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	**:**	H116

PROJECT TITLE (10 words maximum)
Long-term cropping systems trial: Effect on soil biology and nitrogen mineralisation

PROJECT DURATION

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

Project Start date	1st July 2016					
Project End date	30th June 2019					
SAGIT Funding Request	2019/20		2020/21		2021/22	

PROJECT SUPERVISOR CONTACT DETAILS

The project supervisor is the person responsible for the overall project

Title:	**First Name:**	**Surname:**

Organisation:
Hart Field-Site Group
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

Seeding systems are an integral part of any modern farm and choosing the right system has implications in terms of financial outlay and production. In the year 2000 the Hart Field-Site Group (HFSG) purchased their own land and saw the opportunity to set up a commercial scale, long-term trial focusing on the then current and newer seeding systems.

Twenty crops later the overall message from the trial has been a good one, in that there is no one seeding systems that gives consistently higher yields. In the current project soil biology and nitrogen mineralisation was a key focus to understand the impact of seeder type and stubble management. There were measured differences in abundance (how many are there) and diversity (who is there) in the soil microbial community. However, there was not consistent differences between seeder types, as often sampling depth or nitrogen management had greater impact.

Project Objectives

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

- To demonstrate the long-term effects of contrasting cropping systems and nitrogen fertiliser inputs.
- Measure the mineralisation, activity and genetic diversity of microbial communities under cropping systems and nitrogen fertiliser inputs.

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.

This project continued to demonstrate the long-term effects of contrasting cropping systems and nitrogen fertiliser inputs on crop growth and yield. The other objective achieved in this project was the assessment of soil nitrogen dynamics (including microbes associated with nitrogen turnover) in each treatment.

Personnel involved during the project:

- Sarah Noack, HFSG was responsible for coordinating the project steering committee, trial development, data collection, statistical analysis and preparation of written and field-based extension activities. Her role also included coordinating growers and subcontractors for the delivery of all trials and laboratory components.
- Michael Jaeschke, Matt Dare, Justin Wundke, Tom & Ashlee Robinson and Peter McEwin were grower participants. Among them they provided use of equipment for seeding / spraying and harvesters to establish stubble treatments (e.g. stripper front harvester for the disc system).

- Expert advice on soil biology and access to specialised methodology / techniques was provided through Dr Gupta Vadakattu, CSIRO Agriculture, Waite campus. His laboratory technicians Stasis Kroker and Marcus Hicks also assisted with laboratory methods. Dr Vadakattu investigates aspects of genetic diversity and functional capability of soil biota in agricultural soils. As part of the collaboration between the HFSG and CSIRO, Dr Noack was able to process the soil samples related to 'soil biology' as a research visitor at CSIRO, Waite.
- John Nairn, Phil Rundle and Patrick Thomas, SARDI Clare assisted with in-season UAN applications for the 'high' nutrition treatments, spraying plot ends and harvesting strips to obtain grain yield.

Difficulties encountered

In 2017 we incurred a delay in the gene abundance analysis. The samples had "inhibition" which means only 20-30% of the DNA was recovered from the original sample. All samples had to be re-extracted and purified to achieve a higher extraction efficiency. This was a minor delay and Noack spent a few additional days at CSIRO, Waite beyond what was initially anticipated.

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.***
Trial planned, three different seeders coordinated to sow the trial.	Y achieved each year	
Soil and plant assessments performed, trial harvested and all results analysed.	Y achieved each year	
Trial results written up for communication and widely publicised.	Y achieved each year	
Field extension activity with Roger Armstrong	Y achieved in 2017	
Field day session cropping systems and soil biology	Y achieved in 2018	

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

Provide sufficient data and short clear statements of outcomes.

Summary of crop rotation

The current project built of the success of Hart's long-term seeding systems trial, established in 2000. For the three cropping seasons covered by this project the trial was sown to wheat, wheat followed by field pea.

Grain yield and quality

One of the main outcomes from this trial has been the lack of consistent performance in terms of grain yield from any one particular seeding system. In the last three seasons of the project (Table 1), two seasons have shown differences in grain yield among the seeding systems. In seasons where yield differences were observed, the strategic and disc alone or together outperformed the no-till treatment.

The cooler and wet finish to 2016 (356 mm GSR) allowed good grain fill and as a result the high nutrition out yielded the medium across all seeding systems on average by 1.2 t/ha. Similarly, the higher nutrition treatment had a higher protein content but, overall N was limiting and protein levels were low (data not shown). A yield advantage was observed in the disc system in 2017 averaging 4.1 t/ha, compared to the no-till and strategic systems which on average yielded 3.5 t/ha and 3.4 t/ha, respectively (Table 1). This could be linked to the disc treatments increased stubble load reducing the effects of evaporation throughout the growing season when rain events were limited. A dry 2018 (160 mm GSR) resulted in low field pea grain yields ranging from 0.7 t/ha to 1.0 t/ha. There were small differences in grain yields among the seeding systems.

Table 1. Grain yield (t/ha) for all seeder and nutrition treatments for the past three seasons.

Seeder type	Fertiliser strategy	2016 Wheat	2017 Wheat	2018 Field pea
		Grain yield (t/ha)		
Strategic	Medium	4.8	4.8	0.8
	High	5.9	5.9	0.7
No Till	Medium	4.2	4.2	0.9
	High	5.8	5.8	1.0
Disc	Medium	5.0	5.0	0.7
	High	5.9	5.9	0.7
	LSD nutrition (P≤0.05)			ns
	LSD seeder (P≤0.05)			0.2
	LSD seeder x nutrition (P≤0.05)	0.3	0.3	ns

Soil biology and nitrogen

The soil microbial biomass is a storage pool for nutrients. Changes in the amount of microbial biomass due to management and seasonal variation can have a significant impact on microbial immobilisation and net N mineralisation. In Australian agricultural soils, microbial biomass carbon accounts for 1.5% to 3.0% of soil organic carbon and microbial biomass N 2% to 5% of soil total N. The amount of microbial biomass varies with soil type and region (Table 2) and is influenced by crop rotation, seeding systems and stubble management practices that the quantity and quality of residues.

In 2016 (post canola) and 2017 (post wheat) soil was collected from Hart's long-term seeding systems trial and analysed for microbial biomass carbon and N supply potential. The microbial biomass carbon ranged from 395 – 986 kg C/ha which is similar to the Minnipa and Appila soils in SA (Table 2). The N supply potential ranged from 19 – 47 kg N/ha across the treatments sampled. This is in line with many of the locations in Table 2. Interestingly, there was little difference among seeding systems in terms or their mineralisation potential (data not shown). Both sampling depth and nitrogen fertiliser history resulted in the largest differences in nitrogen mineralisation potential.

Seasonal conditions at Hart in 2016 and 2017 were contrasting resulting in different amounts of nitrogen mineralisation. In 2016 the site received above average rainfall (365 mm GSR) and N mineralisation would have been close 50 kg N/ha (Table 2). In 2017, Hart only received 191 mm of GSR and the soil surface experienced long dry periods. It is expected that net mineralisation was lower (i.e. less than 20 kg N/ha) compared to the N supply potential which is measured under 'optimal' (moisture and temperature) conditions. This understating of the N supply potential can be used to assist with in-season N fertiliser calculations.

Table 2. Amount of microbial biomass carbon, nitrogen immobilisation and supply for various locations and soil types in South Australia (Gupta, 2016).

Location	Soil type	MB-C (kg C/ha)	N immobilisation potential (kg N/ha)	N supply potential (kg N/ha)
Hart, SA	Clay loam	395 - 986		19 - 47
Appila, SA	Loam	450 - 585	32 - 42	35 - 45
Karoonda, SA	Sand and sandy loam	150 - 300	15 - 25	10 - 35
Streaky Bay, SA	Calcarosol - sandy loam	210 - 400	15 - 30	20 - 50
Minnipa, SA	Calcarosol - loam	560 - 710	40 - 51	42 - 56

Soil available nitrogen was measured in autumn across all three seasons and ranged between 59 kg N/ha to 190 kg N/ha (Figure 1). In 2016 and 2017 the high nutrition treatment had accumulated on average 70 kg N/ha more compared to the medium nutrition treatment. This effect was not carried over in 2018 where the high nutrition treatment had 97 kg N/ha and 78 kg N/ha for the medium treatment. The lack of difference can be explained by high wheat protein levels (6.7% protein in medium versus 10.8% protein in the high) in the high nutrition treatment in 2017 extracting more nitrogen from soil reserves. Low summer rainfall would have also reduced soil nitrogen mineralisation and contributed to reduced soil available nitrogen pre-seeding.

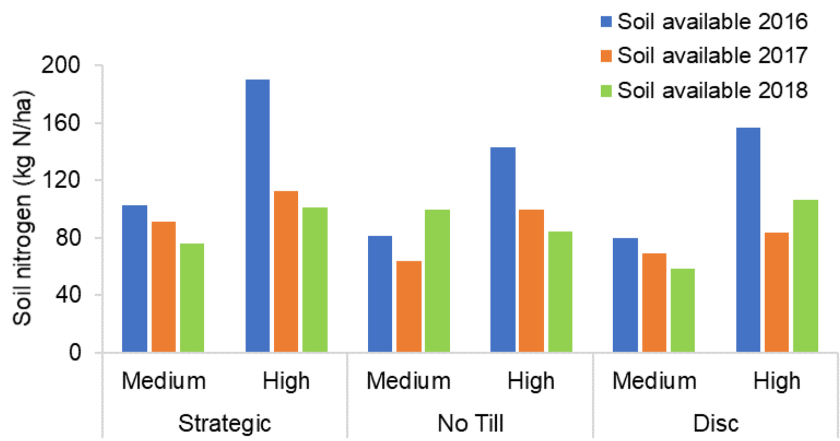

Figure 1. Soil available nitrogen (kg N/ha) pre-seeding for Hart long-term seeding systems trial from 2016 – 2018.

There were observed differences in the microbial community between seeding systems. This was shown in both 2016 and 2017 soil samples (Figure 2). The results indicate there are different microbial communities under the seeding systems which is a result of carbon (stubble) availability and soil disturbance caused by the different seeders. Across the two seasons there are also differences in the sampling depths for each seeding system. This is due to the different levels of disturbance / soil throw created, where strategic > no-till > disc seeding system.

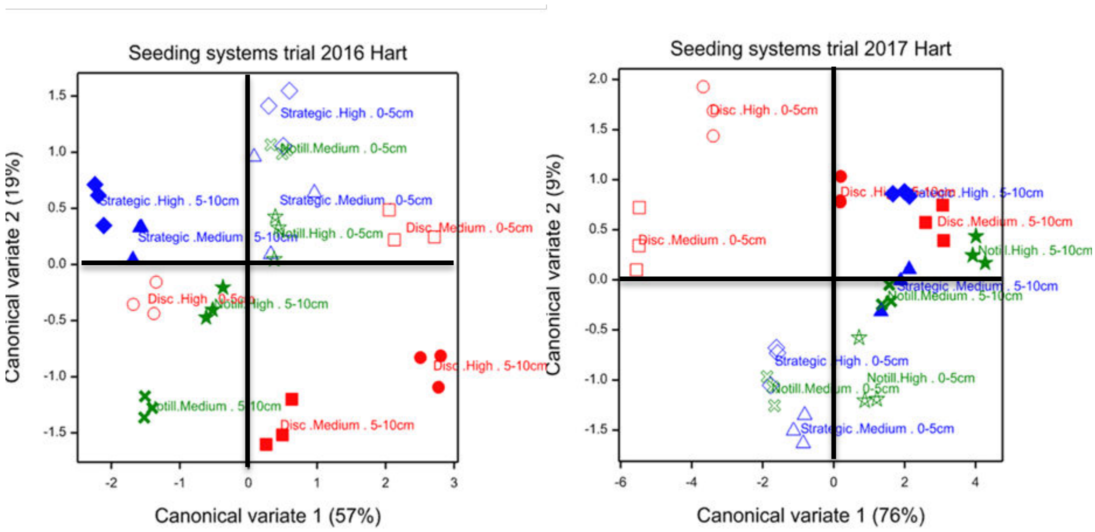

Figure 2. Canonical variate analysis of catabolic diversity profiles for microbial communities in surface soils after 18 years of different seeding systems and nutrition, following canola 2016 (left) and following wheat 2017 (right).

Gene sequencing data (not shown, refer to progress report 2019) provided more information into the diversity of fungi and bacteria in the seeder and nitrogen treatments. Large differences within fungi families compared to bacteria were observed in all treatments. In total 2,044 operational taxonomic units (OTU) of fungi were identified in the Hart soil samples. Of these 50% (1,082) were common in all three seeder types. However, 7-9% of OTUs were only present within a single seeding system. In soil microbial terms this is a large difference. In comparison there were few differences in bacterial diversity among seeding systems with 91% of OTUs detected in all samples. Within fungi there were clear differences between seeding systems at the family level. These differences are due to the different levels of disturbance / soil throw created, where strategic > no-till > disc seeding system. It is expected the extensive hyphal networks created by fungi are sensitive to these changes in soil disturbance. These differences have implications to both the pathogenic (e.g. Rhizoctonia, Fusarium, Common root rot) and beneficial fungi (e.g. mycorrhizae, disease suppressive).

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

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

The overall outcome from the seeding systems trial has been a good one for farmers. No particular system or nutrition regime has given a consistently higher yield which means the decision about which seeding system to use has to be for other reasons, such as weed and pest management, speed of sowing or stubble management. This result is reflected across the southern region, where a large variation now exists in stubble management and seeding strategies.

In the last decade there have been a number of molecular tools developed to increase the speed and diversity of soil microorganisms measured in soil. Across a range of management factors investigated, we found nutrient additions (nitrogen) and sampling depth were a key driver of microbial differences, followed by seeding system, (e.g. seeder and stubble management).

In 2016 and 2017 the Hart seeding system trial was sampled as part of this study. The main findings from the results were:

- The analysis of seeding systems and nutrition regime showed distinct differences in microbial communities under each treatment.
- Disc treatments were dominated by more fungi compared to bacteria.
- Within fungi there were clear differences between seeding systems. In general, the difference observed in the microbial community (e.g. how may and who is there) were attributed to the different levels of disturbance / soil throw created, where strategic > no-till > disc seeding system. It is expected the extensive hyphal networks created by fungi are sensitive to these changes in soil disturbance. These differences have implications to both the pathogenic (e.g. Rhizoctonia, Fusarium, Common root rot) and beneficial fungi (e.g. mycorrhizae, disease suppressive).
- While there are anecdotal suggestions that some seeding systems result in “better” or “healthier” soils, this study has shown in terms of nitrogen dynamics it is hard to identify one seeding system which continually outperformed another.

- Despite observed differences in the soil microbial community, nitrogen mineralisation potential across all three seeding systems was similar in both 2016 and 2017. For farmers this means all three seeding system had the potential to mineralise similar amounts of soil nitrogen in-season to the growing crop.

Intellectual Property

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

Not applicable.

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.

The HFSG have used multiple platforms to deliver information to growers from this project including large events, discussion groups, social media and other traditional communications (results articles).

- At the 2016 Hart field day the HFSG launched the "Seeding systems trial: A summary of 16 years of research" booklet. Over 200 hardcopies of the book were distributed and further copies downloaded from our website (1,074 copies as at Feb 2019). Invited guest speakers were Greg Butler, SANTFA and James Barr, Uni SA who shared some of the innovations and advancements occurring in seeding technology. Mr Butler spoke about SANTFA's work with precision planting and ultra-high pressure water jet for cutting through stubble at seeding.
- Special guest speaker Prof. Roger Armstrong, Agriculture Victoria discuss outcomes from his long-term SCRIME trial at the 2017 Hart Field Day. The session was titled "Rotations, tillage and long-term soil fertility". The trial at Longerenong (similar to Hart's) was established in 1998 and was designed to address questions relating to the effect of crop rotation and tillage system on both crops and the soil that supports them. This specific session was attended by 159 people, placing it in the top five session attendance for the day.
- Sarah Noack was joined by guest presenter Gupta Vadakattu, CSIRO speaking on soil biology and nitrogen cycling at Hart the 2018 Hart Field Day. The session was focused around a number of outcomes from this project and the GRDC stubble initiative. The soil biology session was attended by 215 people, placing it in the top five session attendance for the day.

Photos taken from the 'Soil biology and nitrogen cycling' session at 2018 Hart Field Day.

- The trial continues to be utilised by the third year University of Adelaide Agriculture students for their lectures and practical class (August 2016, 2017 & 2018).
- Other additional group's visits to the Hart Field Site have viewed and discussed the outcomes with Hart staff / board members including: ACIAR tours of growers and researchers from Morocco and Tunisia and a WA grower trip.
- Lastly, articles summarising the 2016, 2017 and 2018 results from the cropping systems trial has been prepared. These articles were released in hard-copy and freely available online from March the following season. They can be accessed here http://www.hartfieldsite.org.au/pages/resources/trials-results.php

POSSIBLE FUTURE WORK

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

The HFSG have proposed to continue the long-term cropping systems trial and provide a resource that can be utilised by growers and the wider research community. Beyond the immediate Hart community this trial has provided significant contribution to the grains research industry. Due to the long-term nature of the trial many research groups have been able to investigate processes which take years to develop.

In 2019 the HFSG submitted an application for SAGIT to continue their investment in the trial. Project H119 Long-term cropping systems trial will run from 2019 – 2021. Feedback from the SAGIT selection panel was to investigate the potential to assess soil physical properties under each treatment.