FINAL REPORT 2015

Applicants must read the *SAGIT Project Funding Guidelines 2014* 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 :	UA0314

PROJECT TITLE (10 words maximum)
Potential N supply and mineralisation as predicted by DGT

PROJECT DURATION

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

Project Start date	01/07/2014
Project End date	30/06/2015

PROJECT SUPERVISOR CONTACT DETAILS

The project supervisor is the person responsible for the overall project

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Office Use Only

Project Code	

Project Type	

ADMINISTRATION CONTACT DETAILS

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

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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 DGT technique was developed to enable measurement of both Nitrate and Ammonia in a single assay.

Both the Mineral N test and DGT techniques moderately predicted the response of 10 S.A. soils to applications of N

DGT on incubated soils performed better than the Mineral N test on the same incubated soils while Mineral N performed on dry soils had comparable results to DGT.

Soils with a high amount of sand had an inability to convert the N applied in the form of urea into plant available nitrate. At high rates this caused excessive amounts of ammonia and resulting reduction in growth. It appeared the plants couldn't benefit from the extra N applied as ammonia form.

Project Objectives

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

Evaluate the applicability of the DGT technique for predicting N requirements and mineralisation potential in soil types applicable to South Australian broad acre agriculture.

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

Develop a mix resin gel capable of binding NO_3 and NH_4 simultaneously

To assess the performance of current soil N tests (KCl, $CaCl_2$) and the new DGT N test for predicting N requirements for wheat on a range of soil types.

Perform a preliminary assessment of N mineralisation potential of a range of soil types through extended deployment times of DGT devices.

Assess the applicability of including a mineralisation measure (from 3) to improve the performance of soil test in 2).

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.

Sufficient experiments were performed to assess the project objectives. There were unexpected results applicable to a few soils that have agronomic significance but reduced the amount of soils used to assess the performance of DGT, Mineral N and $CaCl_2$ soil tests with plant growth (see technical information).

Md Mobaroqul Ahsan Chowdhury (Technical Officer) assisted greatly on the project producing excellent Nitrate/Ammonia results and developing the new DGT gels. John Swincer and Yulin Zhang (both casual officers) together performed the glasshouse experiment and mineralisation experiments.

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.*
Develop a mix resin gel capable of binding NO3 and NH4 simultaneously.	**Y**	
Assess the performance of current soil N tests (Mineral N - KCl, $CaCl_2$) and the new DGT N test for predicting N requirements for wheat on a range of soil types.	**Y**	
Perform a preliminary assessment of N mineralisation potential of a range of soil types through extended deployment times of DGT devices.	**Y**	
Assess the applicability of the including a mineralisation measure (from 3) to improve the performance of soil test in 2).	**Y**	

Technical Information (Not to exceed __three__ pages)

Provide sufficient data and short clear statements of outcomes.

Further results and graphical information has been included in a supplementary document.

Develop a mix resin gel capable of binding NO3 and NH4 simultaneously.

The project successfully developed a DGT device capable of measuring both NO_3 and NH_4 simultaneously in-situ. Capacities of the resin gel for NO_3 (~ 800 μg) and NH_4 (225 μg) appear to be adequate for determination of both NO_3 and NH_4 for longer deployment periods (figure 1). As a comparison binding capacities for the gel used for measuring DGT P is 10 μg.

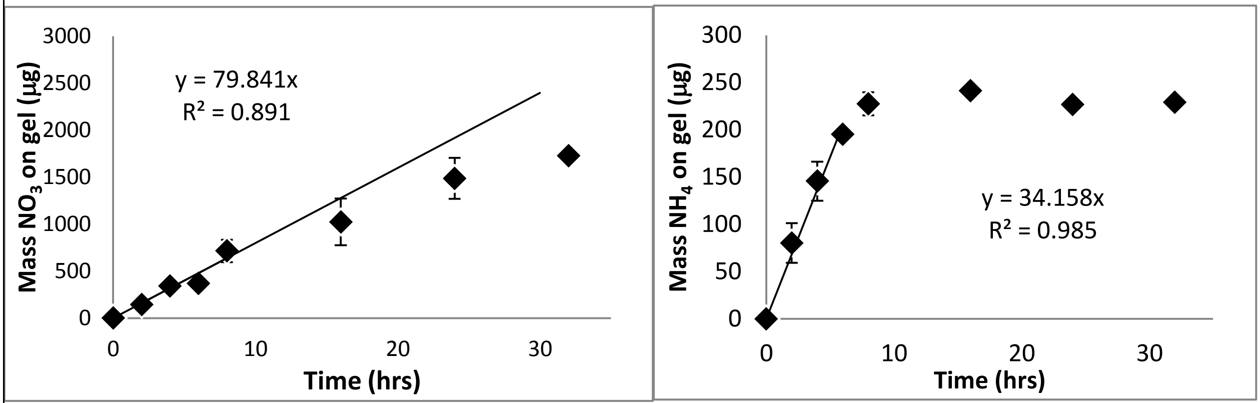

Figure 1. Accumulated mass of NO_3 (left) and NH_4 (right) on the combined resin gel incorporated in DGT devices that were deployed in a solution of 50 mg/L NO_3 and NH_4 over various times. Capacities of the gel are calculated at the point where accumulated masses deviate off the point of the linear relationship.

Assess the performance of current soil N tests (KCl, $CaCl_2$) and the new DGT N test for predicting N requirements for wheat on a range of soil types.

A significant glasshouse trial was performed that assessed the response of wheat to applications of N as Urea on 15 broad-acre agricultural soils from S.A. Four application rates of N (0, 50, 100, 200 mg/kg) were used with each treatment being replicated three times. Regions that the soils were collected and associated responses found can be found in table 1.

Unfortunately 4 of the soils which had high sand contents (Karoonda, Ngarkat, Parilla and Wharminda) expressed an inefficiency to convert the applied N as ammonia (Urea) to nitrate and therefore no growth response to applied N was seen (table 1). The high rate of N (200 mg/kg) and lack of conversion to nitrate meant that high amounts of ammonia in the soil reached toxicity levels. With increasing N rate on these 4 soils there appeared to be slight decreases in nitrate values as expressed in all soil tests. Yield penalties also occurred even at the first rate of N where toxicity effects from NH_4 wouldn't have been expected. It appears the wheat plants in this experiment weren't able to take up N in ammonia form.

For correlations with soil tests these 4 soils have been excluded for the reasons stated above. One additional soil (Minnipa) had poor establishment and for some treatments only one replicate was obtained therefore this soil was also removed from correlation analysis.

Relationships between the three soil tests (DGT, $CaCl_2$ extractable and mineral N - KCl) were high for measurement of soil nitrate (table 2). The $CaCl_2$ extract was more powerful that the mineral N test (KCl extract) while DGT extracted similar amounts of NO_3 as the mineral N test. For the NH_4 component poor relationships were generally found between all soil tests apart from a moderate correlation between $CaCl_2$ and Mineral N for the control soils only (R^2 = 0.67). Each soil test measured different components of NH_4 sources derived from the applied Urea.

Soil test relationships with wheat response to applied N revealed that DGT performed moderately well explaining 61% (DGT NO_3) - 62% (DGT N total) of the variation (table 3). Critical DGT values were 53 mg/L for both nitrate and nitrate/ammonia measures combined. DGT measured ammonia was minimal with respect to nitrate. Mineral N values on incubated soils (1 week) didn't perform as well with nitrate and nitrate/ammonia measures explaining 37 and 36% of the variance in response respectively. Critical values were in the order of 54 mg/kg (nitrate) and 64 mg/kg (nitrate/ammonia). Mineral N measures were subsequently performed on dry and incubated control soils to study the effect of dry/moist on the accuracy of predicting N deficiency (see below). $CaCl_2$ extractable N performed poorly and possibly due to this poor correlation had elevated critical values.

When all rates were considered the DGT method and the standard mineral N test had comparable R^2 values when related to relative yield (R^2 = 0.5 – DGT NO_3, R^2 = 0.46 Mineral NO_3, R^2 = 0.52 Mineral N).

Table 1. Soil chemical characteristics and summary of growth responses to applied N across 15 soils collected across S.A. broad acre regions. *Note - awaiting analysis for Condowie, Parilla

Soil ID	EC dS/m	pH H2O	OC %	$CaCO_3$ %	Clay %	Y0 g/pot	Ymax g/pot	Relative Yield %	
Avon	0.177	8.60	1.95	9		0.112	0.223	50	
Condowie						0.152	0.172	88	
Karoonda	0.03	6.44	0.61	BDL	3	0.171	0.223	77	*
Keith	0.2	5.58	1.64	BDL	15	0.215	0.215	100	
Koppio	0.149	6.20	4.15	0.2		0.340	0.340	100	
Lock (Polky)	0.172	8.50	1.73	29		0.074	0.195	38	
Mid North (Jacka)	0.32	7.60	2.90	30		0.223	0.293	76	
Ngarkat	0.02	6.66	0.83	4		0.224	0.224	100	*
Parilla				BDL		0.171	0.171	100	*
Roseworthy	0.19	7.88	1.91	BDL	20	0.205	0.205	100	
Tumby Bay		4.60	3.00	BDL	17	0.133	0.322	41	
Waramboo	0.08	8.95	BDL	61	5	0.174	0.174	100	
Mt. Damper (Cliff)	0.168	8.50	1.00	1		0.152	0.285	54	
Minnipa (Jericho)	0.149	8.60	1.20	3		0.179	0.209	86	#
Wharminda	0.05	6.8	0.85	BDL	1	0.120	0.236	51	*

*Soils not included in soil test correlations due to NH4 toxicity and no increase in NO3

#Soil not included due to poor emergence generating only one replicate for two treatments

Table 2: Relationship between various soil tests for measuring soil nitrate

Control soils only

Slope	$CaCl_2$ NO_3	Mineral NO_3	DGT NO_3	R^2	$CaCl_2$ NO_3	Mineral NO_3	DGT NO_3
$CaCl_2$ NO_3	1	0.55	0.5	**$CaCl_2$ NO_3**	1	0.85	0.8
Mineral NO_3	1.55	1	1.16	**Mineral NO_3**	0.85	1	0.78
DGT NO_3	1.63	0.82	1	**DGT NO_3**	0.8	0.87	1

Table 3: Soil test performance (control soils only) with wheat response to applications of N

Soil test	DGT NO_3 mg/L	DGT N mg/L	Mineral NO_3 mg/kg	Mineral N mg/kg	$CaCl_2$ NO_3 mg/kg	$CaCl_2$ N mg/kg
R^2 with % RY	0.61	0.62	0.37	0.36	0.18	0.23
Critical Value	53	53	54	64	137	124

Perform a preliminary assessment of N mineralisation potential of a range of soil types through extended deployment times of DGT devices.

Run concurrently with the glasshouse response trial a mineralisation experiment was performed. Briefly control soil samples from above had water contents increased to field capacity with multiple DGT devices deployed on day 1 of the glasshouse trial. DGT devices (3 replicates) were systematically removed at different times to result in deployment times of 1, 3, 7 and 14 days.

DGT uptake profiles of nitrate and ammonia with time for most soils reduced with DGT deployment time (see supplementary document). Spikes in Ammonia were recorded for 3 day DGT deployment for the following light textured soils, Karoonda, Koppio, Ngarkat, Parilla, Tumby Bay and Wharminda. Accumulated ammonia quickly decreased for most of these soils with longer deployment times. Correspondingly, nitrate levels remained relatively stationary for the soil type's mention above but decreased significantly for the heavier textured soils. It is possible that a couple of contributing factors didn't allow for mineralisation profiles to be achieved in terms of accumulated N on the DGT.

1) Soil moisture was too high and with adequate temperatures this promoted N vitalization. Soils were covered with film to try and avoid this situation.
2) Competition of other cations on the uptake of ammonia on the DGT resin.

Due to the disappointing results with DGT a smaller scaled second mineralization experiment was performed (see next section for more details).

Assess the applicability of the including a mineralisation measure (from 3) to improve the performance of soil test in 2).

Due to potential N losses incorporation of DGT values at any extended deployment time didn't improved correlations with relative yield.

A further experiment was performed to assess what effect moisture had on the control soils in terms of mineral N measurements. The three soil treatments in which mineral N was measured were as follows; 1) Dry (to replicate soil state in commercial laboratories), 2) Soils incubated for 1 day at 50% WHC and 3) Soils incubated for 3 days at 50% WHC. Various N profiles with treatment were obtained with nitrate levels generally increasing with moisture and time of incubation for soils that had greater clay contents (see supplementary document). Nitrate and ammonia levels remained relatively stable for sandy soils. Correlating mineral N values from the three different treatments with relative yields of wheat obtained above revealed that total N – dry soil was most accurate in predicting variance in RY % (R^2 = 0.69) followed by mineral NO_3 – dry soil (R^2 = 0.45). Mineral NO_3 or N values obtained on incubated soils were poorly correlated with RY % ($R^2 < 0.36$).

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

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

DGT technology has now advanced to allow for measurement of both nitrate and ammonia availability in various soil types. The DGT measure of nitrate appears to be highly related to the nitrate levels extracted by the standard mineral N (KCl extract) soil method. Accumulated amounts of Ammonia on the DGT gel don't appear to reflect measured ammonia from mineral N extraction. This could possibly be due to competitive effects of other cations in solution for binding sites on the resin used in the DGT method.

Both DGT nitrate and nitrate/ammonia moderately predicted the response of wheat to applied N over a wide range of soil types (10) applicable to S.A. broad acre agriculture. The DGT method outperformed the mineral N procedure on the same soils that had been incubated for a period of one week.

Further examination of the mineral N technique revealed that when the test was performed on the same soils but in a dry state (as performed in a commercial laboratory) mineral N (nitrate and ammonia) correlations with wheat response were as good as DGT. Moist incubation for a short period of time reduced the mineral N capacity to predict N deficiency.

Caution should be exercised around these results as not all 15 soils tested in this project could be included in the analysis and therefore results can vary significantly using just 10 data points.

Five of the soils used expressed no response to applied N as urea even though that had very low levels of nitrate and ammonia. At high rates of urea the wheat growth was reduced and therefore yield maximums couldn't be obtained.

Attempts to measured forms of N mineralised with time by deploying DGT for longer periods of time (up to 2 weeks) were unsuccessful potentially due to conditions favouring N loss through volatilisation. To ensure good contact between the DGT device and soil, moisture levels of the soils need to be relatively high. The DGT devices were also deployed on the soil surface where most of the impacts of N loss would occur.

Intellectual Property

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

This is the first reported study to assess the performance of DGT in predicting N deficiency in a range of soils and therefore a significant amount of IP has been generated.

The realization of the potential to commercialize the DGT technique for N would require further evidence that DGT outperforms the now standard test for N (mineral N through KCl extract). This evidence would also need to contain a significant amount of field trials.

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;

DGT has been developed to enable measurement of soil available nitrate and ammonia. Measurement of DGT nitrate is highly correlated with nitrate extracted using the mineral N method however the DGT method proved to be slightly more accurate in terms of predicting N deficiency when soil samples were left to incubate (1 week). Mineral N assessed on dry samples performed as well as DGT. Attempts to measure mineralized N as assessed by DGT have been difficult to achieve potentially due to the current deployment conditions required for DGT.

Soils with high amounts of sand appear to have a limited ability to convert forms of N (applied as urea) into nitrate form which appears to be predominant plant available form.

A statement of potential industry impact

Achieving a soil test that accurately assesses available N in a range of soils together with an assessment of the amount of potentially mineralized N in a short period of time would be of great significance in the industry. The potential of the DGT method for this purpose hasn't been realized in this project.

Publications and extension articles delivered as part of the project;

Due to the very recent obtainment of results/outcomes no extension of project messages have been performed.

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

Not applicable at the moment (see future work)

POSSIBLE FUTURE WORK

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

If it was feasible to further test if DGT is a suitable soil test for N and a significant improvement on the current mineral N soil test the next step would be to start assessing the performance of DGT against crop responses in field environments. It does appear that DGT measures similar amounts of nitrate as the current soil N test and therefore any further benefit of DGT is debatable. One small attractive feature of DGT is that it could be easily developed to measure both P and N together providing potential cost savings associated with both being measured in a single assay. The strength of and measure of DGT P has been well documented.

The real strength of a DGT method for N is the potential that DGT can be deployed for longer periods of time which has the potential to capture forms of N entering the available pool through mineralisation. Unfortunately at the moment it appears that the deployment conditions required for the DGT method promotes n loss through volatilisation. Future work could look at refining the deployment conditions by mainly reducing soil moisture levels and potentially burying devices under the surface to assess N chemistry where losses aren't prevalent. It would be recommended that this is performed in relation to field trials in order to better capture soil conditions encountered in the field.

There is some anecdotal evidence that different forms of N upfront have varying degrees of benefits of supplying N to the crop. Improved efficiency of Ammonium Sulphate and UAN over Urea has been discussed. To the best of our knowledge this concept hasn't been assessed properly especially on sandy textured soils. This project has shown that potentially these soils (Sands) have a limited ability to convert forms of ammonia from applied Urea to nitrate from which appears to be the preferred form of N for plant uptake.

Note* Full financial acquittal will be sent to SAGIT from UA at close of this project

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Signature:
Date: 03/09/2015

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.