# Soil testing for phosphorus

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# Soil testing – history of using extractants

## Chemistry of Vegetable Physiology and Agriculture.

**Soil Statics and Soil Analyses** (Part II). By HERMANN V. LIEBIG (Zeitschr. d. Landw. Vereines, 1872).

THE author's analyses of the first 9 inches of surface soil from Mr. Lawes' wheat field are already given (page 318 of this volume); the second and third 9 inches gave the following results. The soils were in all cases boiled for half an hour with four times their weight of dilute acetic acid, the clear solution decanted, and the residue thoroughly washed with boiling water.

von Liebig H. (1872) Soil statics and soil analyses. Zeitschrift dür Landwirtschaflichen Vereins in Bayern 1872, 837-838.

XV.—*On the Analytical Determination of probably available "Mineral" Plant Food in Soils.*

*(Illustrated by Examination of the Permanent Barley Soil of Hoos Field, Rothamsted.)*

By BERNARD DYER, D.Sc.

Dyer B. (1894) On the analytical determination of probably available "mineral" plant food in soil. Journal of the Chemical Society London 6`5:115-167.

# Phosphorus tests commonly offered

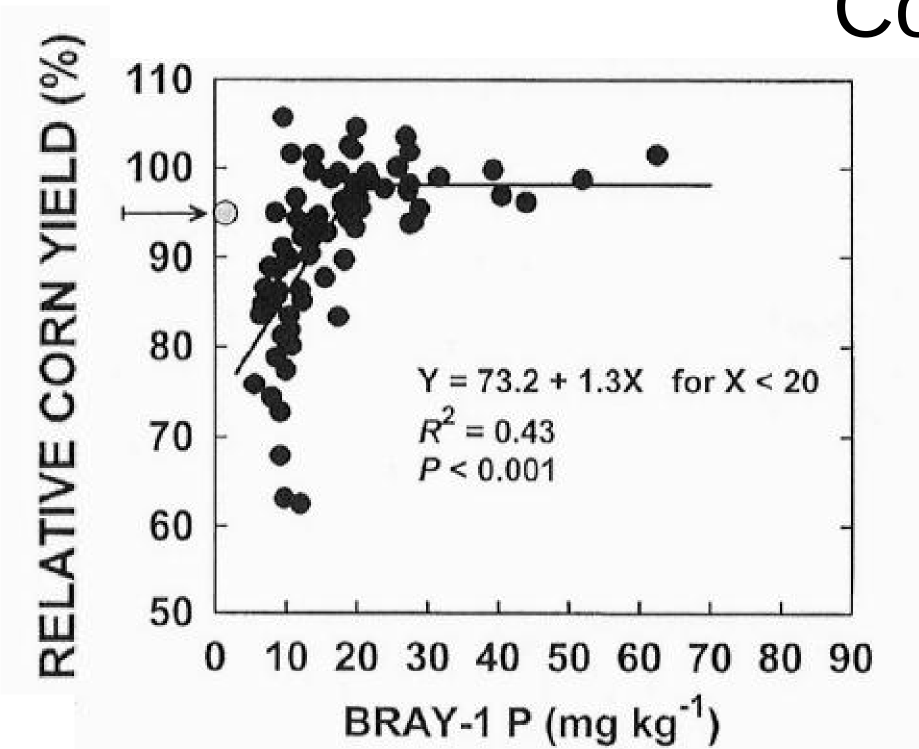
| Soil test | Extract | pH | Soil:soln | Shaking |
| --- | --- | --- | --- | --- |
| Bray I | 0.03 M NH4F<br>0.025 M HCl | 3.0 | 1:7 | 1 min |
| Mehlich 3 | 0.25 M $NH_4NO_3$<br>0.20 M $CH_3COOH$<br>0.015 M $NH_4F$<br>0.013 M $HNO_3$<br>0.001 M EDTA | 2.5 | 1:10 | 5 min |
| Olsen | 0.5 M $NaHCO_3$ | 8.5 | 1:20 | 30 min |
| Colwell | 0.5 M $NaHCO_3$ | 8.5 | 1:100 | 16 h |
| Resin | Water<br>Mixed resin | 6.0-7.5 | 1:10 | 16 h |
| DGT | Solid-phase | ambient | Field Cap. | 2 days |

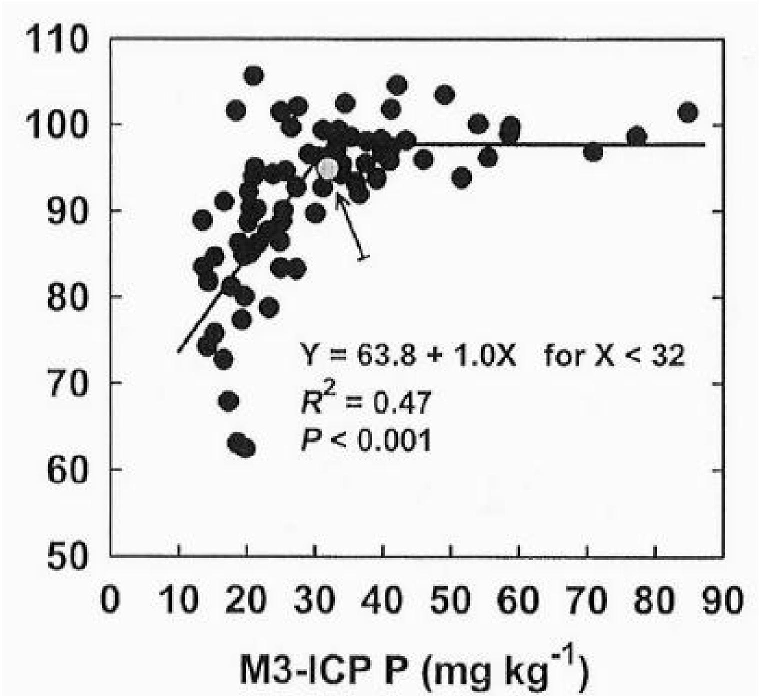
# Utility of soil P testing

- A soil test is only useful if it correlates with crop response to fertilizer or other amendment (lime, gypsum, etc.) to trigger farmer action
- Many soil tests are developed with laboratory expediency in mind – multiple elements, short extraction times, simple analyses – with poor correlation to crop responses
- The best soil tests will be robust, fast, cheap and <u>well correlated</u> to crop responses <u>*in the field across a wide range of soils*</u>

# Correlating soil P to crop response

Corn



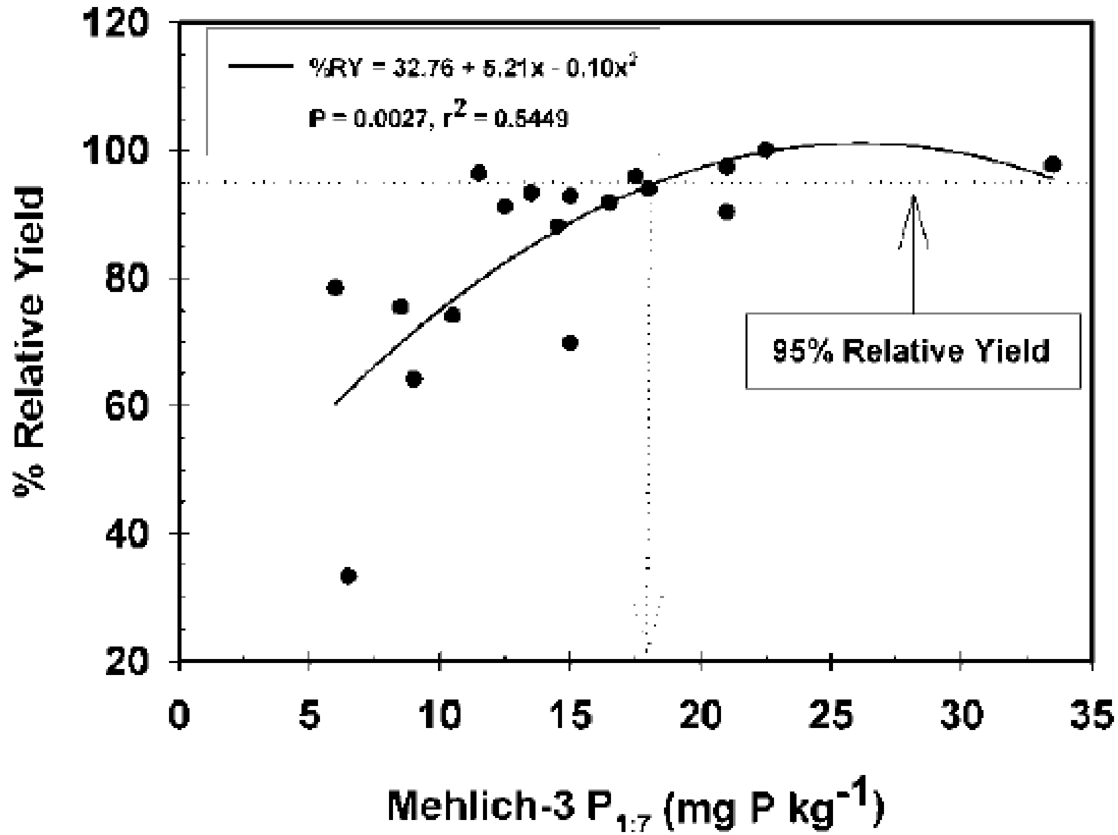

78 site years, 59 locations


Mallarino, A. P. (2003). "Field calibration for corn of the Mehlich-3 soil phosphorus test with colorimetric and inductively coupled plasma emission spectroscopy determination methods." Soil Science Society of America Journal **67(6): 1928-1934.**

# Correlating soil P to crop response

## Wheat

18 site years
3 soil series




Slaton, N. A., K. R. Brye and R. K. Bacon (2005). "Correlation and calibration of Mehlich-3 phosphorus recommendations for winter wheat following rice in Arkansas." Communications in Soil Science and Plant Analysis **36(7-8): 993-1004.**

# Improving soil P test relationships

- Adding a measure of soil P sorption to aid interpretation of the soil test – P buffer Index (PBI)

Burkitt, L. L., P. W. G. Sale and C. J. P. Gourley (2008). "Soil phosphorus buffering measures should not be adjusted for current phosphorus fertility." Australian Journal of Soil Research **46(8): 676-685.**

Burkitt, L. L., P. W. Moody, C. J. P. Gourley and M. C. Hannah (2002). "A simple phosphorus buffering index for Australian soils." Australian Journal of Soil Research **40(3): 497-513.**

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(1): 55-62.**

- Examine new test methods that more closely respond to crop P uptake - DGT

Mason, S., A. McNeill, M. J. McLaughlin and H. Zhang (2010). "Prediction of wheat response to an application of phosphorus under field conditions using diffusive gradients in thin-films (DGT) and extraction methods." Plant and Soil **337(1): 243-258.**

Mason, S., R. Hamon, H. Zhang and J. Anderson (2008). "Investigating chemical constraints to the measurement of phosphorus in soils using diffusive gradients in thin films (DGT) and resin methods." Talanta **74(4): 779-787.**

# Improving soil P test relationships

## P buffer Index (PBI)

- Single point method
- Single addition of 1000 mg P/kg $KH_2PO_4$ in 0.01M $CaCl_2$, 1:10 soil:solution ratio
- Shake end-over-end for 17h @ 25$^{o}$C
- Determine P remaining in solution

$$PBI = (Ps + Colwell\ P)/c^{0.41}$$

PBI = P buffer index, Ps = P sorbed (mg/kg), Colwell P = extractable P by Colwell method (mg/kg), c = final solution P concentration (mg/L)

Burkitt, L. L., P. W. Moody, C. J. P. Gourley and M. C. Hannah (2002). "A simple phosphorus buffering index for Australian soils." Australian Journal of Soil Research **40(3): 497-513.**

# Improving soil P test relationships

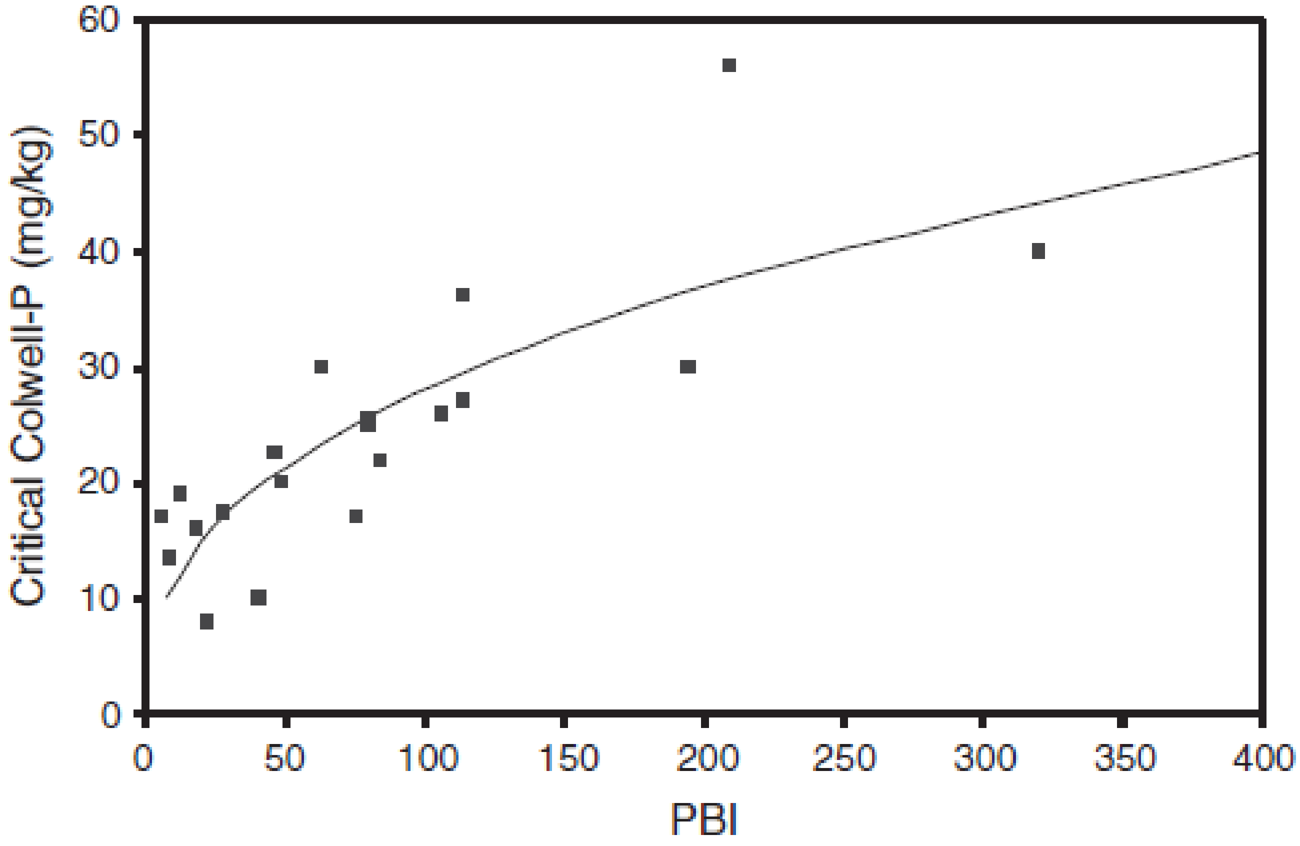
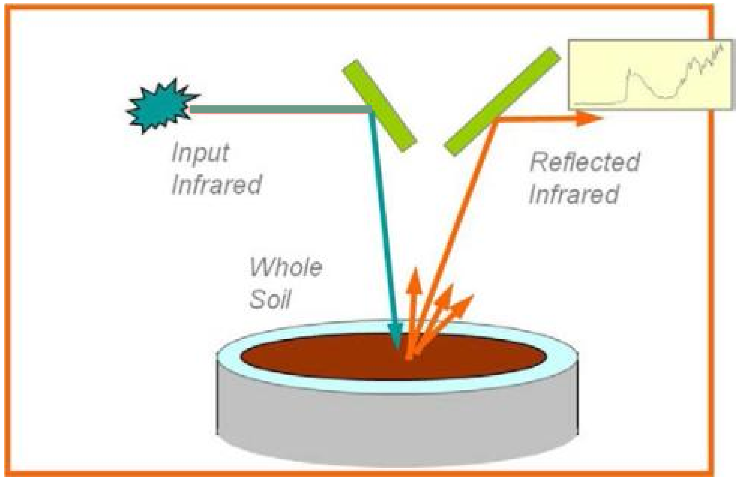



**Fig. 4.** Effect of PBI on critical Colwell-P (0–0.10 m) required for 90% maximum grain yield of wheat. Equation of line of best fit is: $y = 4.60\ (\pm 1.60)\ x^{0.393(\pm 0.073)}$ ($R^2 = 0.63$).


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(1): 55-62.**

# Improving soil P test relationships

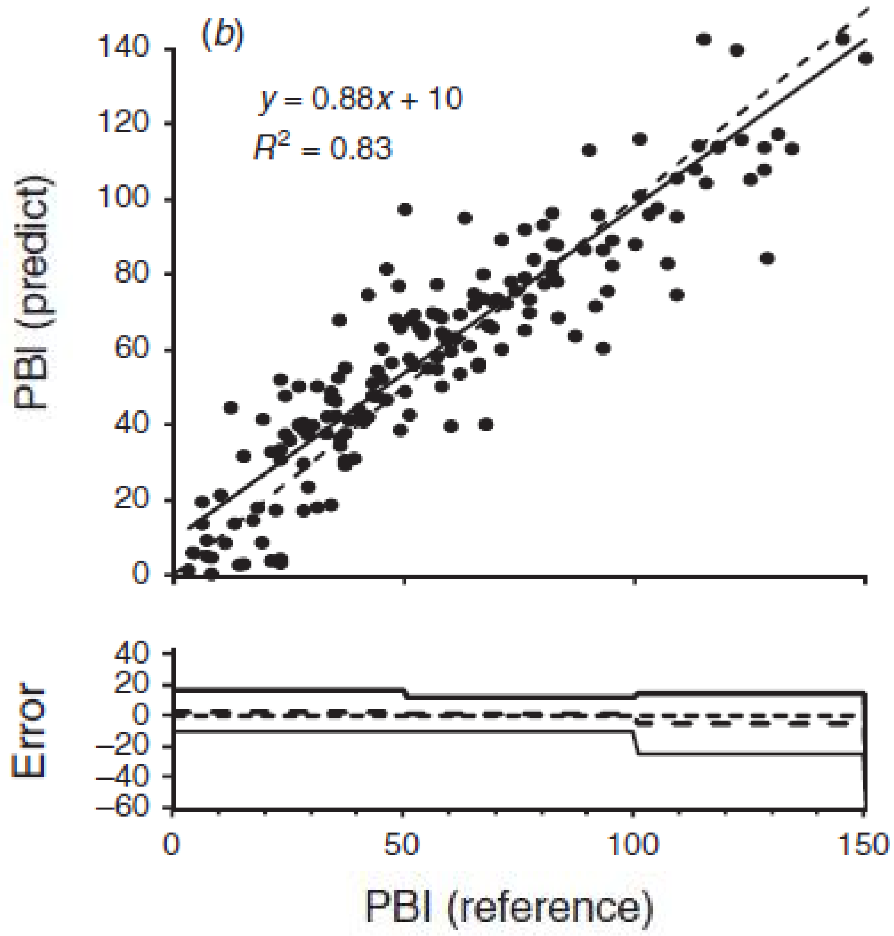
## Fast measurement of PBI (+in field)




- Diffuse reflection of infrared radiation from surface of neat soils, ground or unground, rapid, no extractants

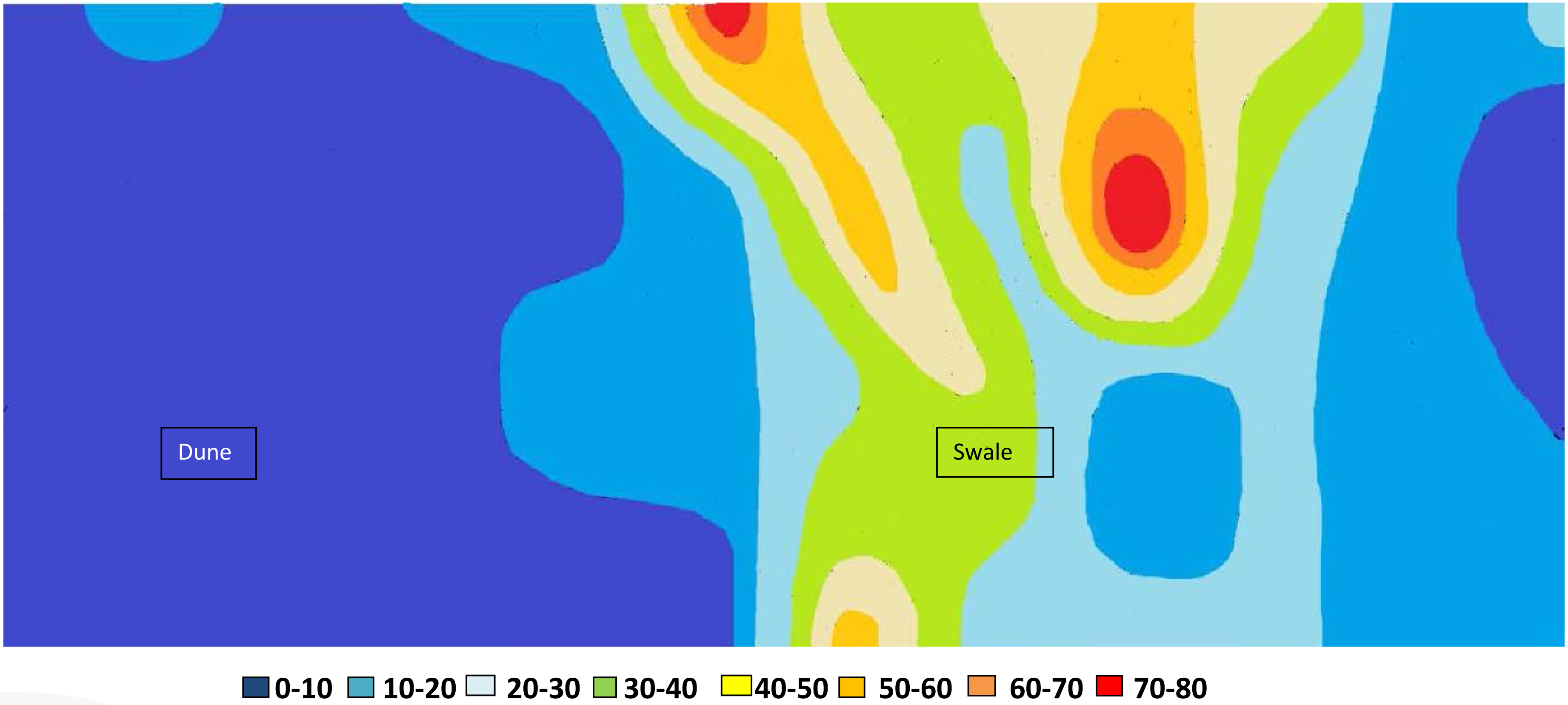

# Improving soil P test relationships

Fast measurement of PBI (+ in field measurement)




Forrester, S. T., L. J. Janik, J. M. Soriano-Disla, S. Mason, L. Burkitt, P. Moody, C. J. P. Gourley and M. J. McLaughlin (2015). "Use of handheld mid- infrared spectroscopy and partial least- squares regression for the prediction of the phosphorus buffering index in Australian soils." Soil Research **53(1): 67-80.**

# Mapping PBI in the field

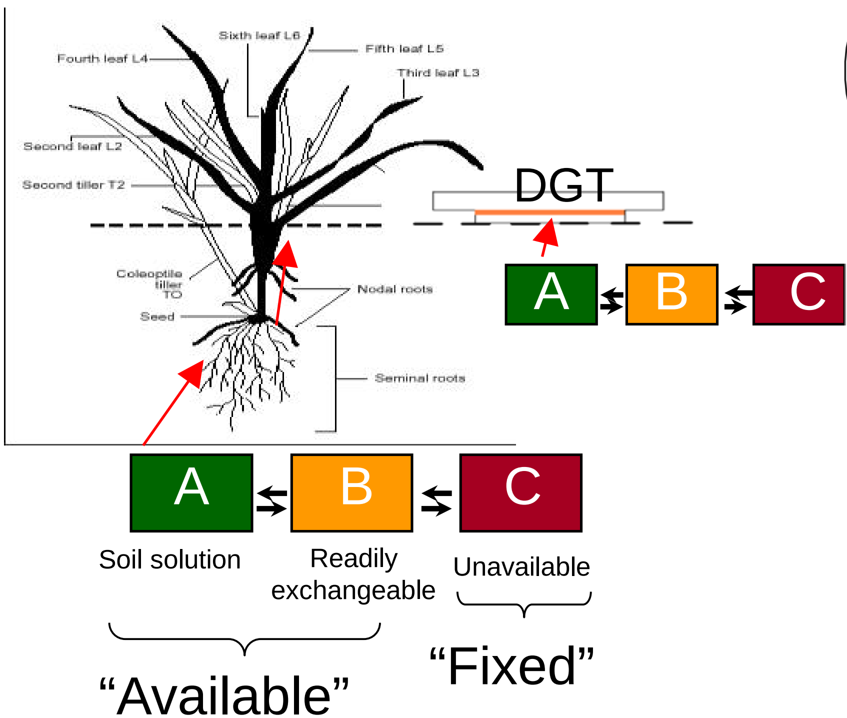


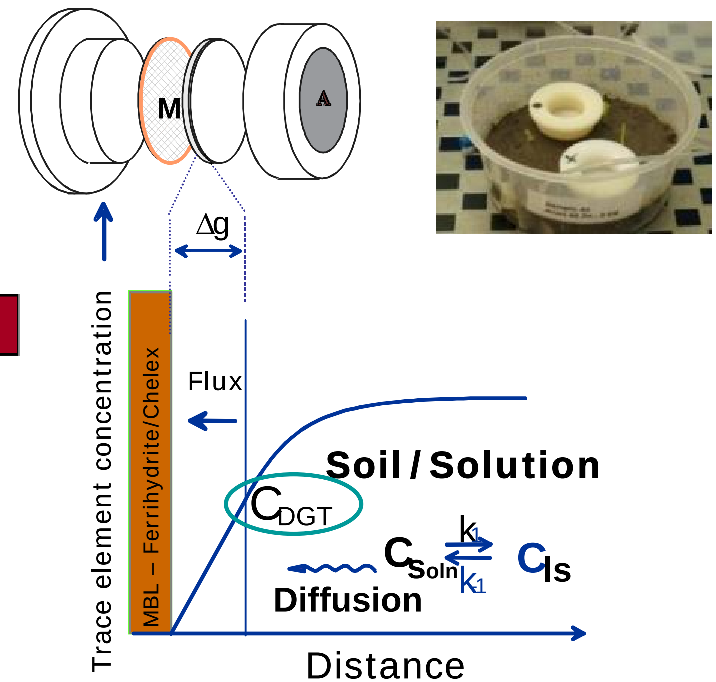
# Improving soil P testing – DGT
# Diffusive gradients in thin films

# Basis of the test

## DGT theory

Most useful in deficiency scenarios where diffusion of elements in the soil to plant roots is limited

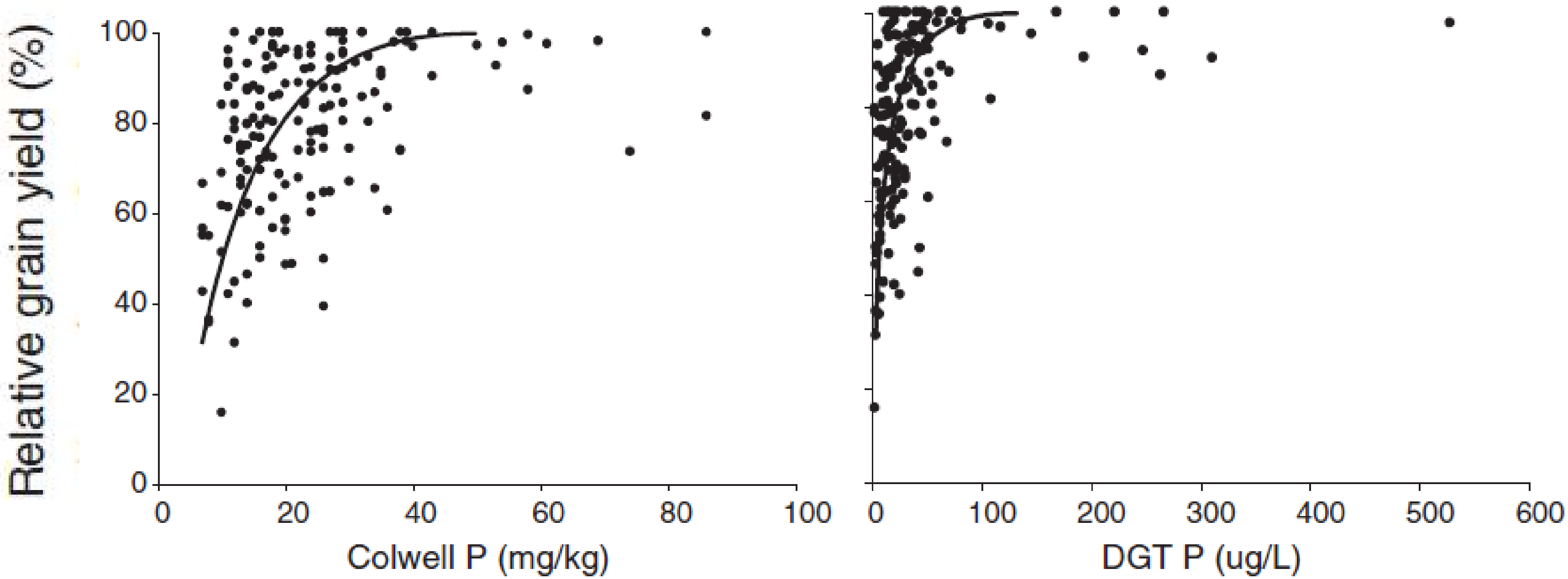




Davison W., Zhang H. (1994) In situ speciation measurements of trace components in natural waters using thin-film gels. Nature 367:546-548.

# Improving soil P testing - DGT




| Method | *n* | CSTV90 | CI95 | *R*-value |
|---|---|---|---|---|
| Colwell-P | 164 | 26 | 22–30 | 0.46 |
| DGT-P | 164 | 38 | 30–49 | 0.55 |
| Mehlich 3-P | 164 | 29 | 23–35 | 0.37 |
| Olsen-P | 164 | 12 | 9.8–14 | 0.43 |
| $CaCl_2$-P | 128 | 0.38 | 0.28–0.52 | 0.49 |
| BSES-P | 163 | 57 | 46–70 | 0.45 |


Speirs, S. D., B. J. Scott, P. W. Moody and S. D. Mason (2013). "Soil phosphorus tests II: A comparison of soil test–crop response relationships for different soil tests and wheat." Crop and Pasture Science **64(5): 469-479.**

# Summary

- Renewed emphasis on deriving accurate calibrations of soil P tests to fertilizer responses
- New soil tests look promising – DGT, PBI – to improve power of soil tests to predict response to P fertilizer
- New spectral methods to analyse soils will revolutionise soil testing and allow greater description of field heterogeneity
- Databases to collate soil test data and crop responses are powerful tools to assist adoption and use of soil testing

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[http://www.bfdc.com.au/interrogator/interrogator.vm](http://www.bfdc.com.au/interrogator/interrogator.vm)

# Acknowledgements

GRDC
Grains Research & Development Corporation

SARDI
R&D
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

# Selected DGT references


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- Mason, S. D., M. J. McLaughlin, C. Johnston and A. McNeill (2013). "Soil test measures of available P (Colwell, resin and DGT) compared with plant P uptake using isotope dilution." Plant and Soil **373(1-2): 711-722.**
- Speirs, S. D., B. J. Scott, P. W. Moody and S. D. Mason (2013). "Soil phosphorus tests II: A comparison of soil test–crop response relationships for different soil tests and wheat." Crop and Pasture Science **64(5): 469-479.**