CROP SCIENCE SOCIETY
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NEWSLETTER

Welcome to the September issue of the Crop Science Society of SA newsletter

Dear CSSSA Members,

Welcome to the September issue of the Crop Science Society of SA.

In this month's newsletter we explore:

- Member in focus – Dan Petersen
- Application of Visible Near-Infrared Absorbance Spectroscopy for the Determination of Soil pH and Liming Requirements for Broad-Acre Agriculture – Bethany Sleep
- Leigh Creek Urea Project
- Narrow-leaved lupin (*Lupinus angustifolius*) response to bixlozone (Overwatch) – Roberto Busi

We hope you are keeping well. Please contact us if you have any requests for content of information.

Kind regards,

Dan Petersen
President, Crop Science Society of South Australia

Member in focus – Dan Petersen, new President CSSSA

As the youngest of four children in a busy household, I was very fortunate that going to work with dad was often the solution to childcare. These experiences at a young age undoubtedly shaped an inquisitive mind and love for agriculture.

After completing a Bachelor of Agricultural Sciences, I undertook an Honours project investigating herbicide resistance in common sowthistle with the Weed Science Research Group at The University of Adelaide. I was then extremely fortunate to continue working with my Honours supervisor Dr Gurjeet Gill on GRDC funded projects that focused on the seedbank biology of emerging weed species, harvest weed seed control and herbicide resistance in barley grass.

I have recently returned to our family business on the Central Yorke Peninsula where I farm under the patient guidance of my dad growing wheat, lentils, barley and canola. We also finish trade lambs in a feedlot and contract feed for some clients. Currently, we are finishing our second grass spray in lentils and starting to apply canopy closure fungicides, in addition to some harvest preparations.

Since my involvement as an undergraduate student, I have cherished the platform this Society has provided to facilitate transparent, dynamic and engaging discussions surrounding new information. I have also appreciated the opportunity to network with some of the brightest minds in the industry.

Our Society has been incredibly lucky to have benefited from the many contributions of the outgoing President, Craig Davis. It is such a privilege to be the new President of this Society; I am confident that we can continue to build on the strong foundations that have been laid for the betterment and advancement of this membership.

Application of Visible Near-Infrared Absorbance Spectroscopy for the Determination of Soil pH and Liming Requirements for Broad-Acre Agriculture

Bethany Sleep Honours Thesis Beth.sleep@elders.com.au 0418327460

Background

Soil acidity poses a significant threat to the future production of South Australian and global agricultural systems. With current amelioration techniques commonly not accounting for spatial variability across paddocks, lime rates are not being matched to the areas which require amelioration most. Moreover, the lime requirement is currently based on only five texture classes, with limited consideration for organic matter. With the use of vis-NIR technology, pH mapping will allow growers to target lime resources where they are most needed, via obtaining pH, texture, organic carbon and cation exchange capacity concurrently, at regular intervals across the paddock. This will accelerate the amelioration of soil pH, in addition to reducing the economic strain farmers currently experience. Additionally, should vis-NIR aid in the increased adoption of soil sampling and soil acidification management, production constraints will be remedied sooner, leading to positive results in terms of overall productivity.

The objectives of this study were to;

Identify if pH and liming requirement can be predicted using portable vis-NIR and what level of accuracy is achievable under field conditions.

Examine the trade-off between sampling accuracies associated with in field vis-NIR measurements and advancements in site specific management of soil resources.

Build upon current datasets, with the intention of validating the use of portable vis-NIR soil measurements in broad-acre agriculture.

Brief Methodology

A focus paddock was sampled following a 1 ha (1oo m X 100 m) grid based pattern, with a total of 85 individual samples collected. At each sampling point a series of vis-NIR spectral readings were collected, between a spectral range of 350–2500 nm, using diffuse reflectance spectroscopy, from a RS-3500 portable spectroradiometer. In the field, two spectral signatures were taken at each sampling point, the first on the cleared, undisturbed soil surface and the second on an undisturbed 0–10 cm core. A sub-sample of soil collected from the core was then dried at 40°C for 24 hours before taking another spectral reading on the dried undisturbed core after which the sample was ground, sieved (2 mm mesh) and mixed, before taking a final spectral reading. The remaining sample was dried at 105°C for 24 hours to determine gravimetric soil moisture.

To assess the economic and agronomic impacts associated with sampling patterns, this study considered the level of accuracy achievable using a vis-NIR sampling device in a grid based sampling

pattern when compared to an aggregated simple random sample, an aggregated transect sampling pattern and grid sampling pattern using chemistry data. These methods were used to identify a blanket lime requirement for the whole paddock.

Results and Discussion

Overall, pH predictive capability was found to be moderate ($R^2 \approx 0.30$–0.49) for the field core, laboratory prepared and laboratory dried sampling protocols, with the field surface sampling protocol giving much poorer results ($R^2 \approx 0.03$–0.37) (Table 1). RMSE values were typically ≈0.6–0.7 pH units throughout the dataset and as a general rule RMSE decreased as R^2 increased. Prediction of pH_{ca} presented increased accuracies compared to pH_w when considering field sampling techniques, while samples scanned in the laboratory produced similar predictions for both pH_{ca} and pH_w (Table 1).

Encouragingly the undisturbed field cores, using no correction method, produced a similar predictive capability (pH_{ca} $R^2 = 0.47$) as the laboratory-prepared sample, using only a baseline correction method (pH_w $R^2 = 0.49$). These findings support the potential use of the vis-NIR technique in broad acre precision agriculture as an in-field sampling method requiring limited sample preparation, as a means to produce results rapidly at high sampling intensity.

Table 1 PLSR analysis, including R^2 and RMSE completed on the focus paddock dataset (n=85) for pH_w (water) and pH_{ca} ($CaCl_2$) predictions, displaying the leave four out, cross-validation model in addition to the prediction model whereby 25% (n=22) of samples were predicted using the remaining 75% (n=63). The most accurate prediction overall, with respect to the R^2 value for each sample set, comparing correction method and pH_w and pH_{ca} is highlighted in grey. The strongest predictive model overall is in bold, judged by R^2.

Sampling Protocol	Correction	Model	pH Water		pH $CaCl_2$	
			R^2	RMSE	R^2	RMSE
Field Surface	Nil	Cross-validation	0.30	0.67	0.31	0.74
	Baseline		0.28	0.69	0.31	0.74
	Baseline. SNV		0.32	0.67	0.36	0.71
	Nil	Prediction	0.33	0.64	0.37	0.73
	Baseline		0.22	0.76	0.11	0.98
	Baseline. SNV		0.03	0.80	0.28	0.81
Field Core	Nil	Cross-validation	0.49	0.58	0.51	0.63
	Baseline		0.46	0.60	0.52	0.63
	Baseline. SNV		0.47	0.60	0.51	0.62
	Nil	Prediction	0.45	0.66	0.47	0.72
	Baseline		0.30	0.90	0.39	0.88
	SNV		0.20	0.98	0.46	0.80
Laboratory Dried	Nil	Cross-validation	0.39	0.63	0.34	0.73
	Baseline		0.48	0.58	0.53	0.60
	Baseline. SNV		0.36	0.66	0.32	0.72
	Nil	Prediction	0.41	0.77	0.14	1.03
	Baseline		0.44	0.77	0.37	0.82
	Baseline. SNV		0.40	0.69	N/A	1.11
Laboratory Prepared	Nil	Cross-validation	0.42	0.62	0.44	0.66
	Baseline		0.35	0.67	0.42	0.67
	Baseline. SNV		0.49	0.59	0.48	0.65
	Nil	Prediction	0.14	0.88	0.22	0.91
	Baseline		**0.49**	0.78	0.48	0.85
	Baseline. SNV		0.35	0.83	0.40	0.89

The lime requirement models (Table 2) had increased prediction capabilities ($R^2 \approx 0.63$) in comparison to pH. This is likely due to the ability of vis-NIR to simultaneously measure the absorbance of multiple soil constituents that affect lime requirement (Eq 1-3), such as soil texture, pHBC, organic carbon, and CEC. As with the pH dataset, there were no correction methods that consistently improved accuracy. Three lime requirement calculations were explored throughout this project, reference in table 2.

Table 2 PLSR analysis including R^2 and RMSE values for the focus paddock dataset (n=85) lime requirement predictions, displaying the leave four out, cross-validation model and the prediction model whereby 25% of samples (n=22) were predicted using the remaining 75% (n=63). The best overall model, with respect to the R^2 value for each sampling protocol highlighted in grey. The most accurate prediction model overall is in bold, judged by R^2.

Sampling Protocol	Correction	Model	Lime Requirement (Hughes & Merry 2000)		Lime Requirement (Merry & Janik 1999)		Lime Requirement (McKenzie et al. 2017)	
			R^2	RMSE	R^2	RMSE	R^2	RMSE
Field Surface	Nil	Cross-validation	0.34	2.59	0.35	0.81	0.36	0.88
	Baseline		0.27	2.77	0.32	0.82	0.31	0.90
	Baseline.SNV		0.31	2.69	0.38	0.80	0.40	0.84
	Nil	Prediction	0.21	2.94	0.04	0.98	0.34	0.87
	Baseline		0.20	3.08	0.37	0.87	0.29	1.02
	Baseline.SNV		0.14	3.00	0.47	0.75	0.48	0.81
Field Core	Nil	Cross-validation	0.45	2.37	0.51	0.70	0.52	0.76
	Baseline		0.47	2.35	0.51	0.72	0.49	0.78
	Baseline.SNV		0.44	3.23	0.55	0.76	0.46	1.04
	Nil	Prediction	0.55	2.36	0.35	0.91	0.50	0.80
	Baseline		0.32	3.44	0.46	0.95	0.50	1.00
	Baseline.SNV		0.44	3.23	0.55	0.76	0.46	1.04
Laboratory Dried	Nil	Cross-validation	0.34	2.60	0.46	0.74	0.38	0.85
	Baseline		0.45	2.41	0.61	0.63	0.57	0.72
	Baseline.SNV		0.30	2.73	0.39	0.77	0.39	0.85
	Nil	Prediction	0.49	2.79	0.53	0.83	0.23	1.21
	Baseline		0.45	3.07	0.46	0.88	0.47	0.95
	Baseline.SNV		0.39	3.08	0.57	0.80	0.55	0.87
Laboratory Prepared	Nil	Cross-validation	0.46	2.42	0.45	0.74	0.44	0.83
	Baseline		0.38	2.58	0.49	0.72	0.48	0.80
	Baseline.SNV		0.43	2.46	0.46	0.73	0.49	0.79
	Nil	Prediction	0.10	3.63	0.31	0.93	0.40	0.90
	Baseline		0.43	3.27	0.59	0.81	0.57	0.89
	Baseline.SNV		NA	3.37	**0.63**	0.80	0.27	1.06

Conventional aggregated sampling methods, which use a blanket lime application approach, were directly compared to vis-NIR grid-based methods using a variable rate application. The below maps (Fig. 1a & b) display the spatial difference when comparing lime application rate between respective lime rates across the paddock. Under a random sampling approach illustrated in Figure 8a, ≈13% of the paddock received a suboptimal lime rate (1 t/ha or more), with ≈12.5% ha of the paddock receiving 1 t/ha or more lime than required. Under a transect sampling approach (Fig. 1b) ≈29% of the paddock would receive 1 t/ha or more lime than required, with only a small proportion of the

paddock receiving suboptimal lime rates under this scenario. Moving to a variable rate lime application derived from vis-NIR analysis in this scenario could achieve the potential benefits of increased crop production on the acidic zones and reduced negative effects experienced in the alkaline regions of the paddock.

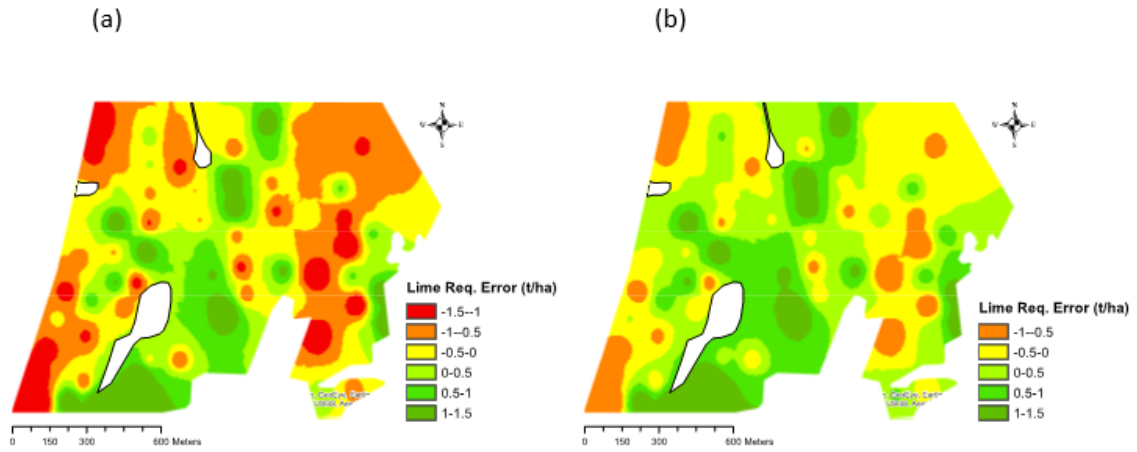

Fig. 1 Spatial differences between a blanket lime requirement derived from either; (a) random aggregated sampling pattern or (b) an aggregated transect sampling pattern when subtracted from the predicted vis-NIR lime requirement derived using Merry and Janik (1999) lime requirement cross-validation dataset with no correction for the field core sampling protocol.

Conclusions

The main limitations associated with the use of vis-NIR in field can be broken down into three main components. Firstly, the masking of the soil surface by historic crop debris and other plant matter causing peaks which are measuring material other than the soil resource. Secondly, the use of insufficient spectral resolution or incorrect mathematical algorithms and software reduced accuracy. Finally, the lack of calibration via consistent ground-truthing. To overcome these limitations further studies involving more samples and locations are required to build a spectral library and knowledge around its application.

Acknowledgements

This paper was completed as part of an honours project, whereby I was mentored by Assoc. Prof. Luke Mosley, Les Janik and Dr Sean Mason, who are also co-authors to the final published paper. The project also utilised equipment from APAL laboratory.

Leigh Creek Update

Leigh Creek Energy (ASX:LCK) is developing its flagship Leigh Creek Urea Project (LCUP), located 550km north of Adelaide in South Australia.

The $2.6 billion LCUP will be the lowest-cost sovereign producer of urea, producing nitrogen-based fertiliser for local and export agriculture markets. It will provide additional security to a critical product for the Australian agricultural sector and avoid supply-side risks associated with international transport, exchange rates, commodity prices and import logistics that Australian farmers contend with.

The LCUP is the only fully integrated urea production facility in Australia, with all inputs (gas feedstock, power and logistics) for low carbon urea production available on-site. The urea plant will initially produce 1 million tonnes per annum of urea, with potential to increase to 2 mtpa. It will use LCK's 1,153PJ 2P gas reserves which are sufficient to operate the plant for 30+ years.

Average nominal operating cost are forecast to be $109 per tonne which is within the lowest cost quartile of the global urea production cost curve. Pre-tax leveraged Net Present Value (NPV) is A$3.4 billion, with an Internal Rate of Return (IRR) of 30%.

LCK will be carbon neutral from 2022 and has a comprehensive environment, social and governance strategy to achieve this. It has produced syngas within all approved environmental parameters set by the regulator and will achieve carbon neutrality through a combination of renewables, purchased offsets and carbon farming programs, eight years ahead of schedule. LCK recently confirmed the engineering and geological viability of Carbon Capture and Storage of CO_2 at the LCUP.

The company has signed an Engineering, Procurement, Construction and Commissioning contract (EPCC) with major South Korean engineering and construction company, DL E&C, (part of the Daelim conglomerate) to provide development of all downstream operations (the above-ground operations that manufacture the ammonia and urea). Daelim is one of the largest and most experienced developers of infrastructure projects of this type in the world.

In conjunction with the EPCC, a letter of support from a major South Korean bank has been issued to LCK to provide debt finance for up to 70% (or AUD ~$1.5 billion) of the above ground development project costs.

DL E&C/Dealim is progressing the Front-End Engineering and Design (FEED) stages, ahead of the Final Investment Decision (FID). It has resourced over 100 professional and engineers on the project, and intends on establishing a presence in SA in the near future. NexantECA will independently manage the Bankable Feasibility Study (BFS) process for the LCUP, on behalf of Daelim.

During construction between late 2021 to 2024, the LCUP will be one of the largest infrastructure projects in South Australia creating thousands of construction jobs. Once operations start the LCUP will create 500 direct and several hundred more indirect jobs for the Northern Flinders Ranges region.

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Narrow-leaved lupin (Lupinus angustifolius) response to boxlozone (Overwatch)

Roberto Busi, PhD Australian Herbicide Resistance Initiative University of Western Australia

Figure 1. Lupin plants (var. Barlock) sprayed with 2.5, 5 or 10 g ai bixlozone / ha (equivalent to 6.25, 12.5 and 25 ml Overwatch / ha, respectively) compared to untreated control (0).

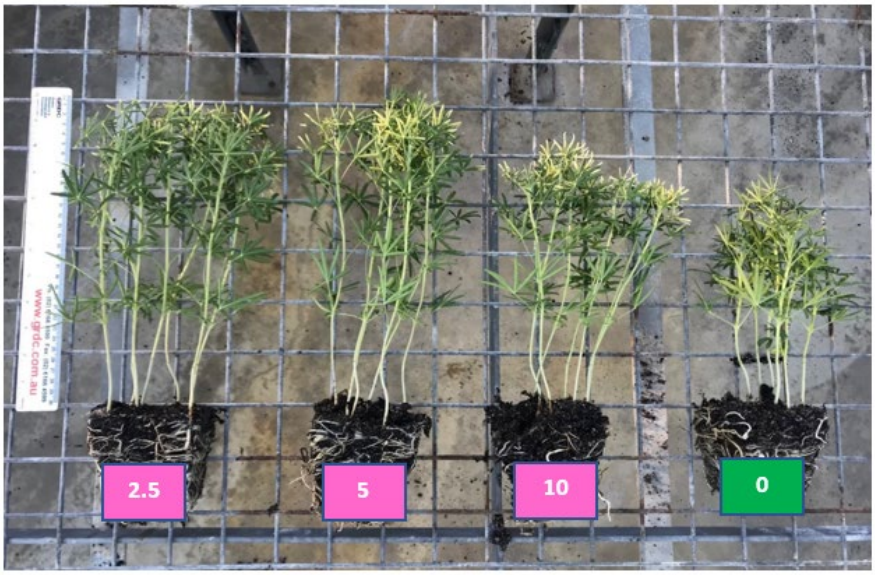

Figure 2. Lupin plants (var. Barlock) sprayed with 2.5, 5 or 10 g ai bixlozone / ha (equivalent to 6.25, 12.5 and 25 ml Overwatch / ha, respectively) compared to untreated control (0). Roots exposed.

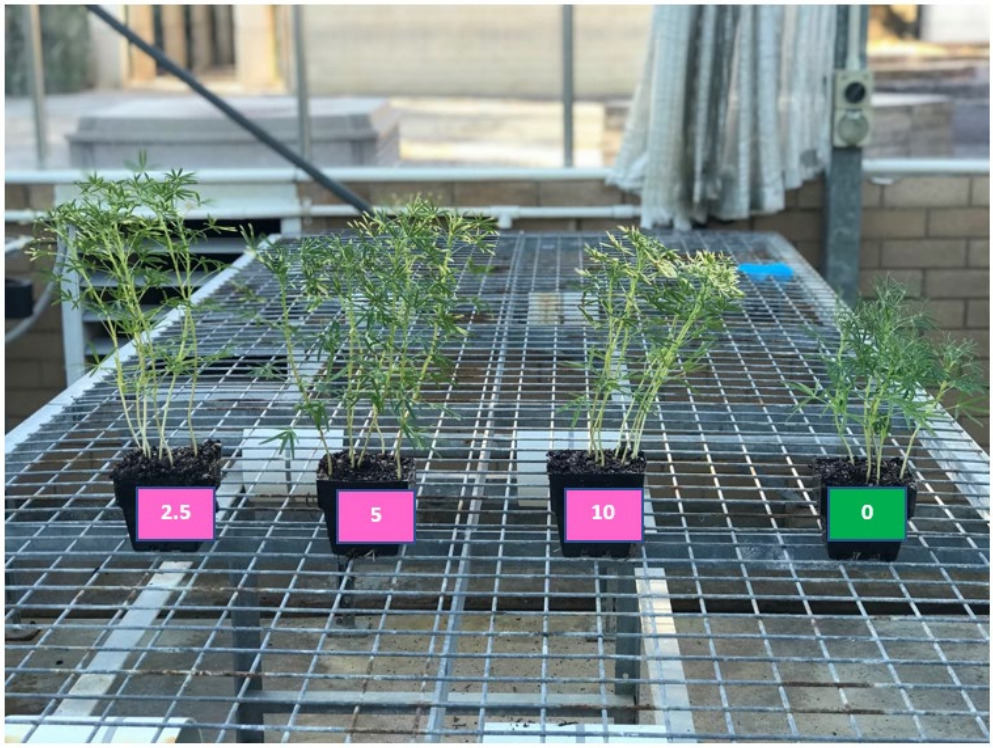

Figure 3. Lupin (var. Barlock) plants sprayed with 2.5, 5 or 10 g ai bixlozone / ha (equivalent to 6.25, 12.5 and 25 ml Overwatch / ha, respectively) compared to untreated control (0).

Figure 4. Lupin plants sprayed with 2.5, 5 or 10 g ai bixlozone / ha (equivalent to 6.25, 12.5 and 25 ml Overwatch / ha, respectively) compared to untreated control (0). Bird eye view.

Table 1. Plant height and fresh weight (aboveground biomass) of lupin plants assessed 3 weeks after herbicide treatment. Data are expressed as percentage of untreated control. The statistical analysis of variance (ANOVA) was conducted on actual biomass (grams) or height values (centimetres). Different letters indicate statistically significant differences in mean values presented ($P < 0.05$).

		Individual lupin plants (*n = 30*)			
ml OW /ha	g OW ai /ha	Height (%)	ANOVA	Weight (%)	ANOVA
0	0	100.0	a	100.0	a
25	10	119.5	b	100.8	a
12.5	5	137.7	c	108.4	ab
6.25	2.5	134.5	c	113.9	b

In this study **Narrow-leaved lupin (*Lupinus angustifolius*)** plants **sown on July 10th and sprayed on August 12th** – were assessed three weeks after herbicide treatments. Plants were grown and kept in a glasshouse environment for the full length of the study. Overwatch was applied post-emergence to fully developed lupin plants about four weeks after sowing. No other herbicides were applied.

Plant biomass and height of lupins treated with **6.25 ml Overwatch / ha** (1/200th of the full label rate) appear **significantly greater** than the **untreated control**. This phenomenon of (plant) growth stimulation in response to a moderate stress or toxin is known in biology with the term of 'hormesis'.

This study is part of a larger series of studies aimed to understand the response of lupins to overwatch herbicide under a **controlled glasshouse environment**. Full results will be presented at 2022 GRDC Grains Updates (depending on acceptance of EOI).

Photos are also available on Twitter: @robbert115, @resistance_test.