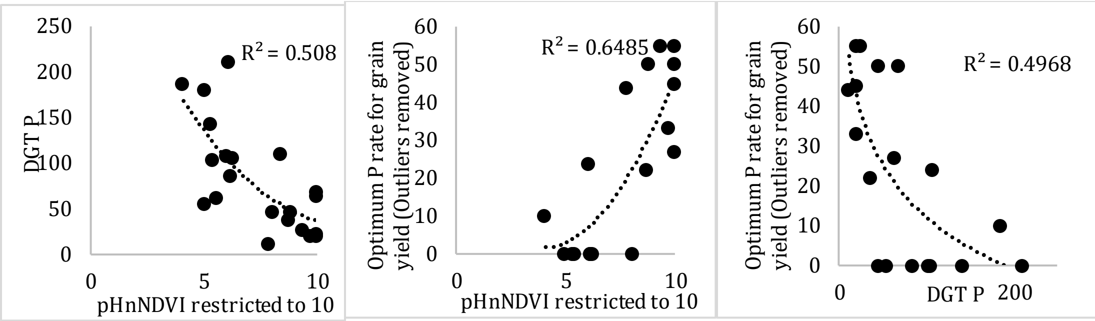

Figure 3: Relationship between pHnNDVI, DGT P and optimum P rate for grain yield derived from 21 P response sites in five paddocks in 2019 and 2020.

At sites with high pHnNDVI the crops are responsive to high levels of P fertiliser, up to 55 kg P/ha, and this has a great impact on crop biomass, measured as Greenseeker NDVI (Figure 3). However, despite large increases in NDVI compared to the control and even conventional rates of P, the high P treatments were not able to match the controls at the non-responsive site. This indicates that application of P alone in a single season was not able to make crop growth uniform across the paddock. Leaf tissue testing did not highlight other nutrient deficiencies that could be limiting production.

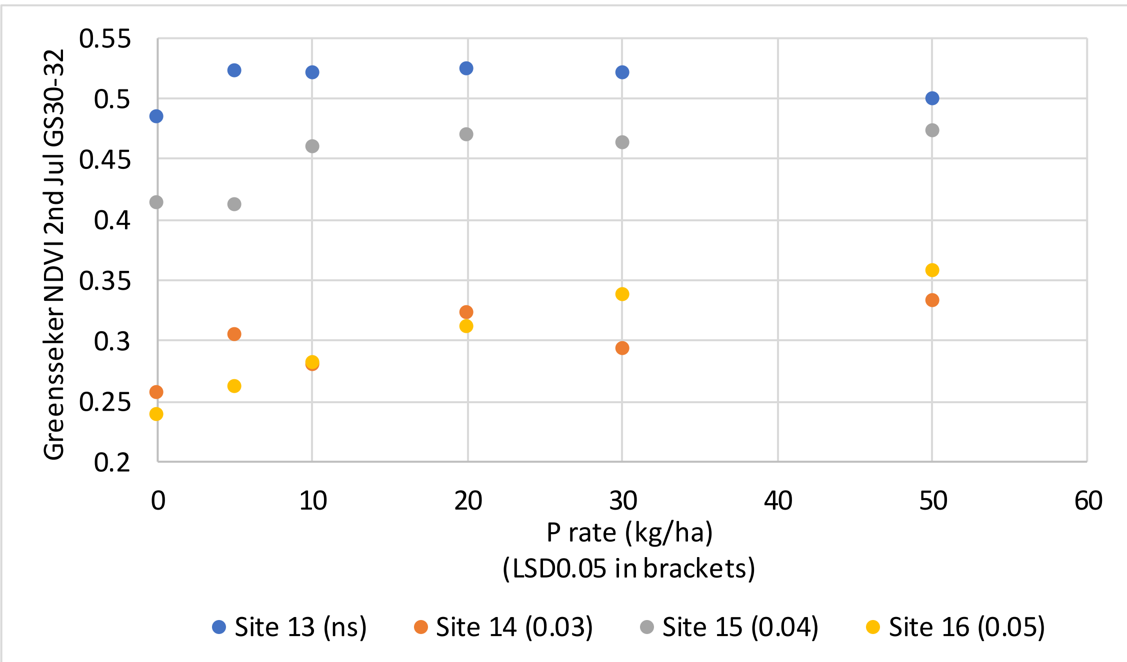

Figure 3: Greenseeker NDVI measured at early stem elongation at four P response trials at Bute. Sites 14 and 16 were P deficient high response sites and sites 13 and 15 were P sufficient low response sites.

Soil pH, PBI and Carbonate relationships

In alkaline soils, P buffering has a strong relationship with calcium carbonate in the soil that is responsible for P ‘tie up’. Mapping of soil pH has been used to differentiate soils that are likely to behave differently with respect to P availability, P tie up and fertiliser P response. Testing the relationship between soil pH, calcium carbonate and PBI has revealed several important points;

- Veris pH has a meaningful relationship with both calcium carbonate and PBI, where higher pH relates to higher calcium carbonate and PBI (Figure 4). This helps to explain why larger P responses are expected on higher pH soils. This validates preliminary data generated by Trengove Consulting prior to project TC219.

- Veris pH measured on-the-go has shown better relationship with calcium carbonate and PBI than lab measured pH ($CaCl_2$ or H_2O) (Data presented in appendix 1). The reason for this is not clear but may be related to characteristics of the Veris antimony pH probe.
- Data presented shows the trends for soils across the region of the Mid North and YP. When the data is broken down to individual farms or sub regions, the strength of these relationships improves (data not shown).
- While these relationships are useful to understand, to improve prediction of PBI would require a sensor that measures PBI or calcium carbonate directly, rather than indirectly through soil pH. Infrared technology may provide this opportunity in the future.

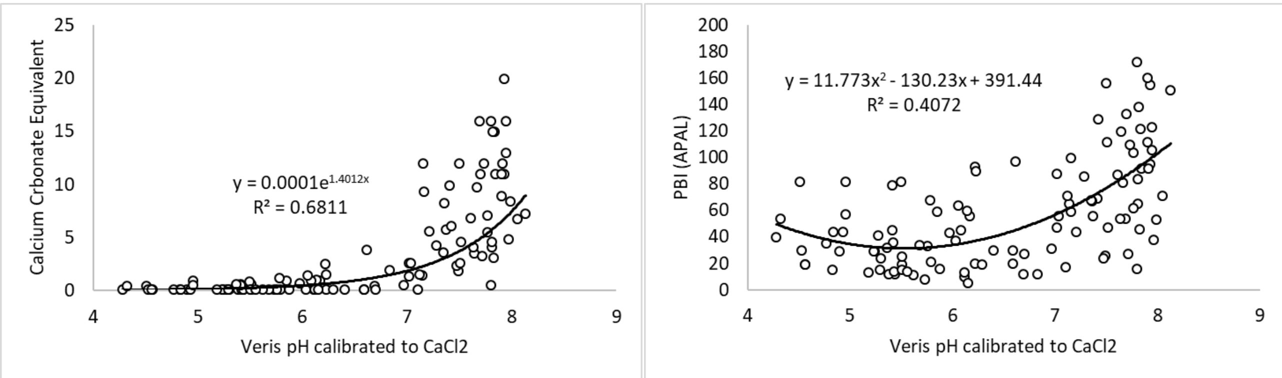

Figure 4: Relationship between Veris soil pH measured on-the-go and lab measurement of calcium carbonate and PBI.

Conclusions Reached &/or Discoveries Made (Not to exceed <u>one</u> page)

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

Results from project TC219 demonstrate that there is large spatial variability in the crop response and economic returns generated from P fertiliser investment. Across 21 P response trials conducted in 2019 and 2020 the optimal P rate to maximise partial gross margin (PGM) ranged from 0-40kg P/ha. Application of optimal P rates at the P responsive sites increased PGM by up to $79/ha compared with returns from replacement P rates through increased yield, with an average improvement in PGM of $41/ha.

The methodology for predicting P responses across spatially variable paddocks has advanced significantly in the past year. Project TC219 was based on the hypothesis that spatial data layers can infer where P responses are likely, with particular reference to soil pH data and satellite imagery being important data layers. Analysis of the 21 P response trials shows that these layers have provided useful prediction of P response in the five trial paddocks. Using Veris soil pH and satellite imagery in a combined index was shown to provide good prediction of P response, the combined index providing a scale of P sufficiency. The P sufficiency index, also being termed pHnNDVI, is simply calculated by dividing soil pH by the normalised NDVI.

- pHnNDVI = soil pH/normalised NDVI

Based on this calculation, paddock zones with high soil pH and low NDVI have a high pHnNDVI value. These areas are predicted to have a higher P response than areas with low soil pH and high NDVI (low pHnNDVI). It is expected that calibrating the historical NDVI data with data on crop P content from tissue test analysis will refine the prediction further, however this needs more investigation.

In the five focus paddocks assessed in TC219 the area of predicted high P response ranged from 16-40% of paddock area based on the derived pHnNDVI value. Based on Trengove Consulting client data it is expected that these paddock areas of high P response would be representative of the region northern YP and western Mid North where the trials were conducted. This represents a large area where economic gains could be achieved through improved P fertiliser strategies.

Longer term economic response to P fertiliser is also sensitive to the accumulation or depletion of P over time and the crop response to changing soil P status in subsequent years. Three responsive trial sites established in 2019 at Bute and Koolunga were monitored again in 2020 when they were sown to lentil. Bute and Koolunga sites received 24kg P/ha and 15kg P/ha in 2020, respectively. At two of these sites lentil yield responses were measured in 2020 to P applied in 2019, with 50kg P/ha treatments increasing lentil yield by 0.22t/ha compared with untreated. These longer-term responses strengthen the economic case for higher P rates on responsive soils.

The highly responsive sites are responsive to up to 30-50kg P/ha in many instances, far higher rates than are typically considered by grain growers. However, these rates of P have not improved crop growth to the extent that these P deficient sites have the same vigour as the low response sites (using NDVI as a measure of vigour). For example, at Bute in 2020 sites 14 and 16 were P deficient and responsive to high rates on P. However, application of 50kg P/ha at these sites did not increase NDVI to match NDVI of the untreated plots at the P sufficient, low response sites 13 and 15 (Figure 3). In addition, the long-term responses at sites from Bute and Koolunga described above indicate further long-term residual benefits of high P rate application. These results suggest that it is difficult to completely overcome low soil P status and severe P deficiency in a single year with fertiliser alone. It suggests that building soil fertility over time and increasing low soil P status will enable greater yields to be attained than fertiliser P can achieve in a single season. A similar concept has emerged from hyper yielding trial sites in the high rainfall zone. That is, it is difficult to achieve high yields on low fertility sites where majority of the nutrient supply comes from fertiliser. Sites with high inherent fertility are required to achieve 'hyper yields'. Similarities are evident with the P responses observed in this project, suggesting that building the baseline soil P status will build yield potential beyond what fertiliser P can attain in a single year.

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.

Main Findings

- Profitability can be increased by targeting P fertiliser to where it is required rather than applying blanket rates across paddocks. An average increase in partial gross margin of $41/ha was demonstrated for P responsive soils by using higher optimal P rates than recommended by P replacement strategies. In addition, on non-responsive soils, a saving in fertiliser could be achieved where lower fertiliser rates could be used without incurring any yield loss.
- Combined use of soil pH maps with historical satellite imagery provides good prediction of likely P response within investigated paddocks in the Mid North and northern YP region. The basic premise is that zones with higher soil pH and poor historical cereal crop growth (defined from satellite imagery) are likely to be responsive to higher P rates, whereas zones with lower soil pH and high historical cereal crop growth are more likely to require lower P rates.
- A methodology has been developed for combining these data layers and generating P prescription maps for use in variable rate seeders and spreaders.

Potential industry impact

Phosphorus fertiliser inputs are one of the largest variable input costs associated with producing crops on grain farms in SA. The five focus paddocks have been representative of the northern YP and western Mid North areas, a region of approx. 400,000ha. The area of predicted high P response ranged from 16-40% across the five paddocks. A conservative estimate across the region is 20% of paddock area is responsive to higher P rates than standard practice, with potential to generate an additional $41/ha, on average, through application of higher optimal P rates compared with replacement P rates. This equates to a potential benefit of $3.28 million to the region annually through increased productivity on P responsive soils, if grower adoption reached 100%. At 25% adoption this still equates to $820,000 benefit annually to this region. The benefit will be increased further through reducing fertiliser cost on non-responsive soils. The application of this work also has potential to extend across a broader geographical area providing benefits further afield, but this requires further validation and testing.

Publications

Northern Sustainable Soils group trial report (2019 & 2020)

Hart Field Site Group Trial report (2019 & 2020)

GRDC Update paper 2020-, Sean Mason, Phosphorus application recommendations based on soil characterised zones – does it pay?

Extension activities

Trial sites visit with Halbury Ag Bureau

Trial sites visit with NSS group

Results presented to growers at FM500 groups, YPASG meeting and SPAA expo

Several twitter posts have attracted a lot of interest to the trial work

Results presented to the Independent Ag Consultants group

Personal communication to clients and aiding early on farm adoption

Several GRDC updates

Path to market and barriers to adoption

There are several steps to take to achieve adoption on farm. The first is understanding the issue and the need for practice change, the second is practical implementation. Demonstrating the scale of variability of P response within paddocks and the improvement in financial return helps improve understanding and the need for change. This can (and has) been achieved through extension activities including on farm trial visits, results presentation at meetings and reports in industry publications.

Practical implementation requires several areas to be addressed

- Access to spatial data: satellite imagery is readily available now through various web-based providers and soil pH mapping services have become increasingly available over the past five years.
- Data management and processing: collating data from its various sources and generating prescription maps requires spatial software and processing skills. These skills are often limited within the general farming community. To overcome this skills shortage would require grower training in this area, or access to skilled service providers that can deliver those services for growers.
- Hardware capability: prescription map based variable rate application requires seeders and spreaders with variable rate capability. Most modern machinery has this capability and as machinery is upgraded this functionality often comes standard, whether the growers utilise the technology or not. Growers using this technology often require support initially on how to setup their machinery and move data in and out of their rate controllers. Machinery dealers and precision ag specialists most often provide this support. Growers using older equipment may not have the machinery capability. These growers may need to invest in retro-fitting their machinery with variable rate technology if they are to adopt prescription based variable rate applications.

POSSIBLE FUTURE WORK

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

Areas for future investigation include

- Further validation of P response prediction based on spatial data. The combination of soil pH and historical satellite imagery were able to predict the P response at most sites in this project. The addition of more sites to this data set will help to validate the P rate calculation. Leaf tissue analysis was also used to assist in the P rate calculation, however more data is required to validate this process.
- Testing in a broader range of production environments and soil types. Promising results have been derived from trial paddocks on the northern YP and western Mid North. This needs to be expanded to include sites encompassing a broader range of soil types to test whether the methodology has application across a broader geographic area.
- Determining best practice long term management of high P response sites. Results from this project have shown that optimal economic P rates on highly P responsive sites can be in the order of 30-50kg P/ha in the first year of

treatment. These rates are much higher than replacement rates or rates currently being used. Further work is required to determine the best long-term strategy, are these high rates required annually, or will excess applied P build soil P reserves and reduce optimal P rates required in time?

These questions will be investigated through a new SAGIT project TC221 “Improved management of variable Phosphorus requirement and strategies for highly responsive soils”.