Office Use Only

Project Code	
Project Type	

FINAL REPORT 2017

Applicants must read the *SAGIT Project Funding Guidelines 2017* 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	**:**	**UA1115**

PROJECT TITLE	Reassessing the value of phosphorus replacement strategies on fixing soils

PROJECT DURATION

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

Project Start date	01/07/2015					
Project End date	30/06/2017					
SAGIT Funding Request	2014/15		2015/16		2016/17	

PROJECT SUPERVISOR CONTACT DETAILS

The project supervisor is the person responsible for the overall project

Title:	**First Name:**	**Surname:**
Dr	Sean	Mason

Organisation:
The University of Adelaide

Mailing address:

Telephone:	**Facsimile:**	**Mobile:**	**Email:**

ADMINISTRATION CONTACT DETAILS

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

Title:	First Name:	Surname:
Ms.	Chelsea	Dubois
Organisation:		
The University of Adelaide		
Mailing address:		

Telephone:	Facsimile:	Mobile:	Email:

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

- Varietal performance for both wheat and barley in terms of maximum yields and optimal P inputs varied across the two growing seasons.
- There is little consistent difference in the response to P among the commercial wheat and barley varieties that were tested.
- Overcoming P deficiency on soil types with moderate to high PBI with high P rates may not be the most economic but defining economic P rates is important as they are still considerably higher than typical replacement rates.
- We continue to endorse the use of farmer strip type trials where P rates are adjusted accordingly. We further advocate using P rich strips which consist a P rate at least double typical replacement rates to determine if high P rates are economical for your specific soil type.
- Development of a P rate calculator through previous SAGIT investment has promise in accurately determining efficient P rates.
- Further development of IR technology to allow in field assessment of P retention potential of soils across a paddock could have significant benefits for precision agriculture.

Project Objectives

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

The aim of this project is to quantify the economic benefit to farmers of

1) Applying relatively high application rates of phosphorus on moderate buffering soils (PBI) across a range of sites with different yield potentials.
2) Growing three-four common wheat and barley varieties that were best performed in recent S.A. NVT trials to assess their phosphorus use efficiency (PUE).

In order to fulfil the project objective, the aims will be:

i) Determine both optimal and economic phosphorus rates on sites with moderate amounts of phosphorus buffering potential.
ii) Compare the responses to P among common wheat and barley varieties.
iii) Estimate the economic returns from P among these genotypes on soils with moderate P buffering potential.

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.

Over the course of the project we conducted six replicated field trials across broad acre regions of South Australia. These trials were designed to allow for the project aims to be thoroughly tested. Two contrasting growing seasons in 2015 (dry finish) and 2016 (wet and cool finish) meant the interactions between climate and variety P responses to applications of P were assessed. To compare P responses of different varieties it is essential the trial is performed on P deficient soil. Unfortunately, the 2016 trial at Cummins was not responsive to P applications. There were also two sites (Cummins 2015 and Urania 2016) that had variable P levels across the trial which meant that responses to P were highly variable. While this made analysis of P rate x variety interactions difficult it was an opportunity to test the capabilities of handheld MIR to predict PBI across the trail plots which was found to be the driver of varying P levels.

Project Personnel:

Assoc. Prof Glenn McDonald (University of Adelaide) – 5% in-kind

Field trial Collaborators:

SARDI (Rob Wheeler and Willie Shoobridge)

Landmark at Cummins (Patrick Head and Richard May)

AgExtra - formerly Peracto (Richard Porter)

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.***
Site selection and survey of soil P levels including DGT/Colwell P and PBI through MIR	Y	
Analysis of data from all sites for the 2015 growing season completed	Y	
Progress report submitted to SAGIT	Y	

Site selection and survey of soil P levels including DGT/Colwell P and PBI through MIR	Y	
Analysis of data from all sites for the 2016 growing season completed	Y	
Progress report submitted to SAGIT	Y	
Final report submitted to SAGIT	Y	

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

Provide sufficient data and short clear statements of outcomes.

Please refer to supplement document for all trial data across 2015 and 2016

Field trial protocol for both seasons:

Four varieties each of wheat and barley were sown at 6 rates of P: 0, 5, 10, 20, 30 and 50 kg P/ha as MAP while N was balanced with applications of urea effectively applying 22 kg N/ha to all plots. Each treatment was replicated 4 times. The varieties sown (wheat – Cobra, Corack, Mace, Trojan; barley – Commander, Compass, Fathom, LaTrobe) were selected were selected as the best performed varieties in NVT trials in previous (2-3 years). Early crop growth was assessed by estimating biomass measures at two-three times per site through NDVI values obtained with a Greenseeker ™ and calibrating the readings with biomass cuts at each site (data not shown).

The harvested grain was measured from each plot and the P use efficiency (PUE) for each variety was defined as the yield at 0 P relative to the maximum yield obtained with P application. The P requirement was assessed by fitting a curve through the yield response data and the yield optimising P rate was estimated as the rate that gave 90% of the yield response. The profit from the application of P was calculated for each rate of P based on prices for 2015 of $260/t for APW wheat and $260/t for Malt barley, and a fertilizer price of $700 (MAP) (PIRSA Gross margin guide 2016) and for 2016 of $220/t for APW wheat and $150/t for Malt barley, and a fertilizer price of $600 (MAP) (PIRSA Gross margin guide 2017).

While input and grain prices fluctuated between the two seasons we have developed a P risk calculator (see below and attachment) which allows for the determination of economical P rates based on these two cost variables.

2015

Trials were sown on the following dates 22nd May (Cummins), 26th May (Sherwood) and 2nd June 2015 (Pinery). Significant ($p < 0.05$) early responses were obtained at all three sites for both wheat and barley as assess by NDVI (data not shown). These significant responses ($p < 0.001$) translated to grain at all three sites for both wheat and barley. Overall yields varied considerably between the three sites providing an opportunity to assess economic P rates under different yield potentials and response characteristics. Maximum yields at Cummins reached 6.43 t/ha (Trojan) and 7.09 t/ha (Compass) for wheat and barley respectively, 3.58 t/ha (Corack) and 3.95 t/ha (LaTrobe) for wheat and barley respectively at Pinery. A dry spring reduced yields at Sherwood with wheat at 1.19 t/ha (Mace) and barley (Compass) at 1.66 t/ha. There were also significant differences ($p < 0.05$) between grain yields of different varieties at all sites for both wheat and barley except for wheat at Cummins. Compass barley consistently performed well at all three sites and was only matched by LaTrobe at the Pinery site. No significant ($p > 0.05$) variety by P treatment effect was seen at any site for either wheat and barley, consistent the results of similar trials in previous years. As a result, calculated PUE % for each variety was very similar particularly for the Cummins and Pinery sites.

Optimum P rates for yield were highest at Pinery which reflected the low P fertility at the site (Table 1, supplement) and the low efficiency of applied P fertiliser due to high P fixation caused by the high concentrations of Calcium Carbonate. Trojan, a longer season variety struggled at Pinery because it flowered late due to the relatively late sowing date and the harsh finish generated by a warm/dry spring experienced at the site in 2015. Overall P rates required to provide 90% of the maximum response for Cummins were 17 and 23 kg/ha for wheat and barley respectively which supports previous trials that showed barley requires higher P rates and has lower PUE compared to wheat. Moderately high P rates (21-23 kg/ha) were still required at Sherwood even with the poor growing rainfall which caused well below average yields.

Calculation of the economic optimum P rates, which we defined as the P rate that resulted in the highest Gross Margin (Table 1 supplement) allows a comparison with P rates required to maximise yield alone. For the Cummins site, where high yields were achieved, the optimum P rates for yield closely matched optimum P rates for profit and therefore in this situation it was important to overcome P deficiency with sufficient P rates. In comparison at Sherwood the economic optimum P rates were comparatively lower than the optimum P rates for yield which were driven by the poor rainfall and low yields obtained at this site and therefore the full benefit of P applications in terms of increasing yield was reduced. At Pinery the optimum P rate for yield was close to the highest rate of P applied, but the economic optimum rate was less than half this rate. The large differences between the two optimum P rates was caused by the high PBI at the site decreasing the efficiency of P applications. The rate of yield increase from high rates of P was not large enough to cover the additional cost of the extra fertiliser applied. For these soil types, there is a decreased importance of maximising yield through P application but determining profit maximising input levels is important. However, it is worth noting that the economic P rates were still significantly higher than typical replacement rates (9-12 kg P/ha) based on 2015 yields and over the long term there may be a gradual fall in available soil P. Under these conditions, monitoring soil P by regular soil testing or using test or omission strips to examine the responses to P is recommended.

2016

Trials were sown on 19th May (Cummins), 23rd May (Urania) and 24th May 2016 (Condowie).

Urania:

Wheat: While there were relatively small responses to P (PUE % 89-95%) there was a significant ($p < 0.05$) grain yield response to P. Relatively large applications were required with an overall optimal rate at 33 kg P/ha. There was a significant ($p < 0.05$) difference between varieties with Cobra and Trojan both yielding better than Mace and Corack. This contrasts with the 2015 trials where Trojan performed poorly due to the tough finish to the season. No variety x P treatment interaction occurred.

Barley: Small responses to P occurred (PUE % 91-98%) but they were significant. Optimal P rate was 22 kg P/ha. Significant ($p < 0.05$) differences occurred between varieties with Fathom outperforming the three other varieties. No variety x P interaction occurred.

Condowie:

Wheat: Moderate and significant ($p < 0.05$) responses to P were obtained (PUE 79-83%). Optimal P rates were quite high (33 – 55 kg P/ha) with the economic optimum around 30 kg P/ha. As with Urania both Trojan and Cobra out performed Mace and Corack. No variety x P rate interaction was found.

Barley: Moderate and significant ($p < 0.05$) responses to P were obtained (PUE 77-82%). Optimal P rates were comparatively lower than for wheat (13 – 55 kg P/ha) with the economic optimum between 10-30 kg P/ha. Statistically Fathom and Latrobe outperformed Commander and Compass. No P treatment x variety interaction was

obtained however further statistical analysis on the response curve parameters suggest differences occurred. This still needs confirmation and further analysis.

Cummins:

Wheat: Responses to P while significant were hard to decipher apart from Cobra (PUE 83%) with typically flat response curves obtained for the other varieties. This is accordance with DGT soil test results suggesting adequate P was available at sowing. No differences in variety performance at this site.

Barley: No significant differences in P treatment, variety or P treatment x variety was obtained. Unfortunately, this coincided with adequate soil test values (DGT) taken at sowing.

P requirement calculator example:

In a deficient scenario, we now have typical P response surfaces for soils that might be prone to poor fertilizer efficiency due to their moderate to high fixation potential. These response surfaces can be similar when converted to a response parameter like relative yield (%) compared to maximum yield over two contrasting seasons which generated vastly different yield potentials. As an example, Figure 1 shows response to P by Mace at Condowie in 2016 and at Pinery in 2015 (both sites had very similar P characteristics, see table 1 supplement) and the responses when converted to relative yield.

Using a very simple P requirement calculator we can assess the impact of various combinations of fertiliser and grain price (table 1). The main sensitivity to high rates not being applicable on this soil type is when fertilizer prices increase to $1000/t and grain prices stay relatively stable. The main impact of a lower yielding year is also felt under high fertilizer prices. This tool in combination with a P rate calculator developed from previous SAGIT investment (see supplement) has the potential to accurately determine when higher P rates will provide an increase to gross margins.

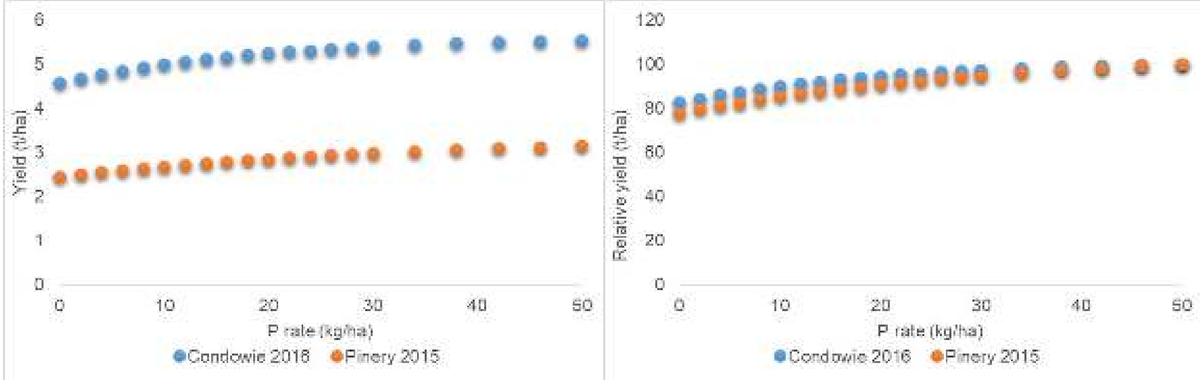


Figure 1: Grain response to applied P in a high yielding year (Condowie) and lower yield year (Piney) – left and the comparative response curves when grain yields are converted to relative yield – right.

Table 1: Outputs from a P requirement calculator developed from the typical response curve developed from Condowie and Pinery with different fertilizer (as MAP) and grain prices.

MAP cost ($/t)	Grain price ($/t)	Economic optimum P rate (kg/ha) Condowie 2016	Pinery 2015
580	220	30	25
1000	220	15	7
580	300	35	35

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

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

- Varietal performance for both wheat and barley in terms of maximum yields and optimal P inputs varied across the two growing seasons.
- P requirements for each variety is dependent on sowing times and seasonal fluctuations which are hard to predict at the start of the growing season when P inputs are decided.
- There is little consistent difference in P response among current varieties of wheat and barley. Therefore, farmers should choose the most appropriate variety for their region
- Overcoming P deficiency on soil with moderate to high PBI, which are prone to P deficiency, with high P rates will not be the most economical management option but defining economic P rates is important as they are still considerably higher than typical replacement rates.
- On soils with moderate to high PBI, the economic optimum P rates may be higher than rates based on P replacement values.
- We continue to endorse the use of farmer strip type trials where P rates are adjusted accordingly. We further advocate using P rich strips which consist a P rate at least double typical replacement rates to determine if high P rates are economical for your specific soil type.

- Using typical P response curves generated on similar soil types and soil P levels a quick calculator can be developed that enables assessment of the risk involved by increasing P to gross margins based on real time fertiliser and grain prices.
- Not every site will have the same starting soil P levels and soil reactions (PBI) to applied P and therefore we have developed a P rate calculator that is sensitive to changing soil types. Briefly (see supplement for more detail) through previous SAGIT funded work (UA0511) we have a strong relationship between the increase in DGT values per unit of P applied across a range of soil types. By knowing your start point (DGT) and the point of sufficiency (DGT critical value) we know how much P is required. Validation of this tool on trials performed in UA1115 is promising and will be tested further in AS216.
- It is becoming increasingly important to assess the varying soil fixation abilities (PBI) across the paddock for PA purposes with significant potential savings in P inputs. Therefore, a rapid, cost effective technique that predicts PBI in the field would be of significance. Results from this project using MIR as a tool to predict PBI across relative small areas of the trial plots are very promising.

Intellectual Property

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

There is the potential for the P risk calculator and the P rate calculator to be used by commercial entities. These tools will supplement the DGT soil test which has been commercialized for 4 years and is providing significant benefits in interpreting P availability on difficult soils.

Using IR technology in the field for predicting PBI also has commercial potential.

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

- Variety choice should be made on yield potentials, flexibility with sowing times and crop rotations and not a variety choice that may have lower P input requirements.
- Soils that have moderate to high P fixing ability (PBI > 80) should be monitored closely for P availability as they have higher P requirements than rates generated by P removal through grain yields.
- Precision P inputs across the paddock should include an assessment of PBI at the very least and not simply based on previous season yield maps. Poor performing parts of the paddock may in fact be due to higher PBI soils and P deficiency which will only be enhanced through yield prescription maps.
- Technology (IR spectroscopy) is advancing to a stage where generation of paddock PBI maps are achievable.
- P rate and P risk calculators have been developed to aid in P decisions that will maximize gross margins. Both these calculators are sensitive to the soil P status

and fertilizer/grain prices and will be continually evaluated with project AS216.

Potential industry impact

Significant areas of broad acre cropping regions of South Australia experience P deficiency and in some circumstances replacement P rates or historical P rates are not overcoming P deficiency in the growing season of application. Results from this project helps build knowledge that higher than P replacement rates on specific soil types are economical. Relatively simple P rate and P risk calculators have been developed that will aid in P rate decisions that ensure gross margins and not necessarily maximum yields are met. These outputs provide significant contributions to refining the guess work when it comes to P rate decisions. There is great potential to further refine P rate decisions through precision agriculture by calculating variable P rate maps that are based on soil types and soil P levels which is a significant advancement on the simplistic variable P rate maps developed from replacement P theory and the previous seasons yield map.

Publications and extension articles

Accepted abstract for the 2017 Agronomy Conference to be held in Ballarat (September)

EPFS 2015 results summary
Hart 2015 and 2016 results summary
MSF 2015 Compendium
GRDC 2015 updates
Independent Consulting Meetings (Feb 2016).

Hart 2016 field day

Hart 2016 winter walk

Path to market

There are no barriers to adoption for those growers that are willing to test out the P rate/risk calculators. We always encourage use of paddock fertilizer strips to further validate any applicable tool that appears on the market.

APAL are interested in providing the P rate calculator to their clients that are interested.

POSSIBLE FUTURE WORK

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

The sensitivity of variety responses to P applications across to contrasting climatic growing seasons (2015 and 2016) has been highlighted in this project. Further work has been kindly funded by SAGIT (AS216) which is looking at the effect of the time of sowing on P requirements across two growing seasons. Outputs from this project will provide the industry with actual numbers of changing P requirements if you sow early in the window or later in the sowing window.

AUTHORISATION
Name: Sean Mason
Position: Research Fellow
Signature:
Date: 31/08/2017

Submit report via email to admin@sagit.com.au as a Microsoft Word document in the format shown ***within 2 months*** after the completion of the Project Term.

Reassessing the value of P replacement strategies on fixing soils – UA1115

Table of Contents

Summary of all the field trial results performed in 2015 and 2016

Variety	Yield (Control) t/ha	Yield (Max.) t/ha	PUE %	GM @ 0P $/ha	GM Maximum $/ha	Colwell P (mg/kg)	PBI	DGT (µg/L)	Optimal P (kg/ha)	Economic P (kg/ha)
Cummins - wheat										
Cobra	5.07	6.15	82	1396	1660	26	43	81	6	10
Corack	5.38	6.35	85	1482	1693	26	43	81	12	14
Mace	4.99	6.18	81	1374	1594	26	43	81	26	24
Trojan	5.42	6.43	84	1493	1628	26	43	81	50	35
Mean	5.22	6.23	84						17	
Cummins - barley										
Commander	4.3	6.16	80	1306	1547	25	59	71	19	20
Compass	5.5	7.09	77	1459	1743	25	59	71	34	32
Fathom	5.05	6.38	79	1338	1596	25	59	71	22	23
LaTrobe	5.39	6.71	80	1431	1695	25	59	71	18	21
Mean	5.22	6.57	79						23	
Pinery - wheat										
Cobra	2.19	2.99	73	558	645	31	135	14	55	24
Corack	2.66	3.58	74	720	752	31	135	14	55	21
Mace	2.45	3.35	73	661	720	31	135	14	55	25
Trojan	2.5	2.81	89	674	674	31	135	14	42	0
Mean	2.453	3.293	74						55	
Pinery - barley										
Commander	2.4	3.2	75	623	754	28	135	17	22	18
Compass	2.82	3.88	73	738	852	28	135	17	55	30
Fathom	2.78	3.68	76	727	826	28	135	17	46	25
LaTrobe	2.94	3.95	74	768	886	28	135	17	44	47
Mean	2.737	3.689	74						46	
Sherwood - wheat										
Cobra	0.23	0.74	32	-16	67	17	11	16	14	11
Corack	0.16	0.87	18	20	155	17	11	16	14	15
Mace	0.35	1.19	30	74	182	17	11	16	37	26
Trojan	0.03	0.59	5	41	126	17	11	16	21	16
Mean	0.198	0.836	24						21	
Sherwood - barley										
Commander	0.32	1.05	31	63	177	17	17	25	21	18
Compass	0.59	1.66	36	135	251	17	17	25	55	34
Fathom	0.76	1.41	54	181	310	17	17	25	10	11
LaTrobe	0.64	1.23	52	149	234	17	17	25	19	15
Mean	0.569	1.273	45						20	
Urania Wheat										
Cobra	8.55	9.58	89	1849	2028	37	142	40	55	30
Corack	7.01	7.86	89	1560	1719	37	142	40	37	23
Mace	7.55	8.13	93	1661	1812	37	142	40	5	6
Trojan	8.87	9.34	95	1951	2043	37	142	40	20	12
Overall	8.04	8.69	93	1768	1883				33	
Urania Barley										
Commander	6.71	7.31	92	1026	1082	36	118	59	41	18
Compass	6.34	6.98	91	958	1059	36	118	59	16	13
Fathom	7.46	7.66	98	1120	1149	36	118	59	0	2
LaTrobe	6.68	7.12	94	1009	1065	36	118	59	19	12
Overall	6.81	7.26	94	1028	1086				22	
Condowie Wheat										
Cobra	5.21	6.64	78	1187	1288	29	146	26	55	39
Corack	4.14	4.96	83	955	1052	29	146	26	33	21
Mace	4.58	5.64	81	1067	1194	29	146	26	46	28
Trojan	5.64	6.88	82	1285	1410	29	146	26	55	33
Overall	4.89	5.96	82	1123	1235				50	
Condowie Barley										
Commander	4.22	5.14	82	972	1128	22	147	15	13	12
Compass	4.38	5.42	81	1014	1116	22	147	15	55	49
Fathom	4.26	5.5	77	986	1189	22	147	15	14	14
LaTrobe	4.57	5.85	78	1060	1221	22	147	15	36	22
Overall	4.38	5.45	80	1008	1143				28	
Cummins Wheat										
Cobra	5.24	6.12	86	1153	1345	38	56	73	0	0
Corack	5.59	5.5	102	1229	1282	38	56	73	0	0
Mace	5.92	6.39		1284	1487	38	56	73	0	0
Trojan	5.93	5.65	105	1292	1350	38	56	73	0	0
Overall	5.63	5.87	96	1240	1383				0	0
Cummins Barley										
Commander	6.38	6.55	97	956	1034	38	56	73	0	0
Compass	7.53	7.54	100	1126	1157	38	56	73	0	0
Fathom	7.89	7.85	101	1179	1225	38	56	73	0	0
LaTrobe	7.21	7.94	91	1076	1223	38	56	73	0	0
Overall	7.25	7.47	97	1083	1145				0	0

P risk calculator

Developed from typical P response profiles of Condowie (2016) and Pinery (2015). Profiles will change depending on soil P levels and characteristics (PBI) – see P rate calculator. This calculator however lets you assess the impact of fertiliser and grain cost ratios to economic P rates.

Yield data from Pinery 2015. Green highlights P rate corresponding to greatest returns.

P rate (kg/ha)	Cost ($/ha)	Yield (t/ha)	Income ($/ha)	Gross Margin ($/ha)
0	0	2.45	539	539
5	15	2.57	566	551
10	30	2.68	590	560
20	60	2.86	628	568
30	90	2.98	656	566
40	120	3.08	677	557
50	150	3.15	693	543
MAP price	600	*$/tonne*		
Grain price	220	*$/tonne*		
Yield potential	3	*t/ha*		

P rate (kg/ha)	Cost ($/ha)	Yield (t/ha)	Income ($/ha)	Gross Margin ($/ha)
0	0	2.45	539	539
5	25	2.57	566	541
10	50	2.68	590	540
20	100	2.86	628	528
30	150	2.98	656	506
40	200	3.08	677	477
50	250	3.15	693	443
MAP price	1000	*$/tonne*		
Grain price	220	*$/tonne*		
Yield potential	3	*t/ha*		

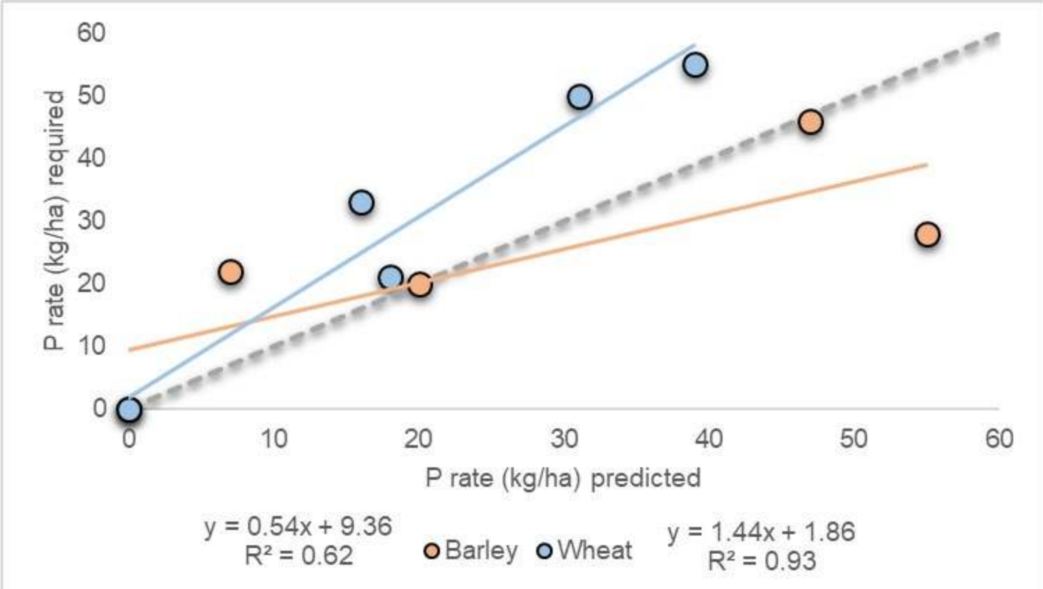
P rate (kg/ha)	Cost ($/ha)	Yield (t/ha)	Income ($/ha)	Gross Margin ($/ha)
0	0	2.45	735	735
5	15	2.57	772	757
10	30	2.68	805	775
20	60	2.86	857	797
30	90	2.98	895	805
40	120	3.08	923	803
50	150	3.15	944	794
MAP price	600	*$/tonne*		
Grain price	300	*$/tonne*		
Yield potential	3	*t/ha*		

P rate calculator

From UA0511 (SAGIT funded) we obtained moderate relationships between the increase in DGT (μg/L) per unit of P applied (mg/kg) for a range of soils with varying PBI values. Essentially the higher the PBI of the soil the more P was required to increase DGT P value by the same amount. Therefore, by knowing the PBI of a field site we can approximate how much P is required to elevate DGT by a certain amount. The certain amount will be the difference between the DGT value obtained at the site and the established critical value (56 μg/L – wheat, 68 μg/L – Barley). We used this calculator on the six field sites established in this project to validate the findings of UA0511. The results were promising with the P rate predicted by the tool well correlated with the optimal P levels found at each site for wheat ($p = 0.007$) but the relationship was not significant for barley ($p = 0.10$) (see figure below). The P rate predicted was a little lower compared to P rates required overall. This tool will be further validated by incorporating data from P response trials associated with AS216.

Example of the P rate calculator based on relationships of varying soil incubations with P (2-52 weeks) and increases of DGT with PBI.

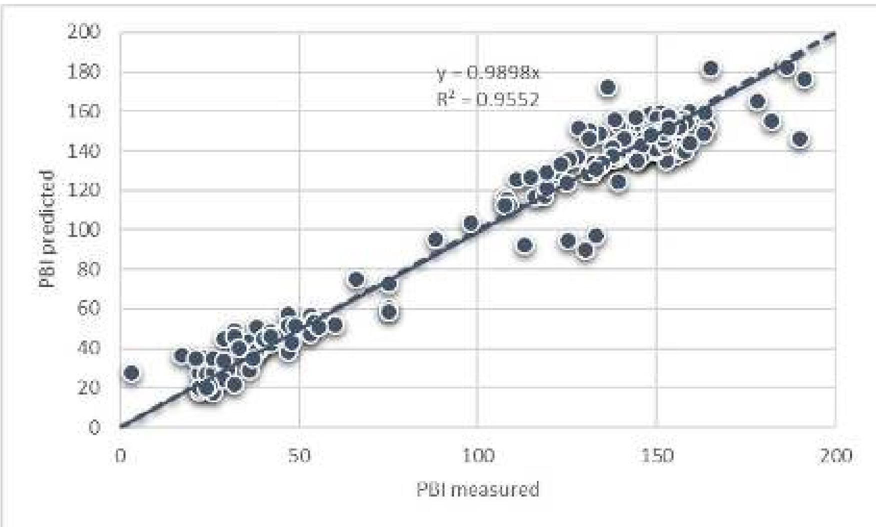
Fertiliser type	Weeks	PBI	DGT	Target DGT	DGT required	Increase in DGT per unit of P with PBI	Amount of P required
Phosphoric Acid	2	50	30	56	26	4.36	6
	8	50	30	56	26	2.345	11
	16	50	30	56	26	2.415	11
	32	50	30	56	26	1.985	13
	52	50	30	56	26	2.595	10
MAP	2	50	30	56	26	2.635	10
	8	50	30	56	26	1.725	15
	16	50	30	56	26	1.905	14
	32	50	30	56	26	1.75	15
	52	50	30	56	26	1.53	17

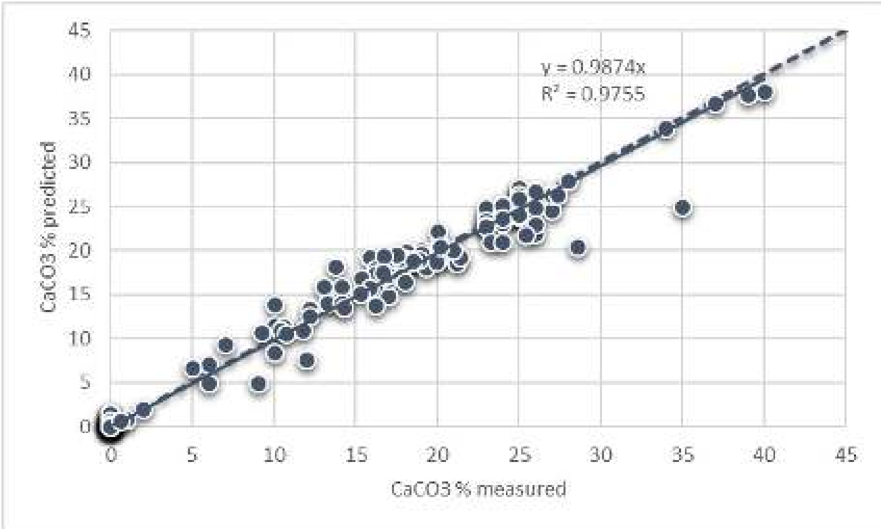


Relationship between the P rate predicted (kg/ha) (see tool above) and the P rate required (kg/ha) for the field sites established in UA1115.

Infrared technology and the prediction of PBI

MIR continues to be able to predict PBI measurements with high accuracy even at the field trial scale (See below). This technology could be very important given the importance this project has shown in measuring PBI and its link to potential P deficiencies. The Cummins (2015) and Urania (2016) site is a perfect example of PBI controlling P availability and responses to P applications where the lowest PBI values resulted in higher P availability and low responses to P. As expected the PBI was explained by the presence of $CaCO_3$ across the six sites which is also highly correlated with MIR (see below).





Cross validations between measured PBI (top) and Calcium Carbonate (%) content (below) with the predicted values though MIR technology. Data points are associated with the 6 P response trials performed between 2015-16.