Office Use Only

Project Code	
Project Type	

FINAL REPORT 2018

Applicants must read the *SAGIT Project Funding Guidelines 2018* 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 :	AKI116

PROJECT TITLE (10 words maximum)
Improving Nitrogen Use Efficiency via Legumes in High Rainfall Cropping

PROJECT DURATION

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

Project Start date	1st March 2016					
Project End date	28th February 2019					
SAGIT Funding Request	2015/16		2016/17		2017/18	

PROJECT SUPERVISOR CONTACT DETAILS

The project supervisor is the person responsible for the overall project

Title:	**First Name:**	**Surname:**	
Mrs	Jenny	Stanton	
Organisation:			
Agriculture Kangaroo Island			
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:
Mr	Darren	Keenan

Organisation:
Agriculture Kangaroo Island

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

The conclusion of a three year project investigating the nitrogen fixation capabilities of four commonly grown legume species (sub clover, field peas, faba beans and lupins) grown on Kangaroo Island revealed they were equally effective. The legumes provided an average 86kg/ha of nitrogen (equivalent to 187kg urea) to the subsequent canola crop bestowing an additional 1t/ha yield advantage. However the nitrogen feeding effect 2 years after the legumes were sown was less conclusive inferring little residual benefit.

The soil moisture monitoring revealed that the non-legume control linseed used more moisture and from a greater depth, than faba beans, canola and oats. In fact, the linseed was able to dry the soil profile out in a decile 10 year (812mm) offering a potential solution to growers in high rainfall zones wishing to dry their soil profile.

See also 'Take Home Messages' under "Application/Communication of Results" below

Project Objectives

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

The aim of the project was to determine if there were any differences between the various legume species grown on Kangaroo Island and to ascertain how much nitrogen they fixed/captured and for how long they fed to subsequent crops. Concurrently, how much N was lost through leaching or denitrification?

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.

Overall the project provided some supporting data to growers on KI which is being reflected in broad acre yields. Prior to the advent of beans in the cropping rotation, the average canola yield was ~1.8t/ha. For the past few seasons (2017, 2018) some farmers have averaged 3t/ha canola crops echoing the results from this trial. However it must be pointed out that these two seasons were deciles 2-3. By contrast, 2016, the first year of the trial was a decile 10 and canola yields averaged 1.2t/ha. This extremely wet season presented issues for the trial in terms of weed control especially the water weeds such as lesser loosestrife. This was most evident in the poorly competitive crop – linseed and because of a lack of access to a small plot sprayer these weeds were left unchecked. Fortunately Ag KI has since received funds from SAGIT to build a plot sprayer for future research. The wet year also meant ryegrass was able to continuously germinate throughout the season setting up a seedbank for future years.

Finding answers as to how much leaching or denitrification occurred was a bit ambitious with a small budget. The Solusamplers provided an indication as to how much nitrate was in the soil solution but I was unable to quantify an exact amount. It was simply unrealistic to gain denitrification data without purchasing gas capturing chambers.

Personnel involved in the project:

Will Stanton – land owner and farmer co-operator. Machinery mechanic

Leighton Wilksch – soil moisture probes and weather station installer and intellect

Ella Putland – Year 12 work experience who assisted in pegging out and sowing the trial in Year 1.

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.*

No.	KPI	Date to be completed
1	Nodulation Scores	Completed
2	Grain Yields of Legumes + Linseed	Partially Completed#
3	Deep nitrate tests per plot prior to sowing	Completed
4	Canola yields per plot	Completed
5	Deep nitrate test per plot prior to sowing	Completed
6	Cereal yield per plot	Incomplete*

- KPI's 1, 3-5 were successfully completed and the results can be found in the 'Technical Information' below. These KPI's provided important data sets for interpretation of the results.
- #No.2 - Grain Yields. Local wildlife sought out the 4 plots of lupins amongst the broad bean crop and resultantly no grain yield was obtained.
- *No.6 - Cereal yields per plot could not be taken due to severe lodging of the oat crop and limitations of Ag KI's 1970's plot harvester. Strong wind on KI laid the oat crop in a westerly direction whilst the plots were aligned in a north south direction meaning there was very little chance of getting a realistic yield result. Photo below.

Lodged 2018 oats in a westerly direction

Technical Information (Not to exceed **three** pages) = 3 of writing + graphs

Provide sufficient data and short clear statements of outcomes.

The trial site was located for the 3 years on the Stantons property Caledonia, 989 Timber Creek Road in Macgillivray. The soil was typical of those used for cropping on the plateau - sandy loam over clay. The site was limed in April 2016 and a soil test (0-10cm) immediately before sowing in May revealed a pHCaCl2 6.1, Colwell P 27mg/kg, PBI 195, Colwell K 176mg/kg, Sulphur 26mg/kg and Organic Carbon 2.6%.

In 2016, two paired 80cm soil moisture probes (SMP's) were installed in a faba bean and linseed plot connected to a weather station. Accompanying these SMP's was a Hydra Probe installed at 80cm which measured ion content, soil temperature and soil moisture. These Hydra Probes tracked and logged the nitrate movement through the 80cm profile.

In order to monitor the nitrate released into the soil water by the various crop species, Sentek Solusamplers – ceramic water collecting tubes, were installed to a depth of 30cm in 2017. These were removed at the end of the 2017 growing season.

Weather data was also recorded at the site with a rain gauge, air temperature & humidity and wind speed & direction sensor. These sensors were logged and the data uploaded every 15 minutes.

The site received 812mm of rain in 2016 (Decile 10), 515mm in 2017 (Decile 2-3) and 518mm (Decile 2-3) in 2018 compared to the long term average of 530mm.

Results

TABLE 1: **2016 Measurements**

2016 Crop	Nodule Score	Dry Matter (t/ha)	Grain Yield (t/ha)
Linseed	0	1.98 c	0.7
Faba Beans	2.5 b	2.74 bc	3.27
Peas	3.3 a	6.53 a	3.18
Lupins	3 ab	3.81 b	NA
Sub Clover	3.4 a	2.58 bc	NA

2016 Results

The peas, lupins and sub clover shared similar nodulation scores (Table 1). A score over 3 is deemed adequate. The nodulation score of the faba beans although not statistically different from the lupins fell shy of the adequate threshold of 3. It was likely that the pHCaCl2 4.8 at the 4-8cm sowing depth was the reason behind the lower nodulation score.

Due to the wet conditions linseed was unable to compete against the tirade of water weeds that overtook the plots. Consequently it gave the lowest biomass yield of 1.98t DM/ha and grain yield of 700kg/ha.

A lupin yield was not obtained due to wildlife eating the 4 lupin plots before harvest.

TABLE 2**: Starting Deep Soil N**

2016 Crop	2017 N (kg/ha)	2018 N (kg/ha)
Linseed	16.8b	23.2a
Faba Beans	43.8a	32.4a
Peas	39.4a	25.8a
Lupins	38.8a	39.0a
Sub Clover	37.7a	35.0a

TABLE 3**: Grain Yield, N Uptake & Quality**

2016 Crop	2017 Canola (t/ha)	2018 Biomass N (kg/ha)	2018 Oat Grain Protein (%)
Linseed	2.16b	92a	11.15a
Faba Beans	3.13a	104a	11.85a
Peas	3.63a	100a	11.70a
Lupins	3.13a	108a	12.05a
Sub Clover	3.04a	108a	11.80a

2017 Results

All the legumes sown in 2016 shared similar starting soil nitrogen levels to 35cm depth compared to the linseed control (Table 2) inferring that they all fixed a similar amount of N in 2016. The average starting N of the four legumes was ~40kg/ha being ~23kg/ha higher than the linseed control. (Soil was sampled to 35cm due to constraints of man power versus B horizon heavy clay)

Similarly, the canola grain yield at the end of the season from the plots of the four legume species was statistically different from the linseed control (Table 3). There are two likely reasons for this outcome. Obviously the linseed being a non-legume did not fix any N in 2016 and thus the 2017 canola crop had less available N. Secondly, the 2016 linseed plots had a higher ryegrass burden attributable to the poorly competitive nature of linseed which consequently allowed numbers to build up. In high numbers ryegrass is a strong competitor and therefore stole nutrients, moisture and sunlight from the canola crop reducing yield.

Based on the canola grain yields in Table 3, it could be concluded that growing any of the four legumes conferred ~1t/ha canola yield advantage over the linseed control.

The site received 106kg N/ha as in-crop fertiliser, which assuming a 50% efficiency meant the crop took in 53kg N. Typically 80kg N is required to grow 1 tonne of canola. The average yield of the canola grown on the legume stubbles was ~3.23t/ha, which meant 258kg of N was utilised by the canola. If 53kg N was supplied from the bag, the remaining 205kg came from the soil N pool.

Likewise, the canola grown on the 2016 linseed stubble yielded ~2.16t meaning it required a total of 172.8kg N with 53kg applied from the bag = 119.8kg N came from the soil N pool.

Therefore it could be deduced that the difference between the linseed and the legume soil N pool was the amount of N fixed by the legumes (205.4kg – 119.8kg) = 85.6kg N [= 186kg urea], which happens to be approximately the amount of N required to grow 1t canola. Isn't it great when the numbers align!

2018 Results

The starting deep N tests taken two years after the legumes were sown showed large variability amongst the different legume plots but no statistically significant differences (Table 2). This was also reflected in the in-crop biomass nitrogen uptake measurement taken in August (Table 3). Unfortunately strong wind in December laid the oat crop flat in a westerly direction making it impossible to harvest with the host organisations plot harvester to produce a reliable grain yield. Instead, grain was collected from each plot and analysed for protein (Table 3) but once again no statistical differences could be found.

Soil Water Nitrate Readings

Soil water nitrate readings were taken fortnightly from each plot from June 1st 2017 ceasing on October 2nd 2017.

The soil water nitrate (NO_3) levels decreased throughout the season for all crop types (Figure 1). In agreement with the results of the starting deep soil N in 2017, (Table 2) linseed had statistically lower soil water NO_3 readings than the other crops until the second to last reading on 19th September.

With the exception of the first soil water nitrate reading taken on 1st June, for the remainder of the season the nitrate readings for the lupins, sub clover, peas and faba beans were statistically similar.

Soil Moisture Probes Summary

2016

Linseed used significantly more moisture, from a greater depth, than the faba bean plots. Linseed roots reached 60cm, whilst the faba beans only reached 40cm at most. Saturation of the profile occurred for many weeks of the season, and the lower layers in the faba bean plots were still near on saturation in Dec 2016. Despite 2016 being a Decile 10 rainfall year, by years end, linseed had essentially dried out the profile.

2017

More moisture was extracted from the 2016 faba bean plot compared to the linseed plot. This was likely due to the fact there was more moisture available in the faba bean profile residual from 2016. Interestingly, at the time of the deep N soil sampling, the faba bean plots appeared to have the wettest soil samples whilst the linseed had the driest soil.

At the end of the growing season there was more total moisture still left in the faba bean plots compared to the linseed, i.e. the canola did not extract all the residual moisture left from 2016, so there was in effect, still residual moisture left for crop in 2018.

The ion sensors showed there was more net extraction of ions from the 2016 faba bean plots compared to the 2016 linseed plots.

2018

The oats drew both the linseed and faba bean sites back to a level playing field. There appeared to be no increased soil moisture or ion content in either plot. There was a saturation event during early August that saw the highest levels of soil moisture since the project began. Since that point, a dry spring saw the moisture extraction in both plots draw down to a similar level. Interestingly, the oats did not extract as much moisture out of the profile as the linseed did at the end of 2016.

In regards to the ion content, it is a similar story with the levels being the same in either plots throughout 2018; in effect showing that there was no residual elevated ion content left over from the 2016 faba bean plots.

Soil Probes Summary

There were differences between the faba bean and linseed in regards to both soil moisture and ion content. Looking at the summed graph from the start of 2018 (Figure 2), it appears that there was slightly elevated levels of moisture still residual from the faba beans in 2016, even after the canola in 2017. This goes in line with the thinking that faba beans are not as deep rooted as linseed and thus the faba beans left behind soil moisture. The canola crop of 2017 had a good growing season with enough winter precipitation to allow it to reach maturity without extracting all of the deep soil moisture reserves. It takes the second season's crop of oats following the faba bean plots to see the moisture levels even out when compared to the linseed plots

In regards to the ion content, the sensors showed a slightly elevated ion content following the faba bean plots towards the end of 2016 (Figure 3). The coarseness of these readings makes it a bit hard to confidently assess the differences, but there was an apparent increase in ion reduction of the faba bean plots (extraction of nitrates?) from the canola crop from mid September to early November 2017. By the time 2018 starts, the ion levels were very similar and mirror each other during the 2018 season.

In short, faba beans left behind more moisture and ions (nitrates) compared to linseed. This was of apparent benefit to the following canola crop and in the case of the soil moisture, may have been of benefit in the second year crop.

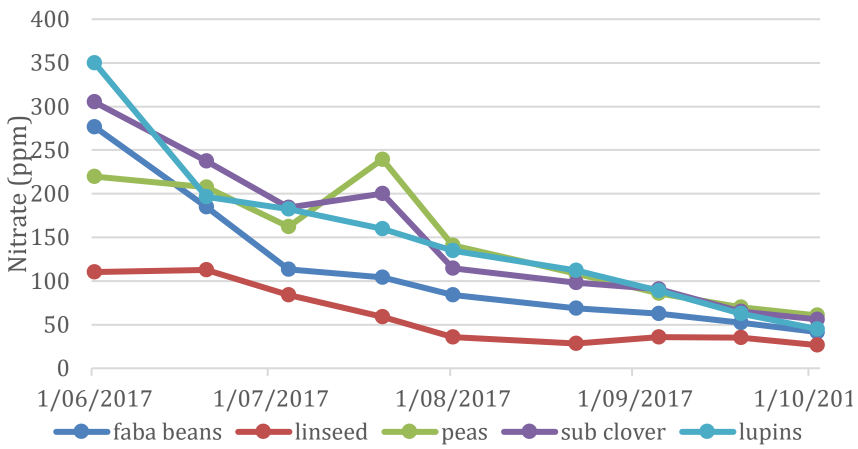

FIGURE 1: Soil water nitrate readings taken throughout the year 2017

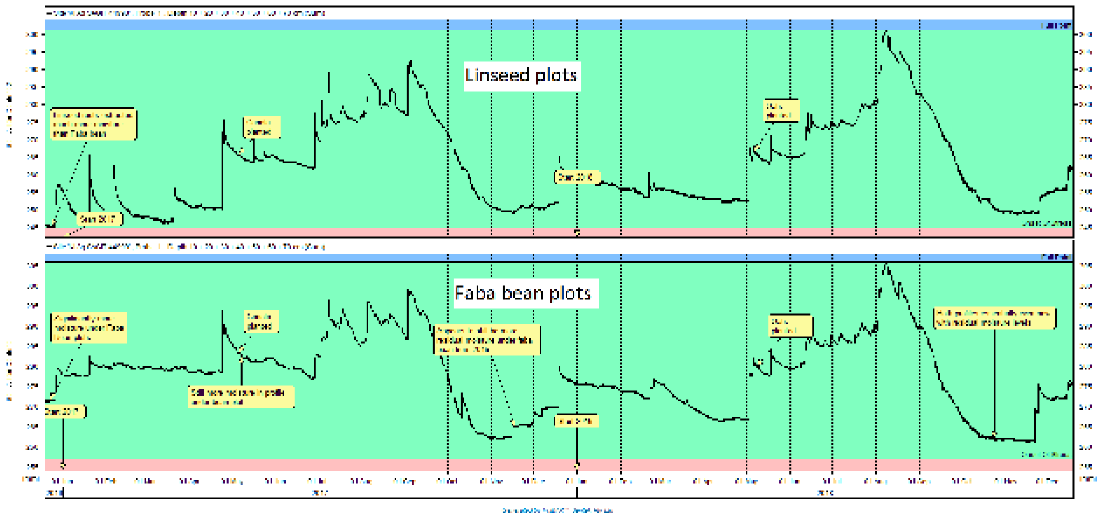

FIGURE 2. Three years of Soil Moisture Graphs. Top Linseed. Bottom Faba Beans.

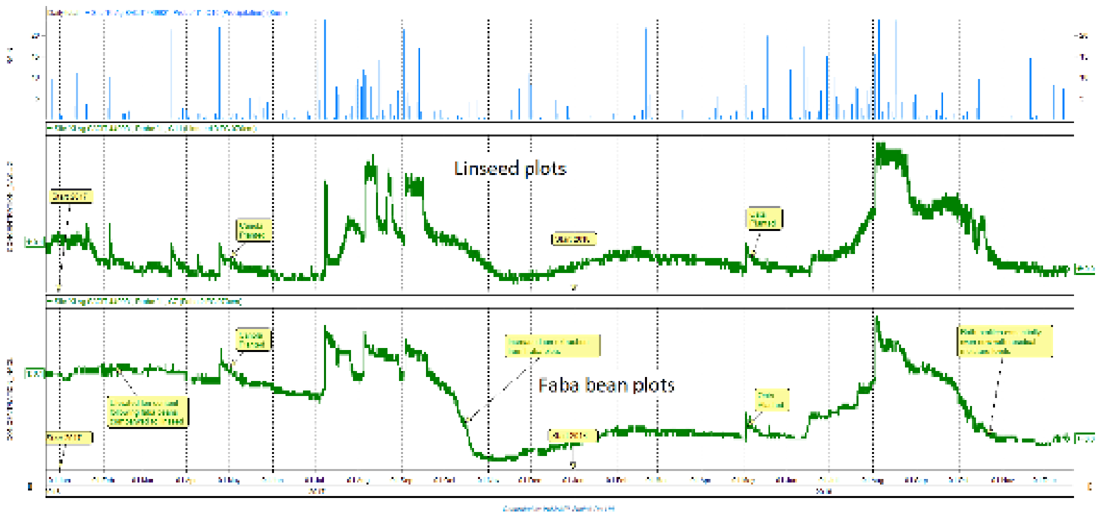

FIGURE 3. Three years of Soil Ion Content graphs at 70cm. Top: Rainfall. Middle: Linseed. Bottom: Faba Beans

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

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

Trial work on KI looking at the nitrogen fixing capabilities of commonly grown legume species (beans, peas, lupins and sub clover) has found that they were all equally effective, capturing ~86kg/ha of N which led to a 1t/ha yield advantage in canola the following year. However, the nitrogen residual feeding effect only lasted 1 year. The trial highlights the importance of farmers doing everything within their control to ensure rhizobia survival and hence adequate nodulation of legumes.

Interestingly, soil moisture probes at the site showed linseed was able to dry a soil profile in a decile 10 year (812mm rainfall). This has potential extension into industry for farmers in high rainfall zones wanting to dry their soil profile after a wet year or if suffering from slug problems.

Intellectual Property

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

Nil to report

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.

Take home messages

- All the legumes sown; peas, lupins, sub clover and faba beans were equal in terms of their nitrogen fixing capabilities, reflecting the importance of having well nodulated legumes.
- The average amount of N fixed by the legumes was calculated at ~86kg/ha =187kg urea.
- In year 2, this residual N gave rise to a ~1t/ha canola yield advantage.
- In year 3, no differences in residual nitrogen from the legumes was measured.
- Linseed extracted more moisture, from a greater depth, than the faba beans in the same year and all subsequent crops – canola and oats.
- The linseed was able to dry the soil profile in a decile 10 year (812mm rainfall). This is a potential solution for farmers wanting to dry out their soil profile.
- Two years after growing linseed, soil moisture levels were even.

Statement of Potential Industry Impact: *see "Conclusions Reached &/or Discoveries Made" above*

Publications and extension articles:

- Yearly reports published in the Ag KI Trials Results Booklet (2016, 2017, 2018).
- Field day held on site on 18th October 2016 and attended by 23 farmers/consultants/agronomists.
- Field day held on site on 23rd October 2017 and attended by 14 farmers/consultants/agronomists.

POSSIBLE FUTURE WORK

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

The finding that linseed extracted more moisture and from greater depth than faba beans, canola and oats has relevance to work conducted by Michael Nash who showed that linseed reduced the build-up of slug numbers (https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2016/02/new-insights-into-slug-and-snail-control). A dry profile means that slugs are less inclined to breed and hence there is a reduction in numbers. In other words, including linseed in the rotation could be considered a cultural control option in controlling slugs.