Diffusive Gradients in Thin-Films (DGT) as the soil test of choice for predicting phosphorus requirements of grain crops

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Grain growing regions across southern Australia

Key messages:

- DGT has shown to be an improved method for accurately predicting crop response to phosphorus (P) applications compared to traditional soil testing methods.
- With the use of DGT, P fertiliser decisions can be made with greater confidence and accuracy.
- Minimal yield responses to fertiliser from the P residual trial at Kerribee were predicted by both DGT and bicarbonate extractable P (Colwell P) + Phosphorus Buffering Index (PBI).

Aims:

- Further validate performance of the DGT method for accurately predicting wheat responses to P in different climatic conditions.
- To compare residual P values from different management treatments after a series of dry years at Kerribee.

Background:

There is a major economic benefit in developing a soil test capable of accurately predicting the P status of a soil, which in turn will facilitate efficient fertiliser strategies. The imperative for optimising fertiliser use has recently been emphasised in grain producing regions of southern Australia due to drought and fluctuating fertiliser and grain prices.

Field validation DGT technology for predicting wheat responses to P has demonstrated DGT is more accurate than other soil tests (Colwell P and the anion exchange membrane technique (resin P)) for assessing available P. The DGT test is said to mimic a plant root by only measuring P that is available to the plant.

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Also available at: http://www.msfp.org.au/research.php?page=compendiums

About the trial:

P replicated field trials across southern Australia

Replicated P response trials that were performed across grain growing regions across southern Australia from 2006 onwards were used in the validation of DGT and to test the performance of other soil tests (Colwell P, resin) for predicting wheat response to P applications in the field. In total 25 field trials were used and the spread of locations were as follows: W.A. (1 site); S.A. (7 sites); VIC (8 sites); and, NSW (9 sites).

Broadly, each field trial had a minimum of two rates of phosphorus fertiliser and a zero P application control in a replicated (3, 4 or 6) small plot scenario with a completely randomised block design.
Soil samples (0-10 cm) were collected from the control plots (zero fertiliser). Soil sampling was performed at the time of sowing each trial and where possible each control plot was treated as a separate sample, otherwise a bulk sample of the control plots was obtained.

Kerribee P recovery trial

This small plot trial has been established since 2007 and is located at the Kerribee Core Research Site which is situated in south west NSW approximately 30 km south east of Mildura. The trial is a completely randomized design with 6 treatments and 4 replicates with a range of input levels (seed, P, N) over the 3 cropping seasons **(Table 1)**. The aim in 2009 was to establish what happens to different P inputs sown in 2007 and 2008 after drought conditions so the trial was sown in 2009 with no fertiliser over all treatments. Summary of total P inputs is shown in Table 2.

Table 1. Treatment inputs over three growing seasons (2007 – 2009) for the Kerribee P recovery trial.

Treatment 2007	Description	P as MAP kg/ha	N kg/ha	Topdress N kg/ha	Seed Rate
1	Low Inputs	5	2.3		20
2	Average Inputs	10	19.5		40
3	High Inputs	15	31.8		40
4	Very High Inputs	20	34.1	20	60
5	Average Inputs half N at sowing	10	12	tactical	40
6	Average Inputs top dress later	10	4.5	tactical	40
2008					
1	Low Inputs	5	25		40
2	Average Inputs	0	25		40
3	High Inputs	0	25		40
4	Very High Inputs	0	25		40
5	Average Inputs half N at sowing	10	25		40
6	Average Inputs top dress later	10	25	topdress	40
2009					
1	Low Inputs	0	0		30
2	Average Inputs	0	0		30
3	High Inputs	0	0		30
4	Very High Inputs	0	0		30
5	Average Inputs half N at sowing	0	0		30
6	Average Inputs top dress later	0	0		30

Table 2. Total P inputs over three growing seasons (2007 – 2009) for the Kerribee P recovery trial.

Treatment	Description	Total P as MAP (07-09) kg/ha
1	Low Inputs	10 (5 in 2007 + 5 in 2008)
2	Average Inputs	10 (2007)
3	High Inputs	15 (2007)
4	Very High Inputs	20 (2007)
5	Average Inputs half N at sowing	20 (10 in 2007 + 10 in 2008)
6	Average Inputs top dress later	20 (10 in 2007 + 10 in 2008)

Assessments:

The collection of data at the replicated field trial sites included:

- Soil P tests – DGT, Colwell P, PBI and critical Colwell P
- Plant data – yields at late tillering (GS30) and grain yields at maturity
- Wheat response to P was obtained by calculating % relative yield
- % relative yield = Yield (control, 0P)/ Yield (Max. with P) x 100

The collection of data at the Kerribee trial site included:

- Soil P tests – DGT, Colwell P, PBI and critical Colwell P
- Plant data – Grain yield at maturity

Results:

Replicated field trials 2006-2009

Soil test relationships with wheat response

Colwell P

There was no significant relationship ($p \leq 0.05$) between Colwell P values and wheat response to applied P at either early growth or maturity **(Figure 1)** highlighting the ineffectiveness of using the Colwell P method to assess available P or predict growth responses to additions of P, especially across vastly different soil types.

Problems associated with this method include using a wide soil (1g): extractant (100ml) ratio. The soil P chemistry can change at these dilutions making a comparison to P chemistry at typical field moistures difficult. The other major complication of the Colwell P method is that the bicarbonate extractant used has the potential to displace relatively stable forms of P that are associated with calcium (Ca) in alkaline soils and potentially iron (Fe), aluminum (Al) in acidic soils. These forms are typically unavailable for plant uptake.

It has recently been suggested that there are benefits of combining PBI measurements with Colwell P values in order to improve the interpretation of Colwell P (Moody 2007). From the 25 field sites used in the relationship between Colwell P and crop response to P, the Colwell P + PBI method correctly predicted the response of 14 sites (56 %).

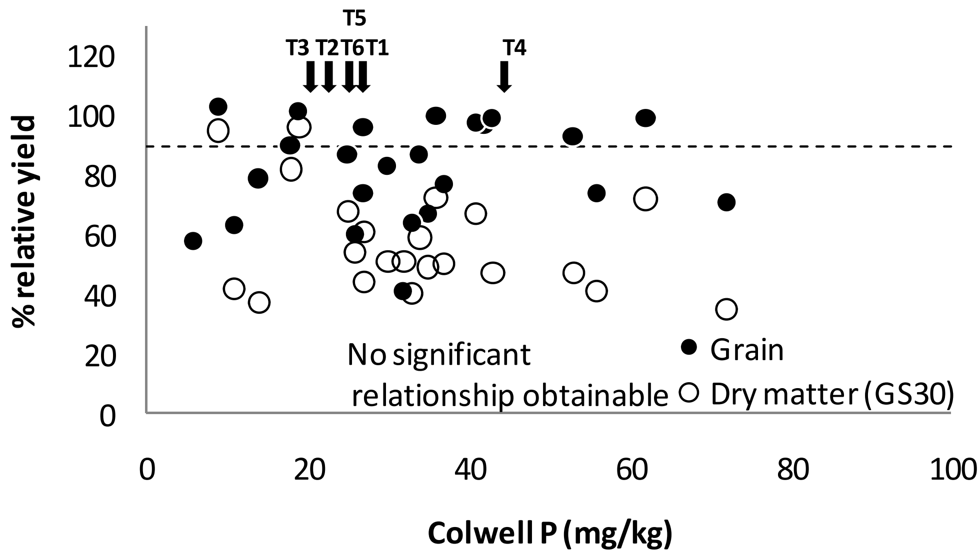

Figure 1. Colwell P relationship with wheat response to P at early dry matter and grain from replicated field trials. Arrows indicate Kerribee Colwell P values for each treatment.

<u>DGT</u>

The DGT method was highly effective in predicting wheat response to applied fertiliser P, producing high relationships between DGT values and both early dry matter production and grain production **(Figure 2)**.

The DGT results presented from these trials provides optimism that a robust technique is available that correctly assesses plant available P and predicts response to application of P regardless of soil type and therefore requires no other corrections or interpretation.

The DGT method mimics a plant root by only measuring P available for plant uptake. By providing a sink for P capture similar to the mechanism of a plant root, the chemistry of P in the soil is relatively undisturbed and the measurement is performed on soils at more relevant soil moistures.

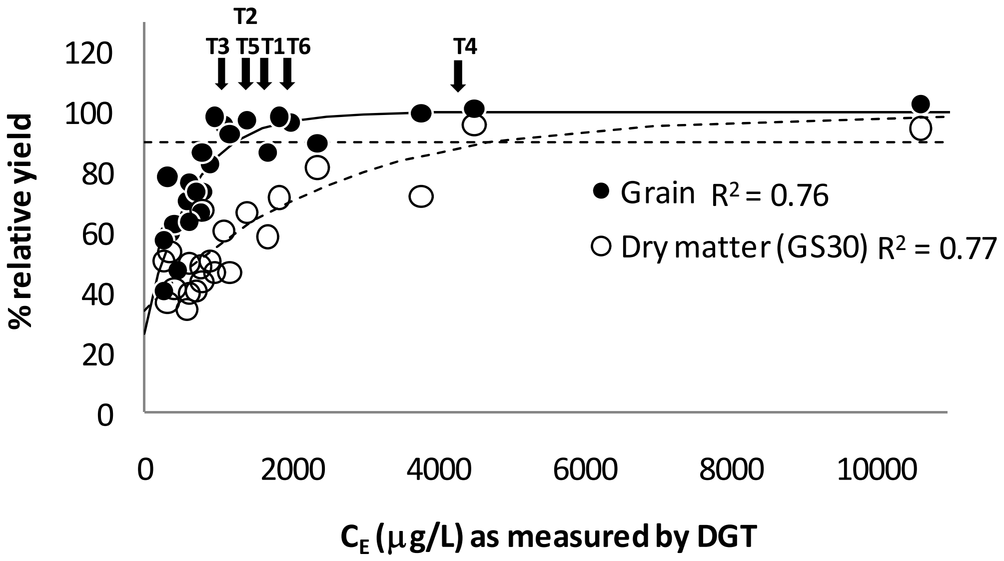

Figure 2. DGT relationship with wheat response to P at early dry matter and grain from replicated field trials. Arrows indicate Kerribee DGT values for each treatment.

Kerribee P recovery trial

Table 3. Soil test results and yields from all treatments at the Kerribee P recovery trial. Values are mean values of 4 replicates.

Treatment	Description	Colwell P mg/kg	PBI	Critical Colwell P* mg/kg	DGT (C_E) µg/L	Grain yield t/ha
1	Low Inputs	28	57	22	1797	1.29
2	Average Inputs	24	56	22	1510	1.22
3	High Inputs	21.5	56	22	1161	1.23
4	Very High Inputs	45	59	23	4278	1.27
5	Average Inputs half N at sowing	26	58	23	1533	1.27
6	Average Inputs top dress later	27	56	22	2029	1.22

*Calulated from Moody 2007 AJSR

Soil tests

Both Colwell P and DGT measurements from all treatments had a similar trend **(Table 3).** The very high input treatment from 2007 has produced the highest soil test values. Treatments 1, 2, 5 and 6 had similar soil test values while treatment 3 had the lowest available P as measured by DGT and Colwell P. The trend in soil test values did not necessarily coincide with the amounts of P applied. There does appear to be some value in applying fresh P as the low input treatment (1) has comparable available P values to treatments 2 and 3 even though they have had similar inputs but all in 2007.

<u>Plant yields</u>
There was no yield (grain) benefit between any treatments in 2009. Similar results also occurred for the 2007 and 2008 growing seasons. This indicates the low input treatment has been sufficient in maximising grain yields over the past three growing seasons. Low PBI results from this site indicate that potential tie up of P fertilizer is low and fertiliser efficiency is high.

Even though both Colwell P and DGT soil tests resulted in a similar trend between treatments, the high relationship between DGT and wheat response from replicated field trials assists in the explanation of expected crop response. All treatments had adequate P (DGT > 1100 μg/L) and as shown in Figure 2, a minimal grain response between treatments is expected. Treatment 3 is close to the threshold of P grain deficiency so increases in yield might be expected with the other treatments if the trial is to be performed again in 2010 with no P inputs. The critical threshold for adequate P required for maximum dry matter response is a lot higher in terms of DGT values. Significant dry matter responses would be expected in this trial between treatments 3 (DGT = 1161 ug/L) and treatment 4 (DGT = 4278 ug/L). In 2007 significant dry matter responses were observed with P rate up to treatment 4 (20 kg/ha). By supplying very high inputs of P in 2007 it appears the higher residual P in this treatment is due to less P removal over the three years as the initial input was sufficient for dry matter production.

Who's Involved:
The trial is supported by;
- MSF Inc.
- GRDC
- All the collaborators who have kindly let the DGT project team be involved in their trials

Activities, Events and Industry Participation:
- MSF field day August 2009
- BCG field day September 2009
- GRDC updates February 2009, Wagga Wagga, Adelaide, Ballarat
- Minnipa field day September 2009
- Crop Doctor – January 2010 New DGT phosphorus soil test getting closer to grower use
- Eyre Peninsula Farming Systems Research book, 2008
- BCG research book, 2008

Future Directions:

- Field validation of the DGT method will continue through the 2010 and 2011 growing season
- Database of the P requirements of other crop types and relationships with DGT will be expanded by using 2009 trial data
- The potential of DGT to predict crop deficiencies for other nutrients will be realised.

References:

Moody P W 2007 Interpretation of a single-point P buffering index for adjusting critical levels of the Colwell soil P test. Aust. J. Soil Res. 45, 55-62.

Acknowledgements:

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For more information, please contact:

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