Performance of DGT and Colwell P in predicting phosphorus responses in the Wimmera Mallee

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Aim

To compare two soil phosphorus (P) tests (Diffusive Gradient Thin Films (DGT) and Colwell P) for their prediction of crop responses to applied-P in farmer paddocks.

Take home messages

- *Starter application of P was important in maximising yields at GS30*
- *Grain yield responses (< 90 percent relative yield) to P were obtained for 35 percent of the paddocks surveyed*
- *DGT accurately predicted wheat responses to P accounting for 64 percent and 79 percent of the variation in early dry matter and grain respectively*
- *Colwell P could only explain 36 percent of the variation in early dry matter and no significant relationship could be obtained with grain*
- *Colwell P plus the Phosphorus Buffering Index (PBI) correctly predicted wheat response in 60 percent of the sites.*

Method

During the 2008 growing season, a farmer survey was undertaken to obtain an idea of the current P levels in the Wimmera Mallee region and whether crop responses to P can be found. Twenty-three sites were located in the north-western region of Victoria (Table 1). Farmers were asked to have a seeder-width control strip in their paddock where no P-enriched fertiliser was applied. This was achieved by turning the fertiliser off for one pass of the seeder. Nitrogen was balanced using Urea (N46:P0:K0:S0) where possible. Soil samples were collected in the control strip for DGT and Colwell P (including PBI) analysis prior to or just after sowing.

Dry matter responses (GS30) were compared between the control strip and the applied P level on each adjacent side to the strip in the paddock by taking four 1m random cuts in each strip (nearest neighbour design). Grain yields in the control strip and adjacent crop either side were obtained from yield monitors (> ten readings in each strip). Where a yield monitor was not available, harvest cuts were taken to determine grain yields using the same method as the GS30 measurements. At the time of writing, these samples had not been threshed to obtain actual grain yields. Grain yields were calculated from the total weight of each cut and an assumed harvest index of 0.35 for the 2008 season. A harvest index is simply the ratio of grain to dry matter, so a ratio of 0.35 means that 35 percent of the dry weight is grain. Anecdotally, the harvest index is usually 0.30 in wet-average years and 0.40 in drier years.

Soil test values were plotted against relative yield (percent) to determine the effectiveness of each test in determining plant available P as assessed by plant response.

Percent relative yield = Yield (control strip)/ yield (applied P in paddock) x 100.

If a soil is deficient in P, then relative yield will be < 90 percent. The lower the number, the higher the deficiency in P

If a soil is sufficient in P, then relative yield will be 100 percent ± 10 percent (sampling variation).

Results

Table 1. Soil test measurements from the 2008 sites including Colwell P, PBI and DGT in respect to relative yields (percent) at GS30 and harvest.

Site	Crop type	% relative yield ~GS30	% relative yield - grain	Colwell P mg/kg	PBI	*Critical Colwell P mg/kg	DGT (C_E) µg/L
Birchip A	Wheat	51	83	26	69	24	926
Birchip B	Wheat	47	83	26	36	19	1293
Charlton	Wheat	92	85	35	92	27	1510
Curyo	Wheat	110	Cut for hay	61	59	23	3457
Hopetoun	Wheat	86	120	32	27	17	4490
Jil Jil A1	Wheat	112	103	48	33	18	4918
Jil Jil A2	Wheat	89	100	46	27	17	7868
Jil Jil A3	Wheat	108	110	73	57	23	3645
Jil Jil B1	Wheat	43	43	36	79	26	234
Jil Jil B2	Wheat	60	102	54	92	27	1061
Kinnabulla	Wheat	81	105	37	80	26	1486
Kooloonong 1	Wheat	70	106	11	10	11	1524
Kooloonong 2	Wheat	69	96	14	26	17	1425
Kooloonong 3	Wheat	82	81	23	104	29	820
Nullawil A	Wheat	na	116	na	na	na	2919
Rupanyup A	Wheat	87	Cut for hay	46	96	28	1941
Rupanyup B1	Wheat	79	88	45	90	27	1567
Rupanyup B2	Wheat	84	99	26	60	23	1321
St Arnaud A	Wheat	109	Cut for hay	61	87	27	3095
Boolite	Barley	70	78	22	68	na	613
Nullawil B	Barley	na	74	na	na	na	1570
St Arnaud B	Barley	70	109	58	52	na	3043
Warracknabeal	Barley	57	91	31	79	na	2055

na = not available at time of writing

**Critical Colwell P was calculated as performed by Moody 2007*

Early dry matter (GS30)

Early dry matter responses (< 90 percent relative yield) to applied-P were observed in 12 of the 19 (63 percent) paddocks sown to wheat and all three sites sown to barley, revealing an application of P was important in most cases. Comparing both Colwell P and DGT to the GS30 dry matter and grain response, revealed that DGT was the better soil test for predicting wheat responses (Figure 1). A moderate relationship was obtained comparing DGT results and early dry matter responses (R^2 = 0.67) expressed as relative yield, while a poor relationship (R^2 = 0.36) was obtained for Colwell P measurements. Critical P deficiency thresholds for DGT in this survey was 2385µg/L which is considerably lower than the threshold established from replicated field trials (3955µg/L). In this type of work, it is unclear whether the rate of P that was used in the paddock was sufficient to maximise yields at all sites at this growth stage, particularly for the sites with higher PBI values. If maximum yields were not reached in some cases, then this would contribute to the lower deficiency threshold obtained. The Colwell P deficiency threshold was 53mg/kg which is significantly higher than the recommended 15mg/kg level used as a benchmark for sufficient available P in the Wimmera Mallee (identified in previous BCG trials).

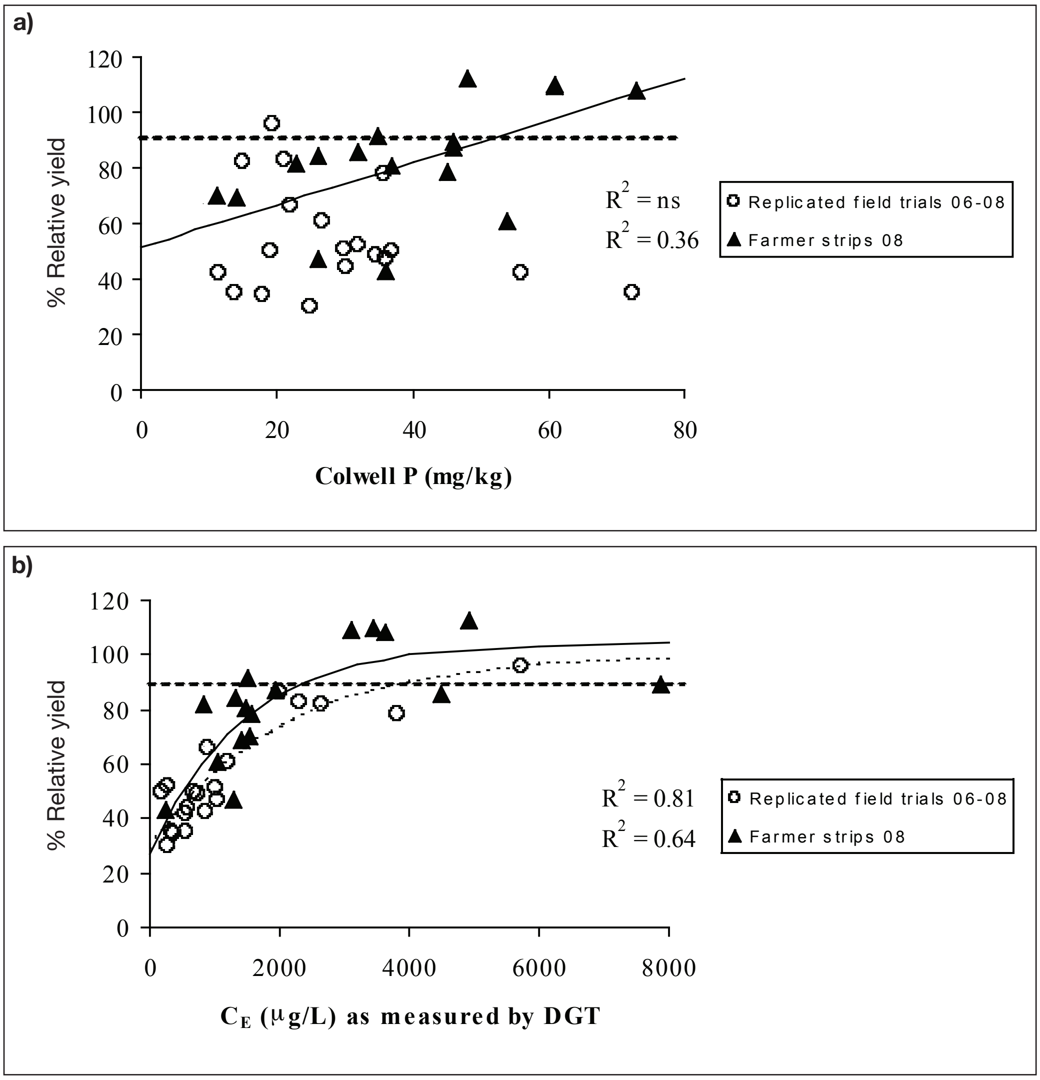

Figure 1. Relationship between wheat dry matter yields taken at mid-late-tillering (expressed as percent relative DM yield) for the BCG farmer strips and replicated field trials with soil available P test value measured using a) Colwell P and b) DGT.

Grain

Grain responses (< 90 percent relative yield) to P were observed in 6 of the 19 (32 percent) paddocks sown to wheat and two of the four (50 percent) sites sown to barley. DGT accurately predicted grain responses producing a good relationship ($R^2 = 0.79$) with grain relative yield, but no significant relationship could be obtained between Colwell P values and grain response to P (Figure 2). Determining the critical Colwell P value from the PBI measurements from each site, as performed by Moody et al. (2007) (wheat only), did not necessarily improve the grain response prediction (Table 1). Out of the 15 sites, the critical Colwell P and actual Colwell P measurements incorrectly predicted the grain response for six sites (40 percent). As an example, Jil Jil B1 had a critical Colwell P value of 26 as calculated from the PBI measurement. The Colwell P value from the control strip was 36mg/kg suggesting there was adequate P available and no response should be obtained from an application of P. The relative yield (both grain and dry matter) from the site was 43 percent indicating a high level of P deficiency.

Critical P deficiency thresholds for grain as assessed by DGT (1104µg/L) closely matched the threshold established from replicated field trials (1114µg/L), which is considerably lower than the critical threshold obtained for early dry matter. 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 and to date there has been no significant grain response to P above a DGT value of 1187µg/L. It is, therefore, not surprising that half of the farmer survey sites that showed a dry matter response to P failed to translate that response into grain. 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 assess if this still occurs under sufficient moisture conditions.

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 potentially reducing the relationship with DGT particularly during early crop growth stages. It is also unclear whether the amount of P the farmer applied as their standard rate was enough to maximise yields especially on sites that have higher PBI values.

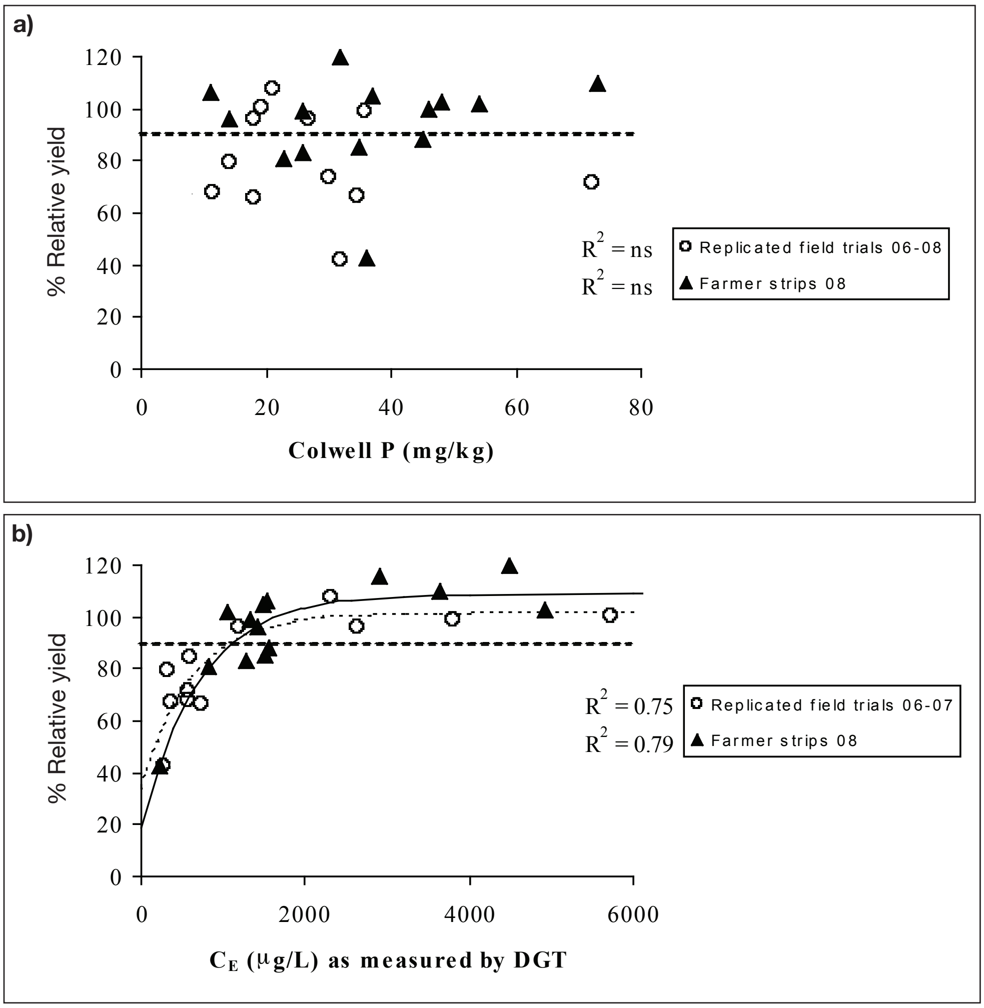

Figure 2. Relationship between wheat grain yields (expressed as percent relative DM yield) for the BCG farmer strips and replicated field trials with soil available P test value measured using a) Colwell P and b) DGT.

Interpretation

The inability of Colwell P to predict crop response to phosphorus both in early dry matter and grain is alarming for the Wimmera Mallee. There is a diverse range of soil types in the survey area which may attribute to the inaccuracy of Colwell P. The Colwell P method uses a relatively small amount of soil to solution ratio, unrealistic to the conditions of a field soil. Soil types respond differently to the large dilution but the response is not always in accordance with the plant P availability in the field. 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. Using PBI to help interpret Colwell P values appears to fail in some cases. The relationship between PBI and critical Colwell P values could be caused by the coincidence of higher PBI values occurring with soils where the Colwell P method extracts unavailable forms of P and therefore this relationship will have errors associated with it.

Initial testing of the DGT method for prediction of wheat response to P in the glasshouse and in the field 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.

Based on improved soil testing chemistry, DGT provides an accurate assessment of plant available P and is independent of soil type.

Application

The relatively new DGT method (currently being validated) continues to provide a more accurate assessment of plant available P in a wide range of soil types. With the use of DGT, fertiliser decisions can be made with greater confidence compared to current available soil tests. Simple trials in which farmer strips that contain no starter P have revealed great potential in validating the DGT test for the Wimmera Mallee. The authors encourage farmers uncertain about the current P levels in their paddocks that the best indication is produced by using a control strip in the paddock. A similar farmer survey will occur in 2009 and any farmers who would like to be involved are asked to contact the authors of this paper.

References

Moody, P. W. (2007) Interpretation of a single-point P buffering index for adjusting critical levels of the Colwell soil P test. Australian Journal of Soil Research, 45, 55-62.