THE CURRENT STATUS OF PLANT AVAILABLE PHOSPHORUS IN BROAD ACRE CROPPING AS ASSESSED USING THE NEW P TEST (DGT)

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Background to new P test

Diffusive Gradients in Thin-Films (DGT) technology has been recently modified for the assessment of available phosphorus and micro-nutrients in Australian agricultural soils. Initial testing of the technology for prediction of wheat response to P in the glasshouse (CSO00007) and in the field (UA00095) has clearly demonstrated the greater accuracy of DGT compared to other soil tests for assessing available P (Colwell P, Olsen P and resin). One reason for this is that the DGT test is said to mimic a plant root by only measuring the P in the soil that is accessible by the plant. Placed on top of a moist soil sample a DGT device contains a ferrihydrite (form of iron) gel which binds the P diffusing towards it. The gel is very specific for P and is free of any other element competition. After a certain time of deployment on the soil (typically 24 hours) the P bound to the gel is removed using an acidic solution and the amount of P in the eluted solution is then measured. It is these DGT deployment conditions and the use of an iron-based gel that sets it apart from other common soil P tests.

Further problems with current common soil P tests are that they use a relatively small amount of soil to solution ratio and either use an extracting solution to displace P or an anion exchange membrane to capture P in the solution. The Colwell P method is dependent on soil type and different critical values have been published for certain types of soil. In addition the method uses an extracting ion (bicarbonate) to assess the ‘available P’ fraction from the soil. In some cases the extracting solution can solubilise relatively stable forms of P and hence overestimate the plant available P fraction. As an example, on calcareous soils the Colwell P can overestimate P availability by solubilising a portion of the unavailable P tied up with the high percentage of calcium in the soil. It has been suggested that for more reliable results on various soil types, Colwell measurements can be combined with the P buffering index (PBI) of the soil. However, in this recent work funded by GRDC (UA00095), using PBI measurements from the field soils did not decrease the uncertainty involved with the Colwell P method.

Early Dry Matter vs Grain response to P

During the period spent validating the new P test (2006-2008) there has been varying climatic seasons but unfortunately all three years have seen a very dry finish to the year putting crops under severe moisture stress. The dry finish has resulted in several P deficient sites not demonstrating significant grain (wheat) response although they did show large responses to P in early growth stages. For this reason the relationship between DGT P and grain response is slightly lower compared to that with early dry matter results (Figure 1) and the critical P deficiency threshold for grain identified from DGT P is also considerably lower than that obtained for earlier growth stages. The conundrum is that whilst P is important in early crop growth stages it may set up a yield potential that simply cannot be fulfilled if there is insufficient moisture available during the later stages. Further studies of grain P response in seasons with more favourable finishes are needed to determine if there is a tighter relationship with DGT P which would be expected from the dry matter responses and the current project will address this.

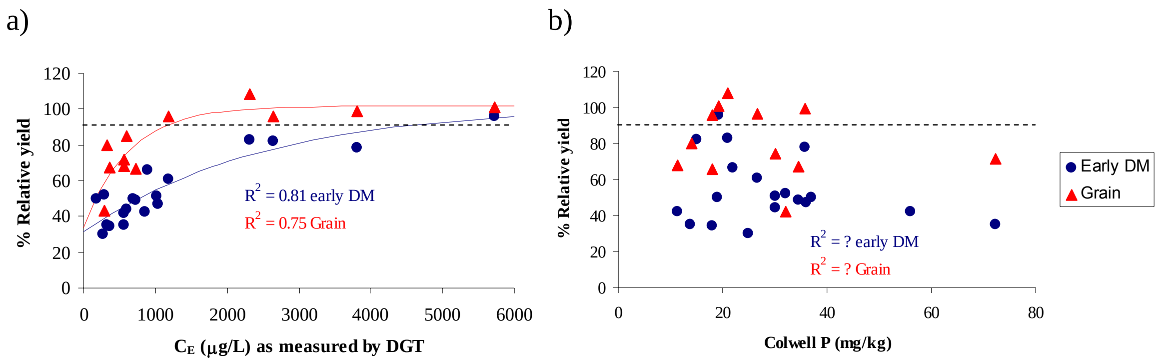

Figure 1. Relationship between crop dry matter yields taken at mid-late tillering and grain yields (expressed as % relative DM yield) with soil available P test value measured using a) DGT and b) Colwell P.

Critical P deficiency thresholds for different crop types

The validation of the DGT test so far has mainly focused on assessing the response of wheat to an application of P. Other crop types will have different capabilities for accessing and mobilising P in soil due to variations in root morphology, distribution and function and therefore will have varying phosphorus requirements. In 2008 work on the validation of the DGT test has expanded to assess other crop types and their P requirements with respect to available P in soil as assessed by DGT. Relationships of early dry matter responses of three other crops (peas, canola and barley) with DGT measurements look promising for determining the critical thresholds of these crop types (Figure 2). The order of critical P deficiency thresholds appears to be peas > canola ≥ barley > wheat. The database for these crop types is currently small but will be enlarged with data from future growing seasons. Reliable assessment of the P requirements of these crops will provide the farmer with valuable information in order to maximise P fertiliser efficiency and help to develop a crop rotation plan that will maximise yields on a paddock basis.

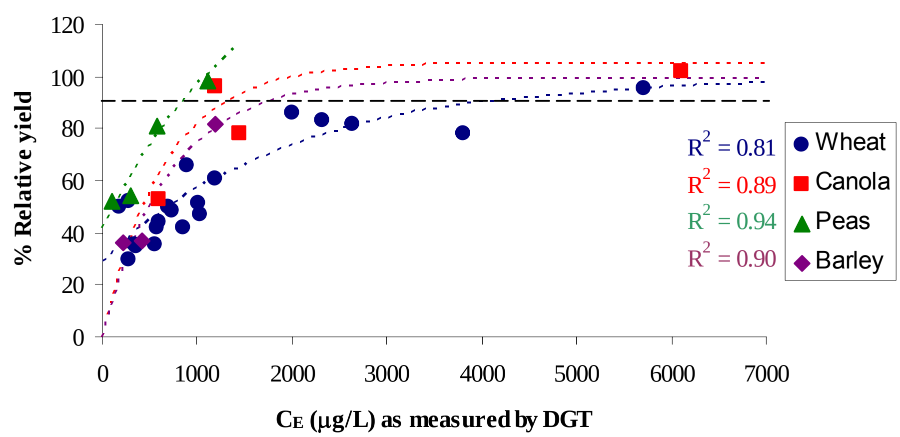

Figure 2. Relationship between crop dry matter yields of four different crops taken at mid-late tillering (expressed as % relative DM yield) with DGT.

Using DGT and PBI to predict fertiliser requirements

Accurate and reliable knowledge of the amount of available P in a given soil is critical to fertiliser decisions such as determining whether it will be safe to reduce the amount of P fertiliser applied in a given year. However the measurement of available P in a soil sample does not provide any indication of how much P fertiliser will be available once it is applied to a soil. The Phosphorus Buffering Index (PBI) provides an indication of this and together with an accurate soil test (DGT) will help improve fertiliser recommendations. From the field sites analysed for P responsiveness (Figure 1) it was possible to determine the amount of P required to obtain 90% maximum dry matter yield. Dry matter yields were used to represent the best case scenario for a P response in a 'perfect' year. Relating the amount of P required to the DGT measurement from that site provides an indication of the minimum amount of P required to maintain yield (Figure 3). Relatively small amounts of starter P (< 5 kg/ha) are required to maximise yields for DGT measurements > 1000 μg/L. Below this value higher P inputs are required and the amount varies depending on the PBI of that particular soil which causes only a moderate relationship with DGT (Figure 3). Different fertiliser types with contrasting P efficiency (e.g. liquid vs granular) will also affect the amount of P fertiliser required to maximise yields.

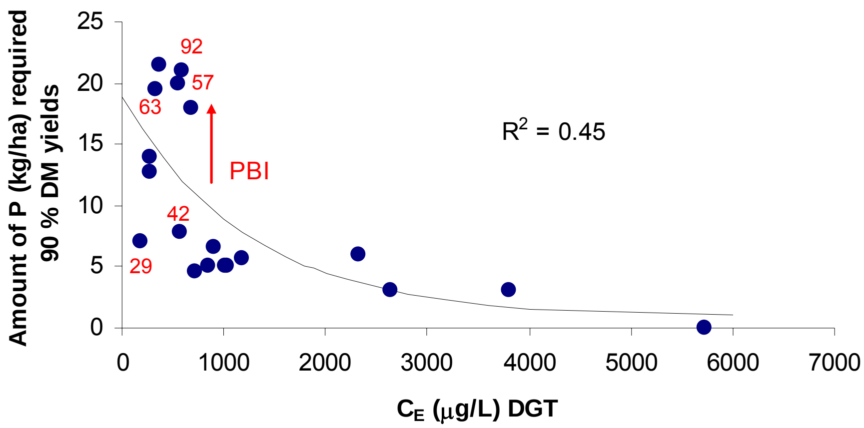

Figure 3. Relationship between the amounts of P fertiliser (granular) required to produce 90 % of the maximum dry matter yield (mid-late tillering) and DGT. Inserted numbers are selected PBI values of that site.

Farmer Survey

During the 2008 growing season a farmer survey was undertaken in order to get an idea of the current P levels in paddocks as assessed by DGT. Location of sites included the Mid North S.A., Mallee, S.A. and both the Wimmera and Mallee districts of VIC. Farmers were asked to have a control strip (0P, seeders width) in their paddock by turning off their fertiliser input. Dry matter and grain production were compared between the control strip and the applied P level adjacent to the strip in the paddock. Soil samples were collected in the control strip for DGT and Colwell P analysis. Relating the two soil tests to early dry matter response and grain response revealed that DGT was the superior soil test and could be used in this type of work to help farmers determine their current P levels in their paddocks (Figure 4). Moderately good correlations using DGT were obtained for early dry matter (R^2 = 0.67) and grain (R^2 = 0.86) responses expressed as relative yield however, no relationship could be obtained for Colwell P measurements. These results are very encouraging considering the nature of this project. The control strips were not replicated and in the majority of cases the farmer did not have the ability to balance N inputs. Outliers that showed a greater response than expected could be contributed to the added N application, therefore reduce the relationship with DGT.

It is also unclear whether the amount of P the farmer applied as their standard rate was enough to maximise yields in some cases. Importantly of the 39 paddocks tested only 11 (28 %) had DGT values below the critical P level for grain established so far from replicated field trials.

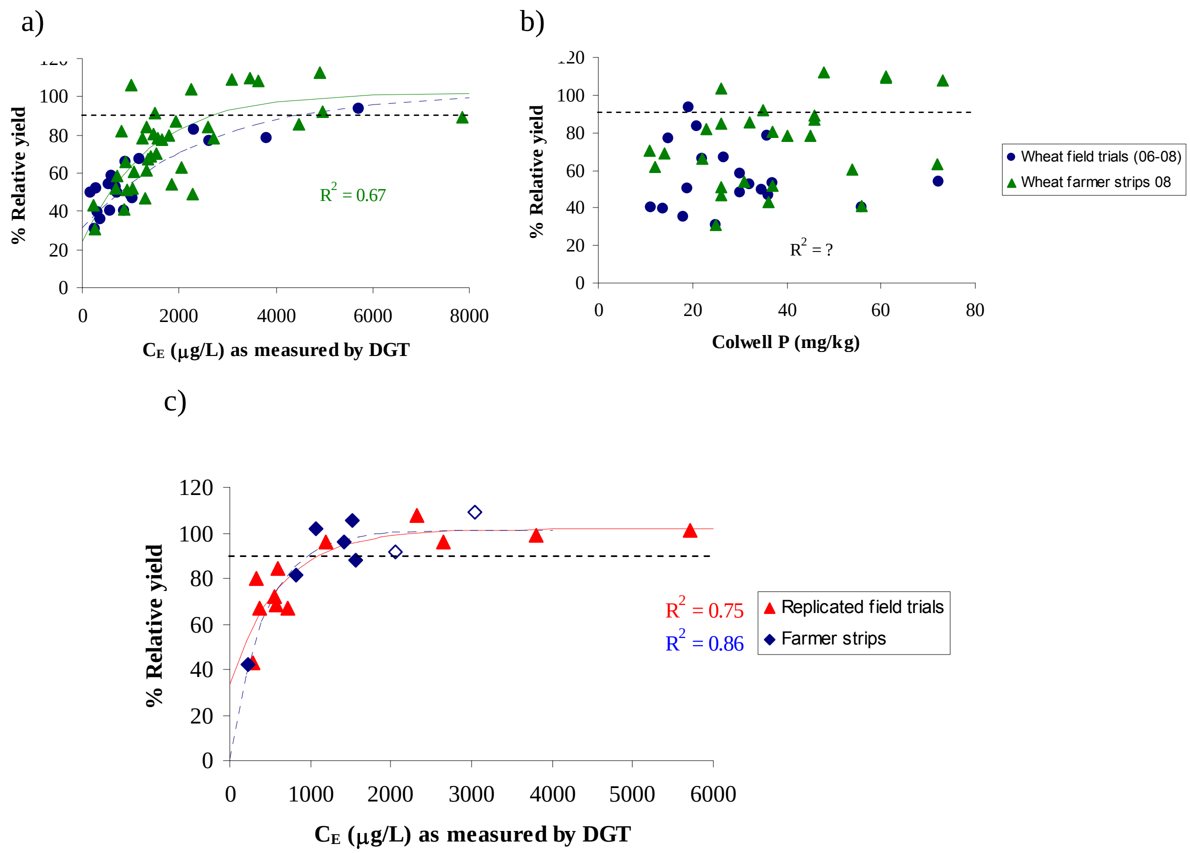

Figure 4. Relationship between crop dry matter yields from farmer strips taken at mid-late tillering (expressed as % relative DM yield) with soil available P test value measured using a) DGT, b) Colwell P and c) Grain yield relationship from field trials and farmer strips (data obtained to date) with DGT.

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