Office Use Only	
Project Code	
Project Type	

FINAL REPORT 2019

Applicants must read the *SAGIT Project Funding Guidelines 2019* 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	:	**AS118**

PROJECT TITLE	Economics of high P rates on Pulses

PROJECT DURATION

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

Project Start date	01/07/2018					
Project End date	30/06/2019					
SAGIT Funding Request	2018/19		20119/20		2020/21	

PROJECT SUPERVISOR CONTACT DETAILS

The project supervisor is the person responsible for the overall project

Title:	**First Name:**	**Surname:**
Dr	Sean	Mason
Organisation:		
Agronomy Solutions Pty. Ltd.		
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:**
Mrs.	Anna	Walker
Organisation:		
Agronomy Solutions Pty. Ltd.		
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

Phosphorus requirements for selected pulses tested (Chickpea, Lentil) at the vegetative stage either have similar response profiles to wheat (Chickpea) or have higher P requirements to fulfill biomass potential (Lentil).

Maximizing biomass potential with P showed trends of increased nodule number and nodule weight per gram of root mass which would indicate a greater potential to fix N into the soil profile.

Due to climatic conditions pulse grain responses to P were hard to decipher due to very poor yields obtained.

Trends of Nitrogen fixation measured by the 15N natural abundance method with P were also hard to interpret but there were some significant increases in N fix for higher P rates compared to standard farmer practice rates for Lentils at Urania.

Increases in surface (0-10cm) mineral N values at harvest with P rate for both sites but particularly for Lentils outlines a greater potential to support the next cereal in crop phase with increased starting soil N levels.

Project Objectives

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

This project aims to demonstrate economic benefits of increasing P rates on pulse crops through increased grain yields and returns on potential extra N fixation for the following cereal.

To fulfil the project objective, the aims will be:

i) Determine optimal P rates for two pulse crops compared to wheat
ii) Assess the flow on effects of extra pulse biomass and in regard to N fixation

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.

We believe the project outcomes were achieved as outlined in the response to the KPIs (see below) albeit with a couple of issues that were out of our control.

Two P response trials were established on P responsive sites as we utilized the site selection process from AS216. In season vegetative biomass assessments were achieved with high accuracy due to adequate seasonal conditions at the time supporting crop growth.

Nodulation counts were taken around GS30 (wheat) as an extra assessment which was not initially written into the proposal but in the end was a key finding.

Natural abundance methods to measure fixed N were taken at stage that was a little late at Brinkworth as the crops quickly senesced due to very dry September/October. Urania sampling was performed at peak biomass.

Poor yields at Brinkworth possibly contributed to an inability to assess grain responses to applied P. In addition, at this site it appeared that Pasture King (P fertilizer used – no N) was poor at providing efficient P to the crops compared to MAP (AS216 – adjacent trial). The wheat in this trial had no grain response to P but AS216 showed strong responses. The Brinkworth site also suffered some frost events.

Pulse grain yields at Urania were also low compared to wheat which made it tricky to determine P response trends with applied P. This was attributed to a significant wind event which occurred between crop desiccation and harvest. On inspection after harvest there was a lot of pulse grain left on the soil surface due to lodging and an inability to harvest all the grain.

Liz Farquharson was responsible for nodulation counts, plant sampling for N15 fixation and natural abundance methods.

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.***
1: Locate P responsive sites – linked with AS216	Y	In conjunction with AS216 two sites were chosen, one at Brinkworth and the other at Urania.

2: Sow P response trials with lentils, chickpeas and wheat	Y	Both sites were sown successfully
3: Harvest P response trials and measure N fixation from pulse crops	Y	Both sites were harvested successfully. There were some difficulties harvesting all pulse grain.
4: Progress report submitted to SAGIT	Y	Please refer to the progress report submitted in Feb 2019
5: Final report submitted to SAGIT	Y	See this report

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

Provide sufficient data and short clear statements of outcomes.

KPI 1: Two locations were chosen in conjunction with AS216 which expressed Phosphorus deficiency via pre-growing season sampling (see attachment for soil test results). Two of the three sites were utilized for this project which were Brinkworth and Urania.

KPI 2: The trial at Brinkworth was sown on the 25th of May 2018 and Urania sown on the following day – 26th of May 2019. The following varieties of each crop type were sown, Mace (wheat), Genesis 090s (Chickpeas) and Hurricane XT (Lentils).

Phosphorus rates (0, 5, 10, 20, 50 kg P/ha) were applied as Pasture King (15% P, with no N) as opposed to MAP in order to limit the background N and maximise nodulation of both Lentils and Chickpeas.

In-season measurements:

NDVI biomass:

Early biomass assessment was performed using a greenseeker when wheat was at the end of tillering (GS30). Responses to applied P was clear at both sites and similar trends were found between the three different crop types. Chickpeas and wheat had similar P response characteristics, but linear responses were found for Lentils indicating P rates greater than 50 kg P/ha were required to maximise biomass (table 1, plus supplementary document).

Table 1: Comparative early biomass responses of chickpea, lentil and wheat to applied P at both sites and the corresponding optimal P required to reach maximum yields. *denotes linear response profiles and an inability to accurately predict NDVI max.

Site	Crop	NDVI control	NDVI max	Relative yield (%)	Optimal P (kg/ha)
Brinkworth	Chickpeas	0.27	0.32	86	40
	Lentils	0.30	0.37*	72*	>50
	Wheat	0.33	0.44	75	26
Urania	Chickpeas	0.32	0.38	85	50

	Lentils	0.38	0.45*	84*	>50
	Wheat	0.54	0.70	77	47

Nodulation counts:

Given the large visual responses in early biomass we took the opportunity to perform some extra analysis not initially written into the project proposal. 12 weeks after sowing (before flowering) nodulation counts were performed (in-kind) on three P treatments (0, 10P and 50P) at both sites. Whole plants were selected within each plot and taken back to SARDI for assessment. Significant ($p < 0.05$) increases in both nodulation numbers (see supplementary data) and nodulation dry weight per gram of root were found by applying 10 kg P/ha compared to the control which is considered the district practice application rate but a further increase in most cases was found by increasing rates up to 50 kg P/ha (Figure 1).

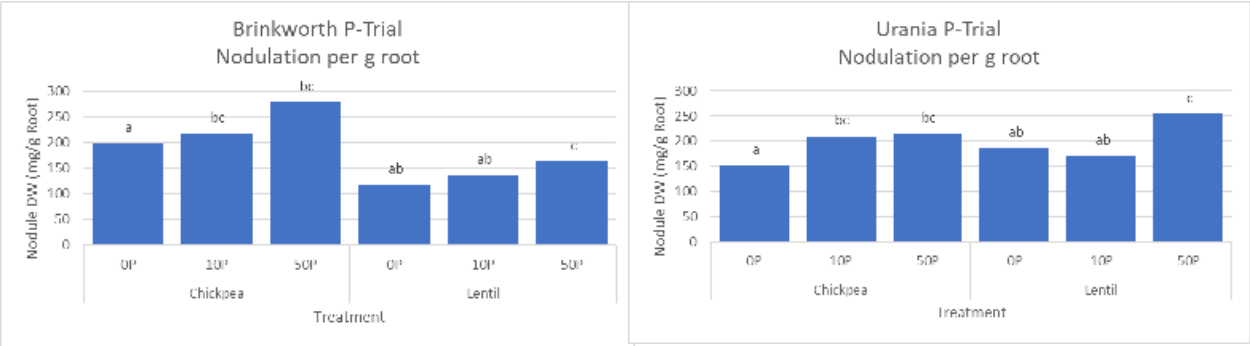

Figure 1: Nodulation dry weights per gram of root for plant samples taken in treatments consisting of 0P, 10P and 50P for chickpea and lentils at both sites. Different letters denote values are significantly different ($p < 0.05$).

Grain yields:

In terms of grain obtained at maturity, the response profiles for both chickpeas and lentils at both sites were erratic mainly due to the poor finish to the season and significant wind events which meant crops were flattened, reducing harvestability (photo 1 of Supplementary data). Pulse yields at Brinkworth were very low and in combination with site variability responses to P were hard to decipher (table 2). Pulse yields at Urania were also poor compared to the yields obtained for wheat which could have been attributed to the delay with harvest (due to rain) which meant there was a too long a time period between desiccation and harvest (table 2).

Table 2: Comparative grain responses of chickpea, lentil and wheat to applied P at both sites and the corresponding optimal P required to reach maximum yields.

Site	Crop	Grain yield (t/ha) control	Grain yield (t/ha) Maximum	Relative yield (%)	Optimal P (kg/ha)
Brinkworth	Chickpeas	0.339	0.498	68	5
	Lentils	0.088	0.121	72	5

	Wheat	1.570	1.770	89	NR
Urania	Chickpeas	1.180	1.220	97	NR
	Lentils	0.809	0.927	87	5
	Wheat	4.264	5.147	83	16

Nitrogen fixation measured by natural abundance

Prior to harvest (peak biomass) natural abundance measures were performed by collecting pulse plant samples and reference canola plants grown in the same plot. There was a significant difference in the total amount of N fixed between standard P rates (10 kg P/ha) and higher P rates for lentils at Urania, with approximately 40 kg/ha more fixed in the latter (See supplementary data). Trends with N fixation generally increased with P rate for Urania but less so for Brinkworth which resulted in no significant differences. The unfavorable finish, low yields could have resulted in less N fixation occurring at Brinkworth and sampling also occurred behind schedule due to do the quick finish of the pulse crops.

Nitrogen fixation with nodulation:

Even though trends of N fixation with P rates were harder to decipher there was a highly significant relationship between nodulation counts and the amount of N fixed highlighting the importance of maximizing biomass growth which in this case was generated for applying optimal P rates (figure 3).

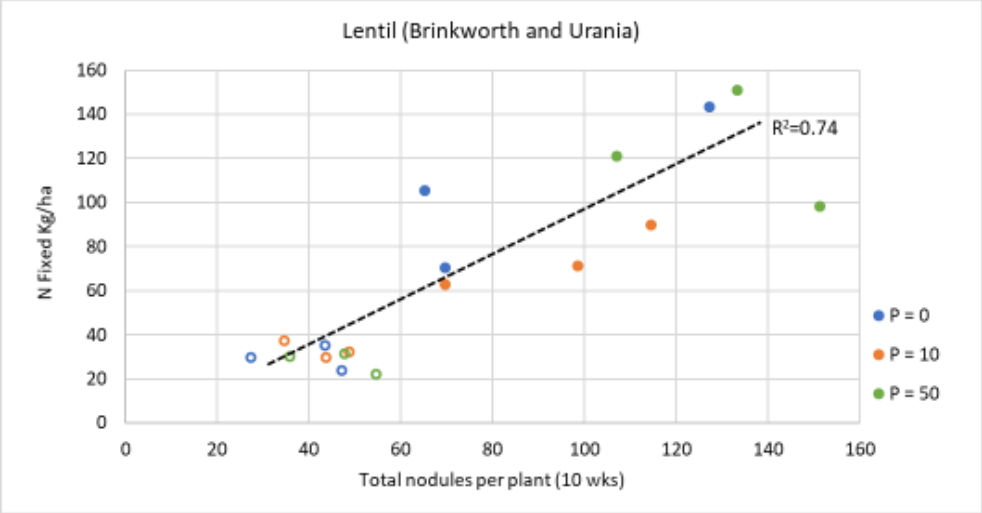

Figure 3: Relationship between lentil nodulation counts at both sites for three different P treatments (0P, 10P, 50P) and the amount of N fix through natural abundance methods. Solid circles represent Urania and open circles represent Brinkworth.

Economics:

Simple economic analysis for both pulse crops at both sites which include the cost of applied P treatments, income from corresponding grain yields, conversion of the amount of N fix into a urea conversion revealed that low P rates (5-10P) produced the highest gross margins for both

crops at Brinkworth (see supplementary data). This was mainly due to the poor returns from low grain yields. At Urania, 10P produced the highest gross margin for chickpea but 20P was the highest gross margin treatment for lentils. It is important to consider that this economic analysis uses an initial estimate of the amount of N fixation and no consideration of the economics resulting from the performance of the next crop in rotation.

Crop P uptake:

Crop P uptake measurements were performed by measuring grain P contents for each P treatment and crop. This dataset gained importance given the uncertainty of grain yield response data which was caused by climatic issues previously discussed. Significant increases in grain P uptake occurred for most crops at both trial locations. The only exception was wheat at Brinkworth which might have been an artefact of using Pasture King as the P source (see previous discussion). Stronger relationships between P rate and grain P uptake occurred at Urania and followed closer the trends of vegetative responses to applied P. High P rates were required to maximise grain P uptake with both pulse crops requiring a larger amount of P applied to reach maximum compared to wheat. The P uptake data for wheat at Urania match closely with the grain yield data which could be used as a control and highlighting that increases in grain yield for chickpea and lentils did occur. Please refer to supplementary data for detailed results.

Soil mineral N post-harvest

All pulse plots from both sites were sampled (0-10cm) and analysed for mineral N values post-harvest (Brinkworth – mid December, Urania – mid January). No significant differences ($p > 0.05$) were obtained between treatments at both sites due to sample variability but increasing trends in soil nitrate values were observed with increasing P for lentils (see supplementary data). Minimal summer rainfall and the relative quick sampling times after harvest potentially meant that the sampling hasn't captured the full mineralization potential of the pulse crops which would occur prior to the next crop in rotation for 2019.

Conclusions Reached &/or Discoveries Made (Not to exceed one page)
Please provide concise statement of any conclusions reached &/or discoveries made.

In season assessments showed higher P requirements for both pulse crops (particularly lentils) compared to wheat.

The increase in pulse biomass with increasing P rates coincided with increases in both nodule number but also nodule weight per gram of root.

Benefits from optimizing pulse biomass growth occurred at P rates higher than what is considered district practice for these crops.

Later season assessments (due to seasonal conditions) meant that the early season increases in yield didn't translate to grain.

Nitrogen fixation measured by natural abundance were highly related to measured nodule number particularly for lentils.

Grain P uptake results supported early vegetative responses and confirmed the higher P requirement of both pulse crops to maximize grain P uptake.

Soil mineral N assessments taken soon after harvest revealed an increasing trend of soil N with increasing P applied particularly for Lentils.

The form of P applied is going to be key in obtaining the right balance of higher P inputs but keeping soil N levels low to ensure peak pulse performance in terms of both yields and N fixation.

Intellectual Property

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

This project has been focused on tweaking current agricultural practices to maximize Pulse production on low P soil types and therefore commercialization opportunities are low.

IP generated from this project and the following work (AS219) will be owned between Agronomy Solutions, SARDI and SAGIT.

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 of the project in a dot point form suitable for use in communications to farmers;*

Please refer to the conclusions reached section for the major findings in dot form which we think are suitable for use in communications to farmers.

- *A statement of potential industry impact*

Growers are potentially not fulfilling the potential of growing pulses due to lower yields and resulting N fixation due to inadequate application of P on selected soil types. Naturally growers tend to reduce the inputs of P as they don't want to increase the background soil N levels which could affect the efficiency of pulses to fix N for future crops. This project has shown that for maximum pulse vegetative production that higher P rates are required compared to wheat. At these higher P rates greater nodulation and N fixation can occur and therefore the initial greater investment related to higher P applications is a two- or three-year return phase with extra soil N pools. Further work is underway that will provide economic analysis to the benefits of increasing P rates when growing selected pulses. The work will also help communicate the potential trade offs of increasing soil N with high analysis fertilizers (MAP, DAP) which is the

most logical option to increase soil P levels. Product evaluation with the following work will allow growers to have a greater understanding of products are available for them to use.

- *Publications and extension articles delivered as part of the project;*

These findings are relatively new but has shown considerable interest in the grower community.

Two field walks to the Urania site, one by an Ag bureau and the other by Landmark sparked significant interest in the trial.

Tweets regarding the trials and results from the nodulation counting received significant traction

A paper was produced and presented at the recently held 2019 Agronomy Conference.

Results were presented at the Landmark agronomy conference held in February.

- *Suggested path to market for the results including barriers to adoption.*

Communication of this projects results plus findings from AS219 will be continually achieved through our networks to achieve increased awareness of the issue and adoption of greater P nutrition for pulses.

Barriers for adoption that we can see would be that if growers only have access to MAP or DAP that the associated increase in N with these fertilizers by targeting increasing P inputs actually suppresses pulse nodulation and fixation and potentially yields.

POSSIBLE FUTURE WORK

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

Our research priorities in the area have been addressed with a newly funded SAGIT project AS219.

In this project we aim to assess the P requirements of Chickpea, Lentil and Faba bean compared to wheat. We are assessing the impact of higher P rates on nodulation and N fixation and quantifying any benefit of increased soil N pools with following crops (wheat and canola) to be sown in years 2 and 3.

Using Lentils as the key indicator of P efficiency we are also exploring the opportunities that growers have in terms of fertilizer products to increase applied P but also increase background N and assessing the impact of increased soil N on potential N fixation of the Lentil.

AUTHORISATION
Name: Sean Mason
Position: Research Agronomist - Director
Signature:
Date: 31st August 2019

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.