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 :	**ELD118**

PROJECT TITLE (10 words maximum)
SA HRZ Canola VRN Project

PROJECT DURATION

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

Project Start date	April 2018					
Project End date	April 2019					
SAGIT Funding Request	2019/20					

PROJECT SUPERVISOR CONTACT DETAILS

The project supervisor is the person responsible for the overall project

Title:	**First Name:**	**Surname:**	
Mr	Adam	Hancock	
Organisation:			
Elders			
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

Various multi spectral sensors were assessed for their potential to be used for creating variable rate nitrogen maps over canola in the South East. A trial site was established by Kalyx comprising of canola seeding rate, nitrogen rate and nitrogen timing at Frances to provide calibration of sensors to be used by the cooperating grower over 10ha. Images were collected at three different stages by Southern Precision Ag (SPA) using a fixed wing mounted with a Parrot Sensor, Vickery spreading contractors agreed to apply the variable rate nitrogen.

- Variable rate fertiliser application is now very accessible and affordable for growers around the South East. Services now exist offering NDVI/NDRE maps and claim to provide accurate results.
- Claims about the accuracy that each spectral sensor has on mapping and prediction of crop nitrogen requirement needs to be carefully assessed and further scrutinised.
- Due to above average rainfall during August the trial site and demo paddock become severely water logged, the trial site received significant damage to three of four replications and the paddock lost trafficability before the VR map could be applied. Results must be interpreted with caution.
- Results suggest the NDVI and NDRE have unique strengths and weaknesses when used at different growth stages, no one sensor was best suited for all situations.
- The variable rate map created for the paddock application using NDRE by SPA and built using Pix4D showed a significant amount of variability across the paddock, indicating it may be a worthwhile exercise.

Project Objectives

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

The key aim was to assess the accuracy of the NDRE and NDVI on detecting response of canola to nitrogen and to use this data to create a variable rate map over 10ha of canola which would be assessed by a yield map and pre + post-harvest deep nitrogen tests.

Various other projects currently exist or have recently finished which aim to achieve similar outcomes and so this project aims to expand on knowledge and data already accumulating.

The RBD trial site was designed to create the opportunity to collect sensor images three times during the season, mainly prior to top dressing decision making. The ten nitrogen treatments were duplicated over two seeding rates to assess how sensitive the sensors are to different plant numbers and how much this impacted the ability to model nitrogen response.

The project also aimed at assessing

- The impact crop shadowing has on the different sensors
- Learn more about the possibility of using drone's over satellites
- Aerial NDVI imagery vs hand held readings
- Assess if NDVI or NDRE is better suited to a particular timing and crop growth stage.
- Determine the growth stage with which the sensors have the strongest relationship with nitrogen response and yield.

Other objectives have also been assessed with the trial site including impact of nitrogen rate and timing on canola yield and the interaction with seeding rate. Due to the unfortunate wet weather event the opportunity has been taken to determine treatment effect on lodging and water logging tolerance.

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.

Unfortunately, not all project objectives were able to be achieved due to the inundation by above average rains during August which prevented trafficability, the cooperating grower further delayed the nitrogen application in anticipation the paddock would dry out but after further rains and August receiving 50mm above average the decision was made to apply urea with the plane which does not have VR capacity, to prevent yield loss.

Good data was collected by the multispectral sensor over the paddock and trial site before the inundation and has presented some worthwhile findings.

Nick Cockerall from SPA was able to conduct three drone flights over the site on July the 13th at around 600GDD, August 17th around 800GDD at top dressing time and again on Oct 7th during late flowering. A paddock variable rate map was constructed from the August flight.

Differences in the budget are explained by the extra operational costs attributed to taking the opportunity to collect additional data being C:N ratios, also salary in scoring water logging damage and additional data analysis.

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 establishment	Y	
VR map created for grower	Y	
Post application image from paddock	N	VR map not applied
Harvest Trial site and analyses data	Y	

Technical Information (Not to exceed <u>three</u> pages)

Provide sufficient data and short clear statements of outcomes.

Key outcomes from the VR project

- NDRE is less sensitive to plant population than NDVI. At 4-6 leaf stage NDVI potentially has a stronger relationship with plant population than it does nitrogen response.
- NDRE is less effected by readings from bare soil compared to NDVI
- Results indicate NDRE is more sensitive to crop shadowing
- Paddock VR imagery shows significant amount of variability
- Strongest relationship with yield appears to be NDVI at 1550GDD, late flowering
- NDRE had a stronger relationship with nitrogen rate at the later stage 1550GDD
- Assessing relationship between the nitrogen applications and sensors at top dressing time (800GDD) shows significant difference when the two plant populations are assessed separately, potentially a large proportion of the variability in sensor readings across a paddock is explained by plant population as appose to nitrogen response.
- Due to above average rainfall during August which prevented the ability to test the paddock application it is still unclear as to whether the calibration of this data is enough that deep nitrogen testing would not be required to select a nitrogen rate for each of the management zones of the VR map.

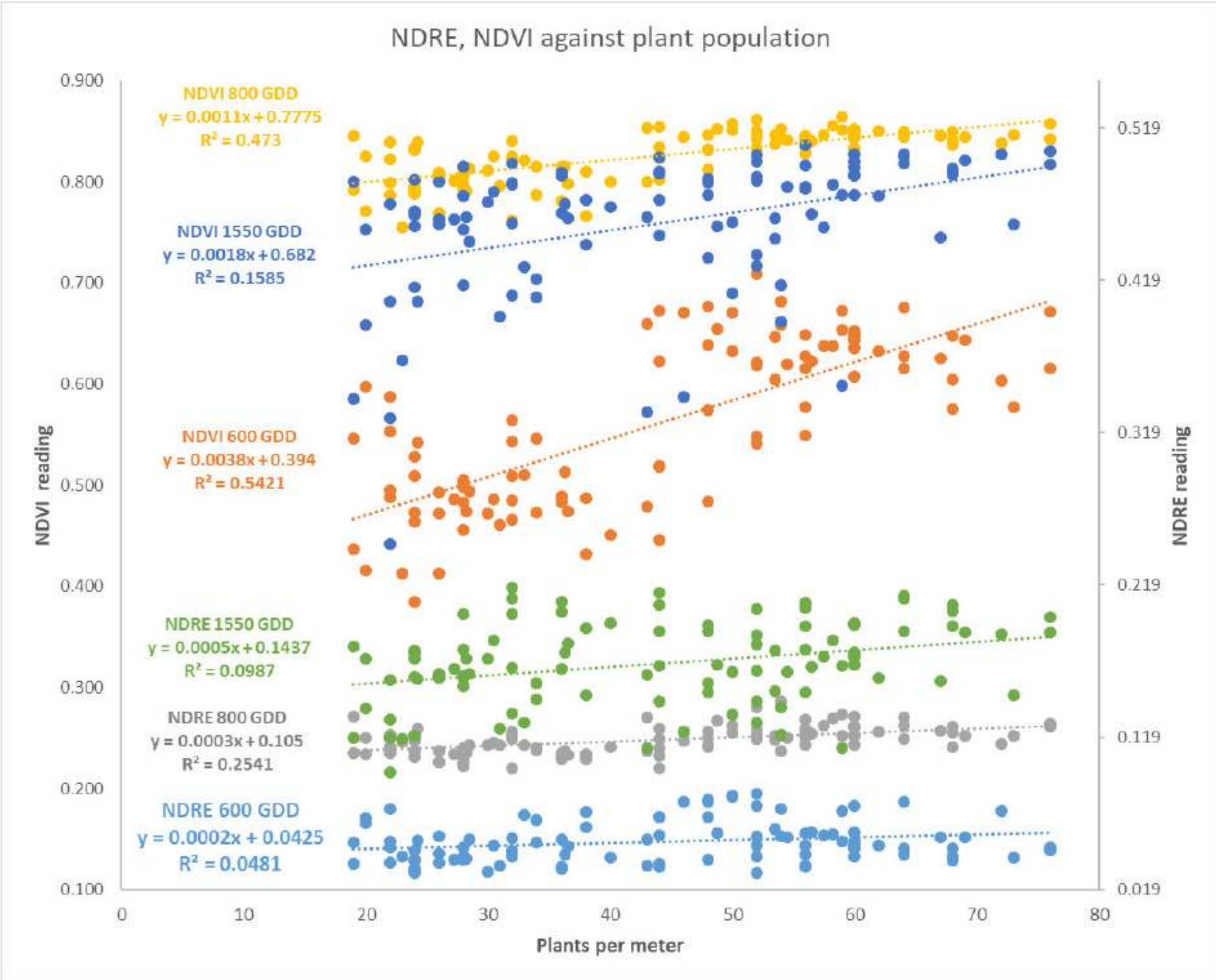
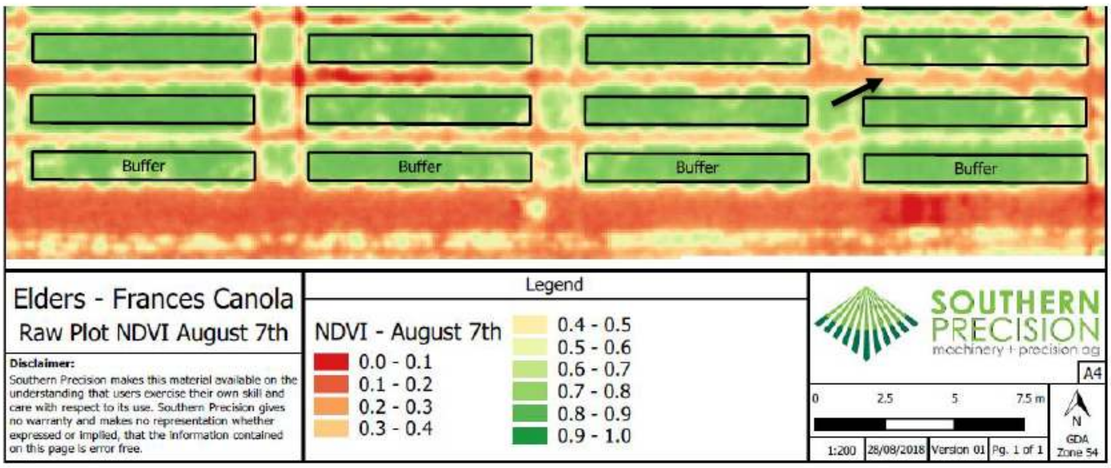


Figure 1:Relationship between plant populations and sensor readings at different times

Figure 1 above shows regression analysis demonstrating the three timings of imagery and the relationship with plant population. Results suggest that a greater proportion of NDVI variability is explained by plant population, much more sensitive than NDRE.



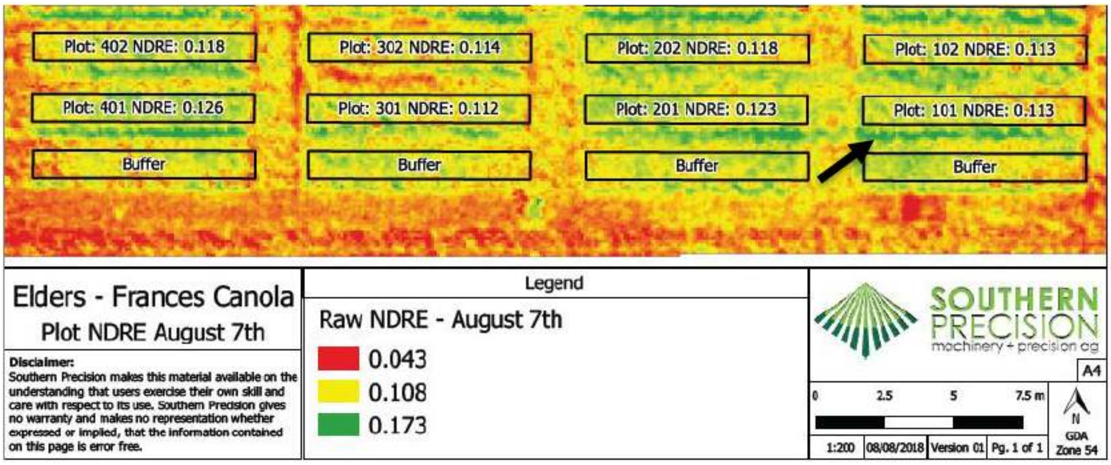


Image 1: Showing NDRE has a strong detection where canola plants were casting a shadow between plots compared to NDVI, top.

Image 1 above showing a cut out of the NDVI and NDRE plot map, due to the time of day and conditions during flight the NDRE shows a strong reading of the shadows between the plots. The first flight was taken during overcast conditions and during the last flight the plots had complete canopy cover. It is uncertain if the shadowing is an issue with the NDRE. If so the solution would be to take imagery during overcast days, which would question the effectiveness of using the Red Edge satellite which can only present an image during clear weather.

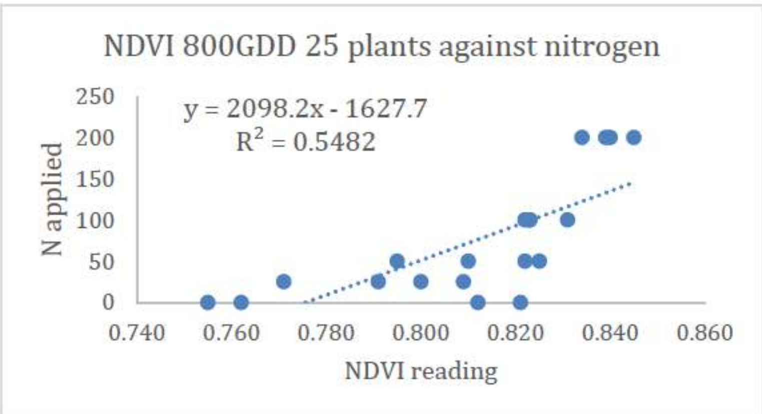


Chart 1: NDVI taken at 800GDD from plots with 25 plants/m

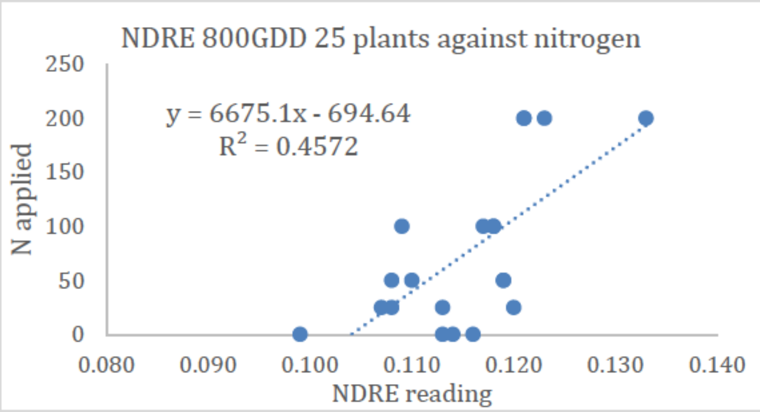


Chart 2:NDRE taken at 800GDD from plots with 25 plants/m

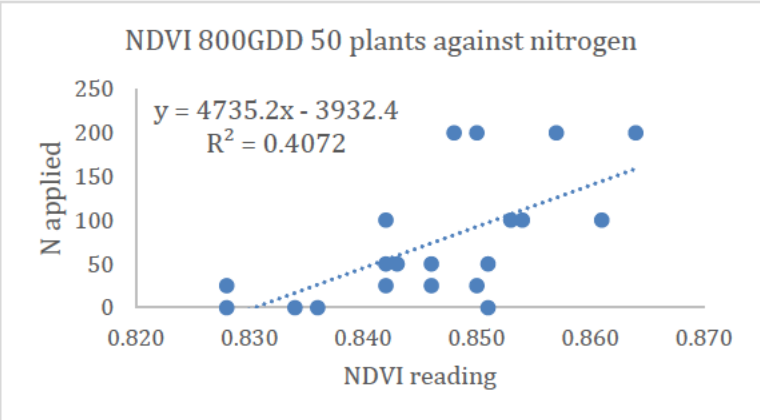


Chart 3: NDVI taken at 800GDD from plots with 50 plants/m

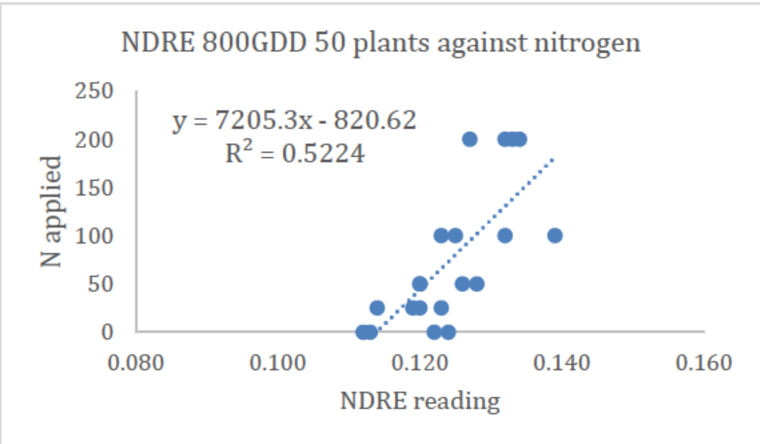


Chart 4: NDRE taken at 800GDD from plots with 50 plants/m

Charts 1-4 showing the relationship between NDRE and NDVI to nitrogen response taken just prior to the first top dress timing.
Results show a significant amount of movement in the data indicating the sensors are significantly effected by other observations other than visual nitrogen responses.
NDVI over 25 plants/m has shown the strongest relationship, which drops from .54 to .40 comparing 25 plants to 50 plants/m. NDRE is the opposite and the relationship between nitrogen and NDRE has improved over 50 plants/m.

Sensor against nitrogen	R Square
NDVI 600 GDD 25 plants	0.819
NDRE 600 GDD 25 plants	0.072
NDVI 600 GDD 50 plants	0.481
NDRE 600 GDD 50 plants	0.057
NDVI 1550 GDD	0.047
NDRE 1550 GDD	0.418

Table 1: R squared from the first and third imagery against nitrogen

Table 1 shows the regression analysis from the first and third imagery.
Results show NDVI is more closely correlated with crop nitrogen status early at 4-6 leaf however NDRE has a much stronger relationship at the later stage mid flower.

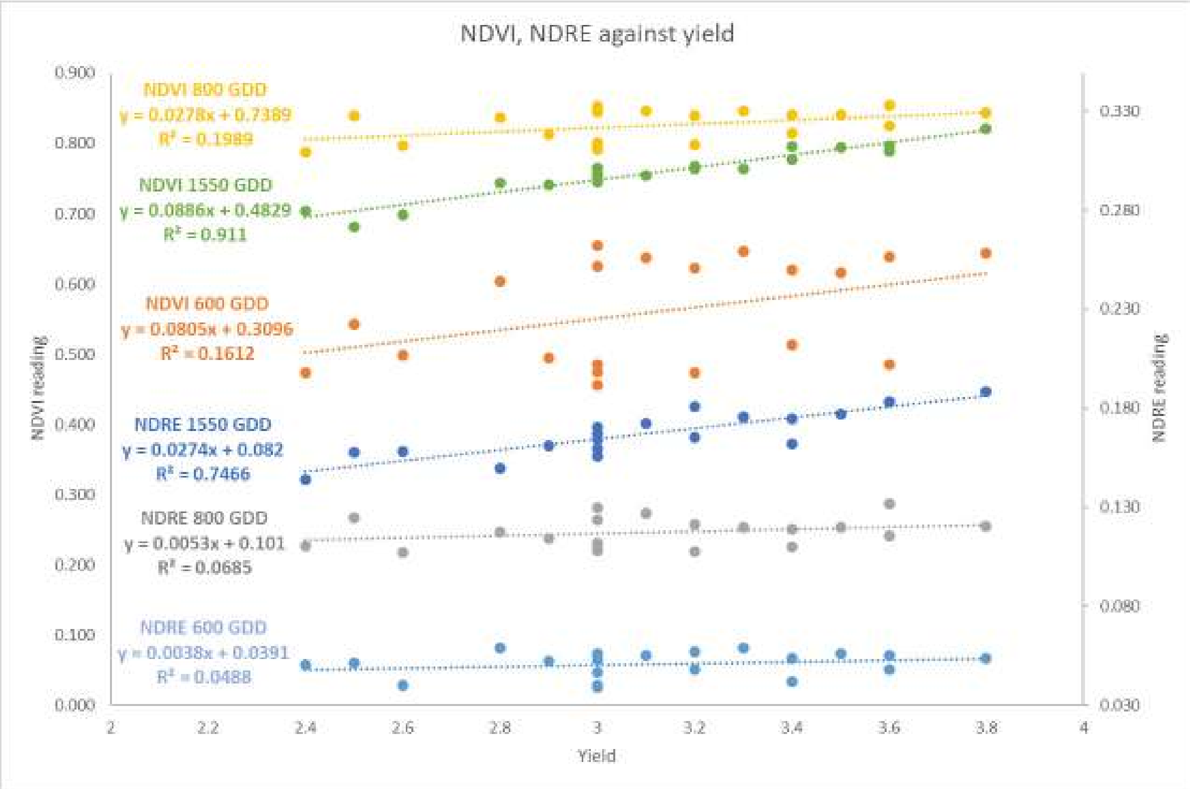


Chart 5: relationship between sensor readings and mean yield of all treatments

Chart five above shows the later stage of imagery taken during late flowering has a reasonable relationship with yield, NDVI being significantly stronger than NDRE which goes against suggestions from other sources. Debates are ongoing about the usefulness of this information and it is unlikely to be useful for any nitrogen decision making at such a late growth stage.

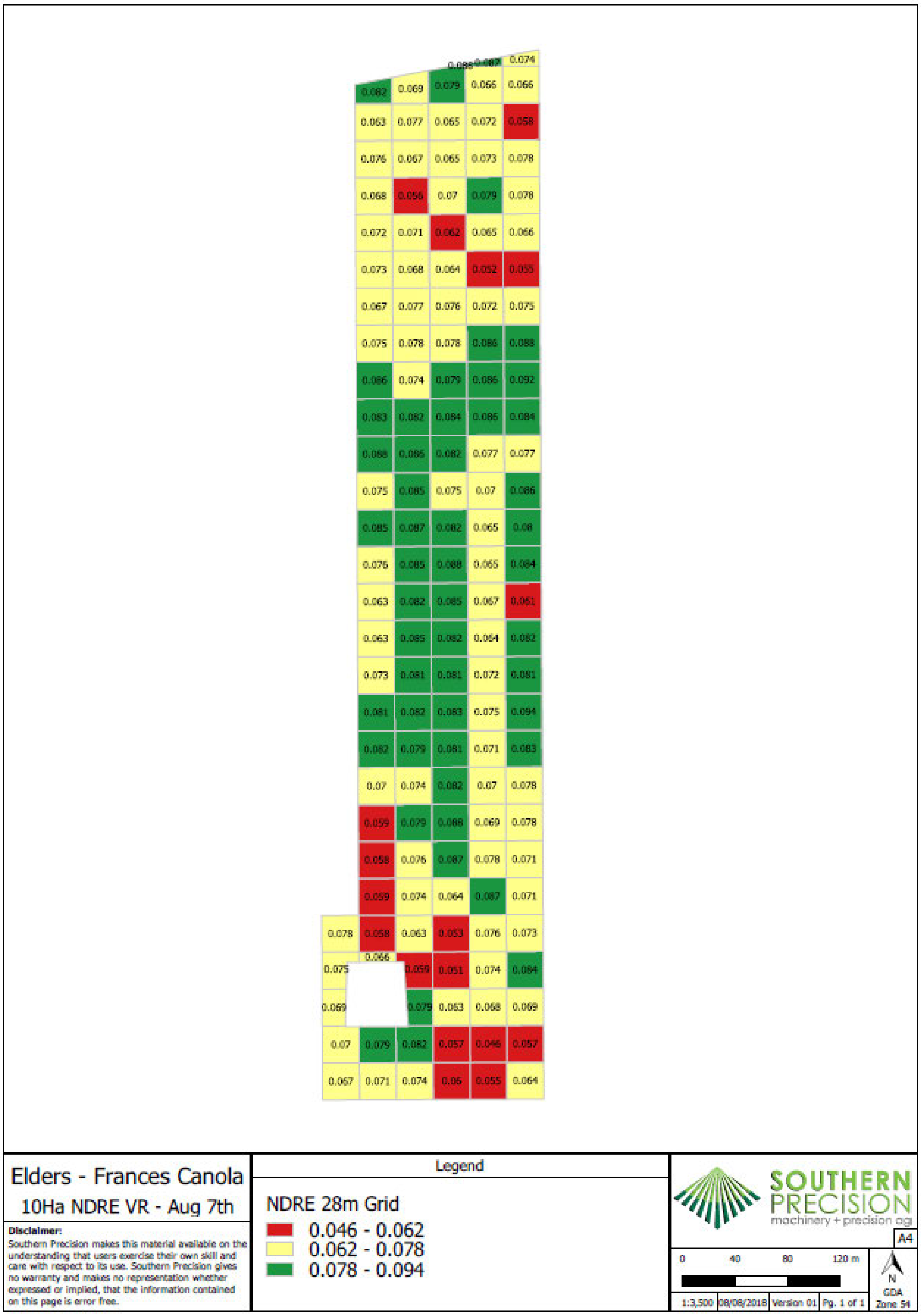
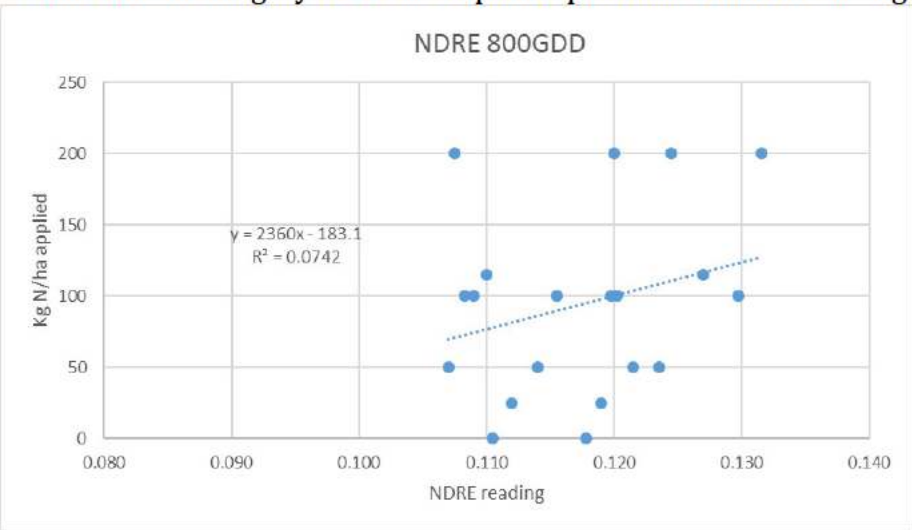


Image 2: The variable rate nitrogen map from 10ha of a canola paddock using NDRE, trial site cut out from bottom left

Image two shows the amount of variability over a 10ha strip of canola, at time of imagery around early green bud stage 800GDD this 10ha had received no nitrogen. This imagery was in line with a typical top dress timing and converted to a 28m grid to line up with the urea spreader. Using the NDRE results from the trial site compared to the plots of increasing rates of nitrogen at the same time the paddock imagery was created, a theorised modeled nitrogen requirement can be calculated. The average of the three zones over the paddock would suggest three rates are required, 180kg of N/ha, 69kg N/ha and 24kg N/ha. However, results suggest that the relationship between NDRE and nitrogen rate at this stage was not very strong. Nitrogen rate selection is mostly influenced by the potential yield at the time of application and working back from 80kg N/t of canola required, growers attitude towards risk and spring forecast.

At this time of imagery NDVI at 50 plants per meter had the strongest R2 at 0.52.



		NDRE	Nitrogen
Enter NDRE result here →		**0.088**	**24.5853**
Slope	2360		
Intercept	-183.1		

Nitrogen response predictive model based on NDRE reading
NDRE result X the Slope of the regression curve + the intercept

Key outcomes from the nitrogen response

Results from the trial site were analysed using ARM. Caution is required when interpreting results due to water logging.
Plots 409, 417, 310, 408, 309, 311, 411 and 308 have been removed from analysis as outliers (1.5 x greater or less than the treatment mean) to achieve a significant difference.

- Deep soil nitrogen testing strongly reflected crop response to nitrogen rate and timing.
- Nitrogen rate was more important than timing in this trial. The 100kg of nitrogen rate was just as effective applied at later stages.
- In this trial applying any nitrogen rate and timing was equally effective at alleviating damage from water logging.
- At the optimum yield 70kg of nitrogen was required per tonne.
- The highest significant yielding treatment was also the most economical with a risk reward return of $4.59.

Trial Details

Crop:	Canola
Variety:	Hyytech Trophey TT
Planting Date:	8/05/2018
Planting Method:	Direct drilled
Planting Equipment:	TPS017
Planting Rate:	1.25 and 2.5kg
Depth	0.5-1.5cm
Stubble Cover:	0
Row Spacing, Unit:	23cm
No. Rows:	6
Paddock History, 2017:	Wheat
Paddock History, 2016:	Phalaris/Balansa pasture
Paddock History, 2015:	Phalaris/Balansa pasture

Site and Design

Treated Plot Width:	1.38m
Plot Centre:	2m
Treated Plot Length:	10m
Treated Plot Area:	13.8m2

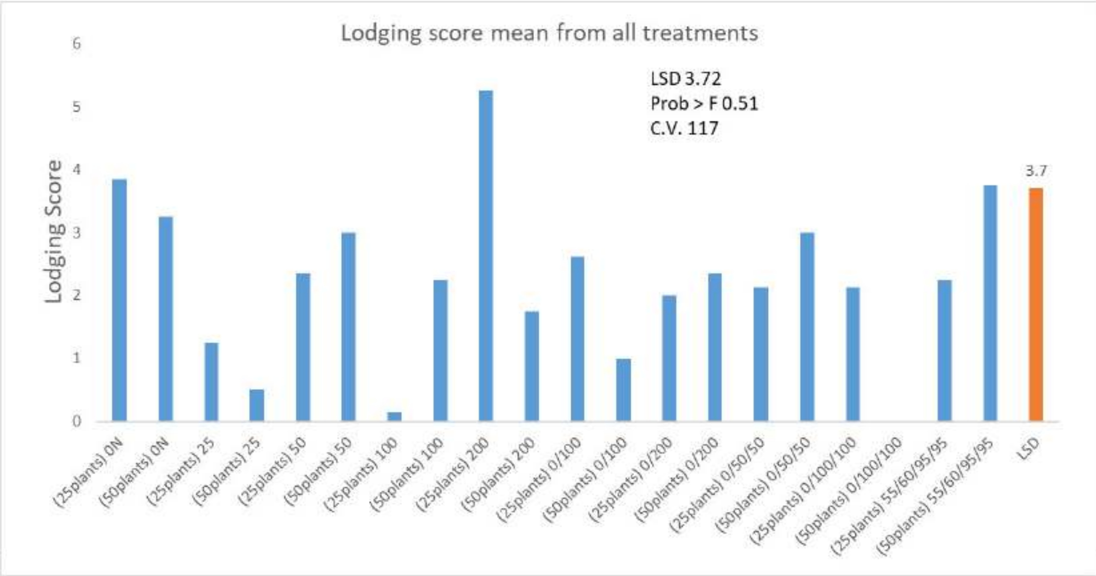
Harvest Details

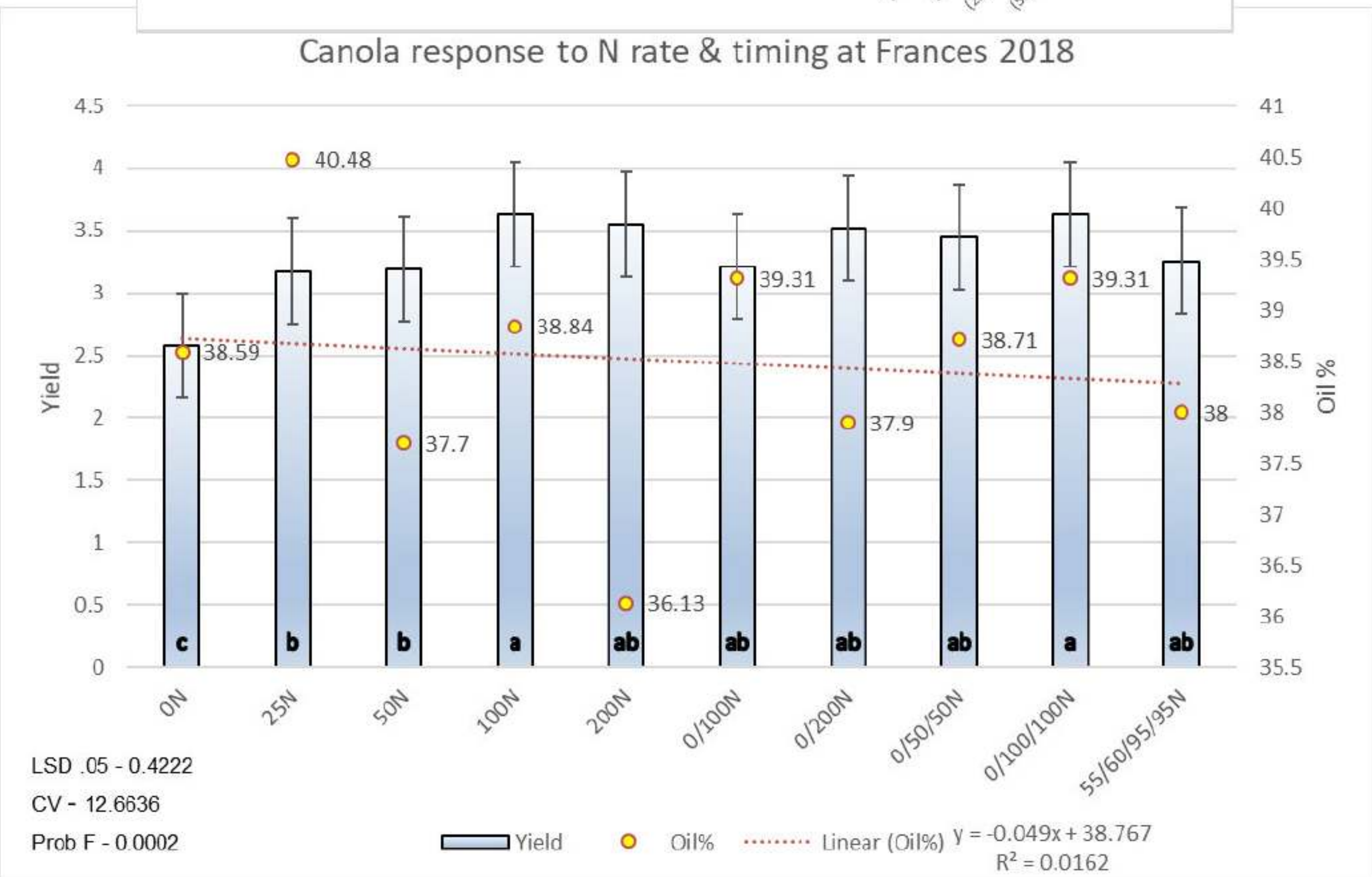
Harvest Date:	26/11/2018

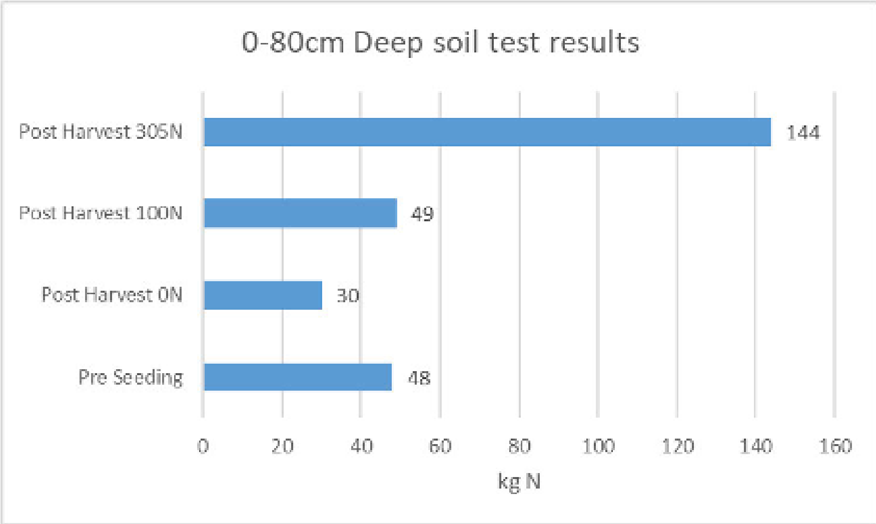
Maintenance

No.	Date	Maintenance Product Name	Rate	Rate Unit	Description
	10/03/2018	Gypsum	2500	kg	
1	8/05/2018	Roundup Ultramax	2.5	L	Knockdown
2		Stomp	2	L	IBS
3		Simazine	1	kg	IBS
4		Granulock Z + Flutriafol	130.0	kg/ha	Below seed
5		Atrazine	1.0	kg	PSPE
6		Astral	250.0	mL	PSPE
7	13/06/2018	Atrazine	1.1	kg	GS11-14
8		Select	500.0	mL	GS11-14
9		Lemat	100.0	mL	GS11-14
10		Lontrel	120.0	mL	GS11-14
11		Hasten	1.0	% v/v	GS11-14
12	16/07/2018	Prosaro	450.0	mL	GS15
13	4/09/2018	Aviator Xpro	600	mL	GS 64

Just prior to harvest the proportion of the plot that had lodged was visibly assessed to the nearest 5%. Lodging was defined as the stems leaning at an angle of at least 10º from the vertical. Lodging occurred late in the season and did not appear to limit yield. No correlation between the lodging score and water logging score, treatment or yield could be found. The lodging scores against treatments was not significant. There was no Black leg canker or sclerotinia present in the trial.







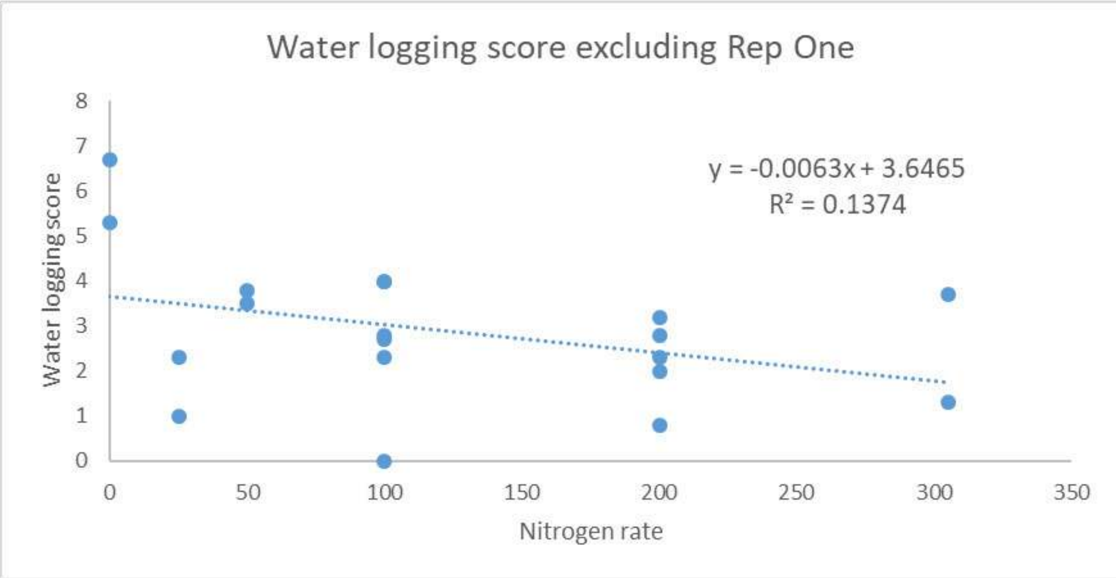
Trial results demonstrate confidence in deep nitrogen soil testing to predict likely response from nitrogen rate and timing. The highest significant yield was achieved once 100kg of nitrogen was applied resulting in 3.6t/ha. Including potential nitrogen mineralisation from organic carbon there was between 70-80 kg of nitrogen required per tonne. Nitrogen rate had the highest impact on yield with 1.06t/ha yield increase over untreated at the most significant result.

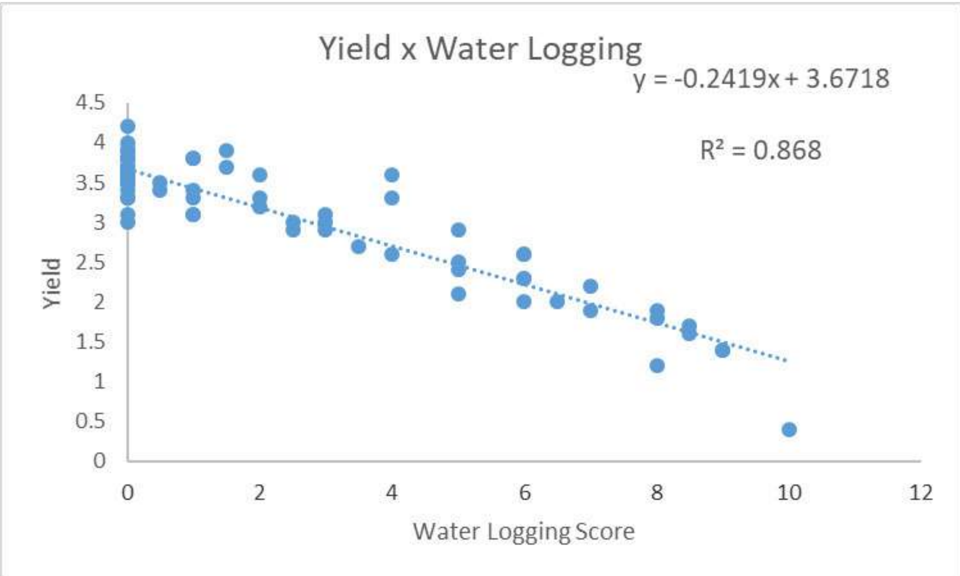
There was no significant yield difference between the 100kg of nitrogen applied all up front at the two-leaf stage, all at the green bud stage just prior to bolting or split 50/50 between green bud and 5% flowering stage. It's important to note that pre-seeding nitrogen levels were very adequate and mostly in the top 40cm however under these conditions this validates that growers can confidently stagger nitrogen applications at later stages to manage seasonal risk without losing yield.

There was no typical reduction in oil concentration seen as nitrogen rates increased, grain quality results were not significant and ranged widely due to site variability.

Water logging scores were assessed against nitrogen rate and timing, no significant difference could be determined in the results, attempts to exclude rep one which received no water logging damage or excluding all plots that did not receive damage did not improve the statistical outcome. The only potential outcome is that applying nitrogen, regardless of rate or timing, has a positive impact on alleviating yield loss due to water logging in canola as seen in chart 6. Water logging scores were above ground visual symptoms only.

Chart 6: Visual water logging damage scores against nitrogen rates





Treatments that received a nitrogen application post water logging period were not significantly higher yielding than treatments of the same application rate applied before water logging, indicating that when severe water logging occurs a post application of "rescue nitrogen" isn't always effective, more work should be completed on the effectiveness of post water logging nitrogen applications before claims are made.

Carbon nitrogen ratios were tested across three treatments to measure how much the over applied nitrogen remains in the stubble. Results showed a significantly lower C:N ratio in the treatments with nitrogen rates in excess to crop requirement, which could mean less nitrogen immobilisation from stubble in the following season.

Because there was no original intention to measure stubble post-harvest the harvester was not setup to do so, if an assumption is made that there was 4000kg of stubble which typically contains 45% carbon content, there would be 1800kg of carbon in the stubble, if the C:N is 95:1 there would be 18.9kg/ha of nitrogen in the stubble, at 52:1 it would be 35.5kg/ha nitrogen. 45kg of nitrogen is required to decompose 4000kg of stubble therefore at 95:1 there is a net loss of 26kg of nitrogen to immobilisation, however at 52:1 there is only 9.5kg of nitrogen immobilised. Refenced from GRDC Managing Soil Organic Carbon.

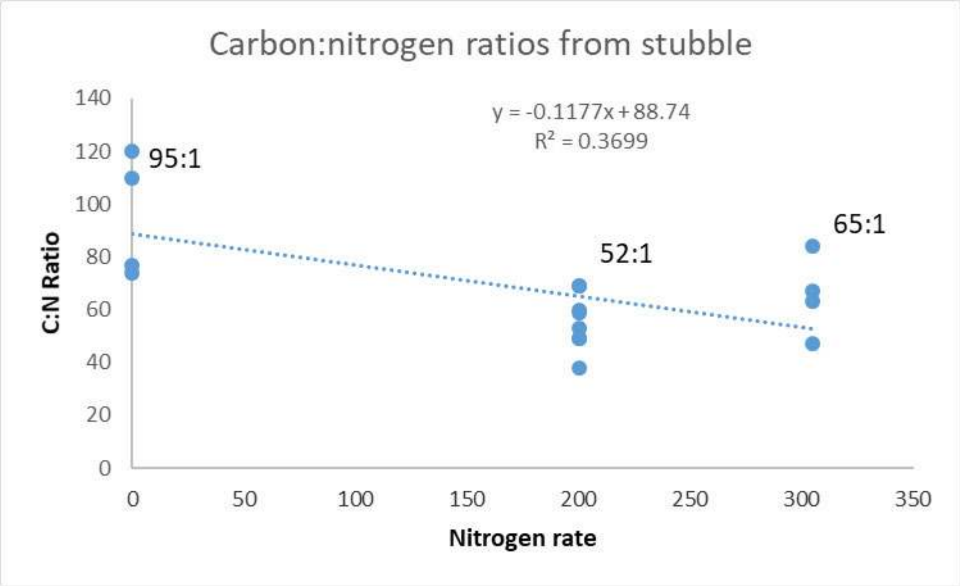


Chart 7 Yield results from seeding rates assessed across all treatments

Seed Rate MEANS	Yield	
25 plants/m2	3.164	b
50 plants/m2	3.473	a
LSD P=.05	0.1888	
Standard Deviation	0.4202	
CV	12.6636	
Prob F	0.0019	

A statistical yield increase over the higher seeding rate by 0.31t/ha was found, however other similar trials in the past have not shared this result, the CV could be considered too high for this scenario so no further claims can be made.

Total N	Yield	Oil	Protein	Moisture	HLW	Screenings
0	2.352	38.13	19.23	11.1	52.6	1.08
0	2.804	39.05	18.98	10.7	52.23	0.95
25	2.973	39.35	18.95	10.5	52.95	0.98
25	3.376	41.6	16.9	10.1	52.28	1.05
50	2.864	39.53	18.75	10.75	52.18	1.08
50	3.509	35.88	21.48	12.48	36.93	0.85
100	3.607	38.88	19.65	10.3	51.85	1.08
100	3.654	38.8	19.9	11.03	51.63	1.13
200	3.479	34.98	22.1	12.2	52.73	1.1
200	3.626	37.28	20.18	10.08	52.13	1.08
100	2.973	39.2	19.8	10.2	52.25	1.03
100	3.451	39.43	19.05	11.05	46.48	1.15
200	3.241	39.05	19.48	11	52.4	1

Despite a large amount of variability of oil results across treatments the data still shows a very strong relationship between oil and protein of R2 0.85. Some significant results do exist in the oil percentage however it does not correlate with yield or nitrogen rate therefore must be due to variable plot damage across the site.

Table 3: Economical analyses of all nitrogen treatments

Total N applied	N cost [1]	Application Timing	Yield	Canola Price	Oil%	Oil Penalty [2]	Gross return inc Oil	$/ha net	Risk Reward
0	$ -	0N	2.578	$500	38.59	-$26	$1,263.43	$1,263.43	
25	$ 36.25	25N	3.175	$500	40.48	-$11	$1,576.10	$1,539.85	$ 8.63
50	$ 62.50	50N	3.187	$500	37.7	-$32	$1,561.25	$1,498.75	$ 4.77
100	$ 115.00	100N	3.631	$500	38.84	-$24	$1,791.80	$1,676.80	$ 4.59
200	$ 220.00	200N	3.553	$500	36.13	-$44	$1,732.48	$1,512.48	$ 2.13
100	$ 115.00	0/100N	3.212	$500	39.31	-$20	$1,585.83	$1,470.83	$ 2.80
200	$ 220.00	0/200N	3.516	$500	37.9	-$31	$1,727.25	$1,507.25	$ 2.11
100	$ 115.00	0/50/50N	3.445	$500	38.71	-$25	$1,697.83	$1,582.83	$ 3.78
200	$ 220.00	0/100/100N	3.629	$500	39.31	-$20	$1,794.33	$1,574.33	$ 2.41
305	$ 330.25	55/60/95/95N	3.257	$500	38	-$30	$1,598.50	$1,268.25	$ 1.01

154kg of nitrogen available from deep soil tests, base fertiliser and mineralisation.

[1] Cost assumes $500/t for urea + $10 spreading costs

[2] 1.5% price deduction for every 1% below 42% oil

Economic analysis shows a positive net return of $413.40/ha from the most significant treatment over the untreated. The risk reward ratios share outcomes with other similar trials when the optimal nitrogen rate is applied there is a return between $4.50-$5 per dollar spent on nitrogen.

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

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

The project indicates that the multispectral sensor could possibly be used to drive variable rate nitrogen application in canola, a good understanding of the strength and weaknesses of the sensors and some careful observations have to be taken into account to have confidence.

The HRZ was selected for this trial to increase the chances of achieving a high yielding canola crop 3-4t/ha, however our experience with water logging and losing trafficability whilst it was above average it is not uncommon, looking at when the ideal time for imagery collection is and the ability to use the VR data it is not uncommon to have lost trafficability at this point, the chance remains that most years this practice will not work as the imagery will not be ready soon enough.

Intellectual Property

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

At this point it is intended that all this data will be made freely available and will posted on the GRDCs OFT website.

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.

Trial site was open and presented at the Mackillop Group Frances crop walk on August 14th.

Discoveries from the project have been made in conjunction with Southern Precision Ag, Vickery Fertiliser and local growers. The raw data and Final Report will be made available for the industry on GRDC's OFT website once complete.

It was intended that a single page simple to read fact sheet was to be created for growers in the South East explaining the process and outcome of using the sensors for VR nitrogen, regardless of the success, however because the paddock scale application did not occur the fact sheet was deferred.

POSSIBLE FUTURE WORK

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

We request for an extension on the project with no alternation of budget for another attempt at using the sensor to create a VR map over a paddock canola. We will consider a second flight one month post application to use as a gauge, if the crop has a more even image over the 10ha post application this may be an indicator of success. Assessments of the three or four rate zones will be taken including in crop deep nitrogen tests followed by a post-harvest deep nitrogen test, plant population counts and biomass will also be used to measure accuracy. A yield map of the paddock may also show evenness.

Further work needs to be assessed on alternative modeling to better fit the nitrogen response curve to sensor readings.

Potentially a ratio could be used of NDRE and NDVI or others to better the fit curve.

Whilst we are yet to use the any of the multi spectral images at a commercial scale the results show some significant challenges for the ability to use the sensors as variable rate nitrogen maps over canola. It would seem a high level of uniformity is needed across the paddock and there must be no other limiting factors other than nitrogen that could have a visual symptom on the crop. It is likely for success the paddock must have even plant population, similar soil type (rooting depth, OC%), be completely weed free and disease free.

AUTHORISATION
Name: Adam Hancock
Position: Agronomist
Signature:
Date:19/4/10

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.