A new test to accurately predict phosphorus fertiliser requirements

Sean Mason, *(University of Adelaide)*

Take home messages

- *The DGT method is an improved soil test for predicting P response from a given soil*
- *Greater confidence in accurately predicting P fertiliser requirements can be obtained from using DGT measurements*
- *Lack of response to liquid and granular P at two trial sites in the Birchip region were explained with greater accuracy using DGT measurements.*

Methods

Diffusive Gradients in Thin-Films (DGT) technology has been recently modified for the assessment of available phosphorus and micro-nutrients in Australian agricultural soils (Mason et al. 2005, 2007). Initial testing of the technology for prediction of wheat response to P in the glasshouse had shown that DGT was more accurate compared to other soil tests for available P (Colwell P, Olsen P and resin P).

Further extension of this work was performed in 2007 with the main aim to determine if DGT could predict P fertiliser requirements for the field and to compare results from the DGT soil P test with other common soil P testing techniques (Colwell P and resin). Two sites were chosen in the Victorian Mallee.

Additional soil samples (0-10cm) were taken at the end of tillering (GS30) from all plots within the row in order to assess the effectiveness of liquid and granular P fertilisers at providing an additional source of P to the soil.

Available P measurements were performed on the soil samples by DGT, Colwell and resin techniques. The Colwell P method was performed as described in Colwell 1963 and the resin P method followed the procedure as described by Saggar in 1999.

Available P measurements for each soil test were compared to early dry matter production (GS30) and grain yield from the two sites. Expected P responses from the two sites were evaluated from the relationship obtained by collating McBeath et al. 2005 and 2007 where soil available P measurements on 56 soils were compared to the response of wheat (at tillering) to an application of liquid P (12 kg/ha).

Results

Soil test results

Soil testing measurements from the two sites at different sampling dates are shown in Table 1.

Site	Sampling date	C_E (µg L^{-1}) DGT	Resin P mg kg^{-1}	Colwell P mg kg^{-1}
Hopetoun 2006	Harvest	2641	12	18
Hopetoun 2007	Sowing	2320	15	21
Hopetoun 2007	Tillering	2037	16	na
Birchip 2007	Sowing	1187	17	27

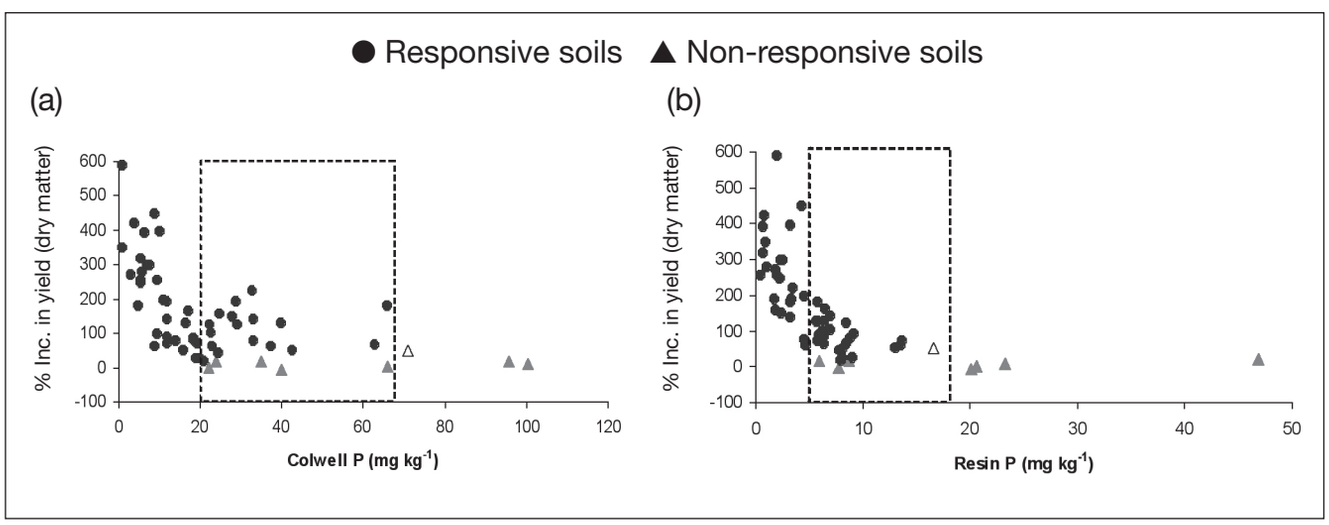
Expected yield response

Expected dry matter response at tillering to an application of P at the Birchip and Hopetoun sites was predicted for the above soil test data using relationships generated from data published in McBeath et al. 2005 and 2007 (see Figure 1).

Due to the poor separation of non-responsive and responsive soils for the Colwell method (Figure 1a), the expected dry matter response for both sites is inconclusive and could range anywhere from a non-response to a significant response (< 200 %). The resin method is also inconclusive but values from both sites again suggest an expected dry matter outcome from a non-response to a significant response (< 50 %). Effective concentration (C_E) values as measured by DGT for both sites are above the critical P deficiency threshold for an application rate of 12 kg/ha and therefore suggest both sites will be non-responsive to an application to P.

Comparing soil P test data between the two sites, both the Colwell and resin method indicate that the Birchip site has a higher amount of available P and therefore any response to P would be greater at the Hopetoun site. The DGT value for the Birchip site is approximately half of that measured for Hopetoun suggesting that any response would occur at Birchip before Hopetoun.

The fact that DGT seems to be more clearly separating responsive and non-responsive soils than the other tests for the McBeath et al. data (Figure 1) should thus give improved confidence in the predictions for Hopetoun and Birchip.



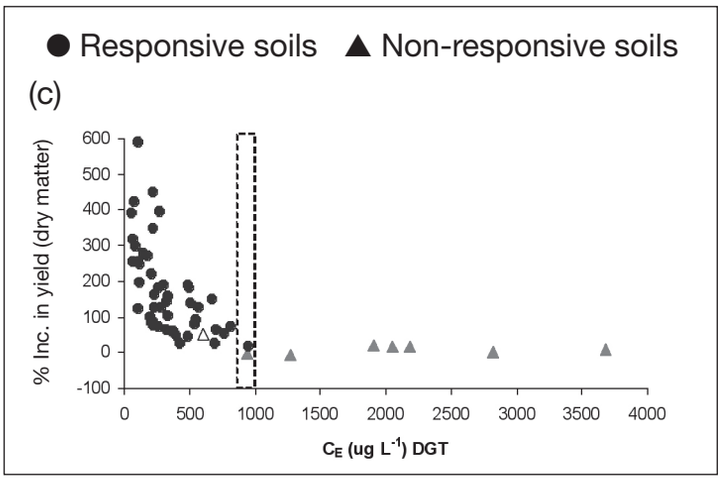


Figure 1. Relationship between % increase in yield (dry matter at tillering) over the control from an application of 12 kg/ha liquid P with a) Colwell P b) resin P and c) DGT. Dashed window represents the area (soil test value) of responsive and non-responsive soil overlap. Data taken from McBeath *et al.* 2005 and 2007.

At P application rate of 12 kg/ha, critical P deficiency thresholds as assessed by soil tests were: Colwell P (22 – 66 mg kg^{-1}), Resin P (6 – 13.7 mg kg^{-1}), DGT (946 – 956 μg L^{-1}, C_E)

Dry matter and grain yield data

There was a significant increase in dry matter yield at tillering obtained from the application of both liquid P (TGMAP) and granular P (MAP) at the Birchip site (Table 2) although predictions based on previous DGT data suggest that the Birchip site should be non-responsive. However, the relatively small dry matter response could indicate that the DGT threshold for responsiveness should be higher than ~ 950 μg L^{-1} which was ascertained from glasshouse studies. This critical threshold was obtained under optimal conditions with no water limitations. Water limitations in the field could exacerbate any P deficiency present.

At Hopetoun there was no significant response to applied P (liquid and granular) up to 18 kg/ha. The two sites both showed no significant increase in grain yield with applied P. Grain yield non-responses are in accordance with predicted yields as assessed by DGT (Figure 1). Both resin and Colwell P predictions were inconclusive for Birchip and Hopetoun although there was a larger uncertainty using Colwell. The early dry matter response from the Birchip site compared to the non-response to P at Hopetoun could only be explained by DGT. The value obtained by DGT (Effective Concentration, CE) at Birchip was significantly lower than at Hopetoun. Yield response predictions based on both Colwell P and resin tests were in fact the opposite as the Birchip site resulted in higher values than at Hopetoun (Table 1).

Table 2. Dry matter and grain yield data from the two sites (Hopetoun and Birchip) at tillering and maturity expressed as a % increase in yield over the control.

Location	Sampling Time	P rate (kg P/ha)	% increase in yield
Hopetoun	Tillering – dry matter	Up to 18kg P/ha	< 15% Liquid
			< 8% Granular
	Harvest - grain	Up to 18kg P/ha	< 6% Liquid
			< 7% Granular
Birchip	Tillering – dry matter	6kg P/ha	49% Fluid
			19% Granular
	Harvest - grain	6kg P/ha	4% Liquid
			3% Granular

Liquid vs Granular P efficiency

Any benefit in yield response from applying P in a liquid form compared to the granular form was masked by the fact that both these two sites were non-responsive to P. However the effectiveness of liquid P application compared to granular P at the Hopetoun site was assessed by the soil testing

methods performed on samples taken from each plot. The available P as measured by DGT and resin P were all substantially higher for the plots with liquid P application when directly related to the same P application rate in granular form for rates above 6 kg/ha (Figure 2). Although the increased available P in the soil when applied as liquid P did not result in any yield benefits, there could be some substantial benefits with an increase in residual P for future crops if the soil does become P deficient over time due to P removal and fixation.

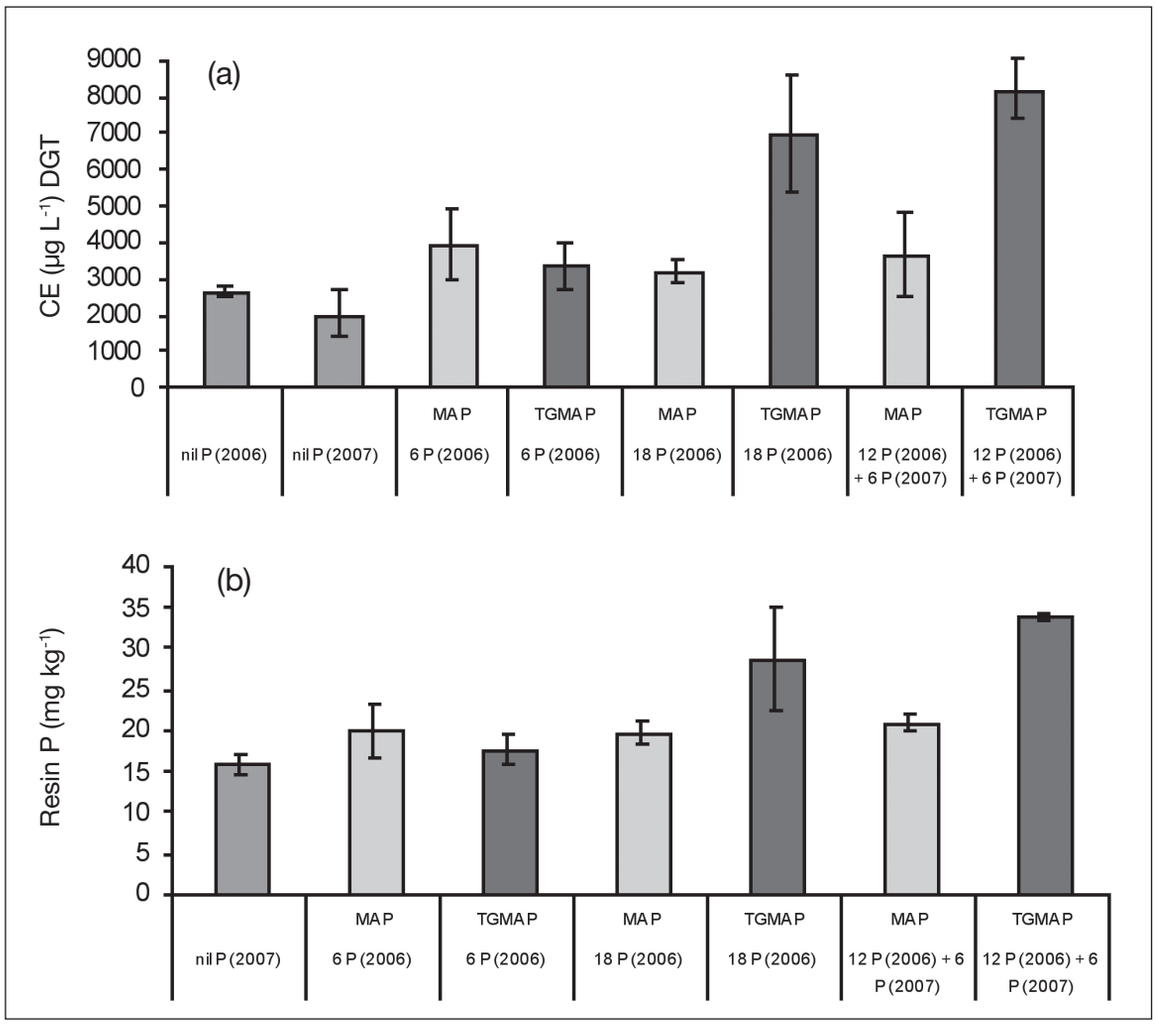


Figure 2. Available P measured by a) DGT and b) resin P from soil samples taken in plots with different applications of P in 2006 and 2007. Refer to Simon Craig's article for detailed site information. **Note:** MAP is a commonly used granular fertiliser; TGMAP has a similar formulation as MAP but is soluble in water (Liquid)

Commercial Practice

Currently DGT is a laboratory based test. If at the completion of the 2007 growing season further data supporting DGT as a better predictor of plant available P is obtained then an attempt will be made to progress DGT as a commercial soil test for P with a view to assisting farmers create better fertiliser decisions. Ideally, however, further testing of DGT is required in at least one more growing seasons to 2007.

References

McBeath T M, Armstrong R D, Lombi E, McLaughlin M J and Holloway R E 2005 Responsiveness of wheat to liquid and granular phosphorus fertilisers in southern Australia. Aust. J.Soil Res. 43, 203-212.

McBeath T M, McLaughlin M J, Armstrong R D, Bell M, Bolland M D A, Conyers M K, Holloway R E and Mason S D 2007 Predicting the response of wheat (Titicum aestivum L.) to liquid and granular phosphorus fertilisers in Australian soils. Aust. J.Soil Res. 45, 448-458.