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The efficiency of fertilizer phosphorus use in cropping systems

Rob Norton, IPNI Regional Director

http://anz.ipni.net

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Better Crops, Better Environment … through Science

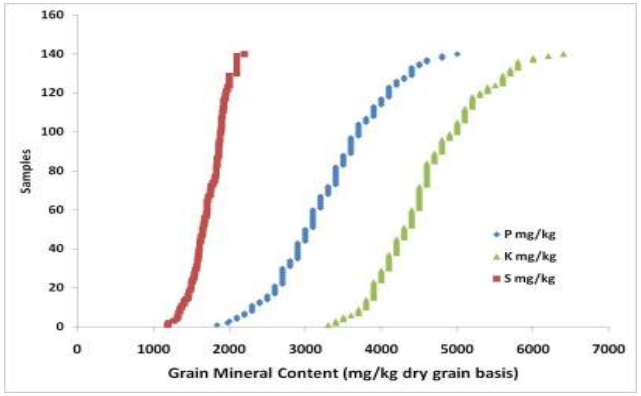
Incitec Pivot Fertilizers, AC Meeting, Hamilton, July 2014.

#1 You get nothing for nothing…….

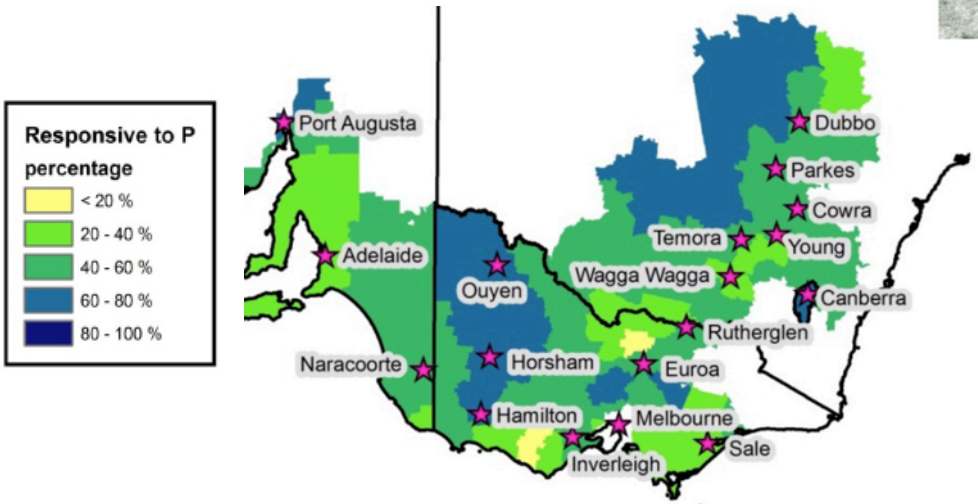
If produce is removed, nutrients go with it – if not replaced, then the soil reserves go down.

This is soil not the "magic pudding".

.....So

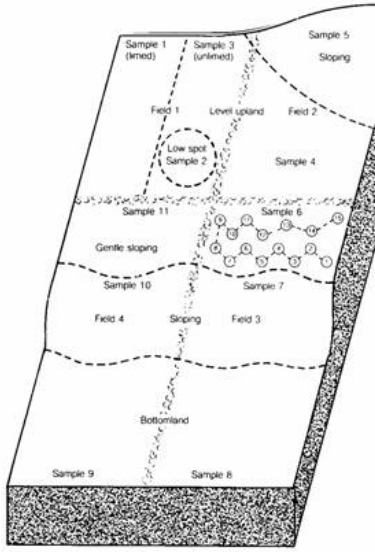


- Cereals contain about 2.7 to 3.9 kg P/t
  - A 5 t/ha cereal/*3 t/ha canola* crop removes from the paddock 17kgP/ha
  - ***Replacement*** rate = 85 kg/ha DAP/MAP
- History tells us the service done by earlier farmers.
- If not replaced soil reserves are depleted



Source, Christy et al. (2014). Derived from ANRA 2001 Audit

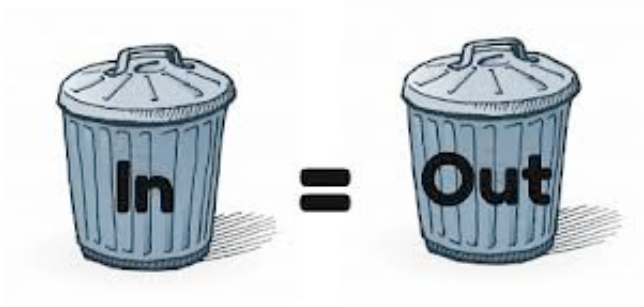
Where are you and your soils?



Soil testing identifies your position

- Take good samples (0.5g = paddock)
  - Sample as you will manage
    - zones, gridded, random.
  - About same time each year
  - Depth is critical (P is not that mobile)
  - Stock camps, gate ways, etc.

Most soil tests calibrated to 0-10 cm.



#2 Do you know what the problem is?

- Its no good checking to see if the hydraulic fluid is OK……..
  - What is limiting production – until that is addressed, then no extra response.

……So …….reading the coffee grounds

Analyte / Assay	Unit	Value			
Soil Colour		Grey	Orange/Yellow		
Soil Texture		Clay	Clay	2	
pH (1:5 Water)		5.30	7.00		
pH (1:5 CaCl2)		4.60	5.70		
Electrical Conductivity (1:5 Water)	dS/m	0.24	0.11		
Electrical Conductivity (Saturated Extract)	dS/m	1.50	0.70		
Chloride	mg/kg	110.0	43.0		
Organic Carbon (OC)	%	1.60	0.66		
Nitrate Nitrogen (NO3)	mg/kg	5.6	2.4		
Ammonium Nitrogen	mg/kg	6.8	2.4	3	
Phosphorus (Colwell)	mg/kg	43	9		
Phosphorus Buffer Index (PBI-Col)		100	77		
Sulphate Sulphur (KCl40)	mg/kg	90.0	24.0		
Cation Exchange Capacity	cmol(+)/kg		10.30		
Cation Exchange Capacity	cmol(+)/kg	8.01			
Calcium (Amm-acet.)	%		36.000		
Calcium (Amm-acet.)	cmol(+)/kg	3.700	3.700		
Calcium (Amm-acet.)	%	46.000			
Magnesium (Amm-acet.)	%		48.000		
Magnesium (Amm-acet.)	cmol(+)/kg	2.900	4.900		

1

Analyses conducted by Nutrient Advantage Laboratory Services

8 South Road, Werribee VIC 3030

NATA Accreditation No: 11958

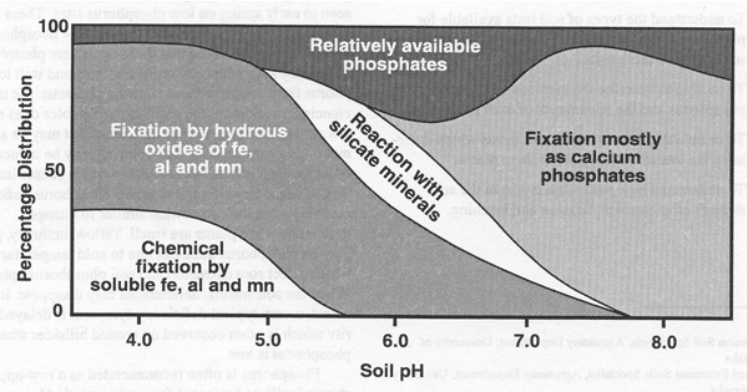
Tel: 1800 803 453

Certificate of Analysis is available upon request.

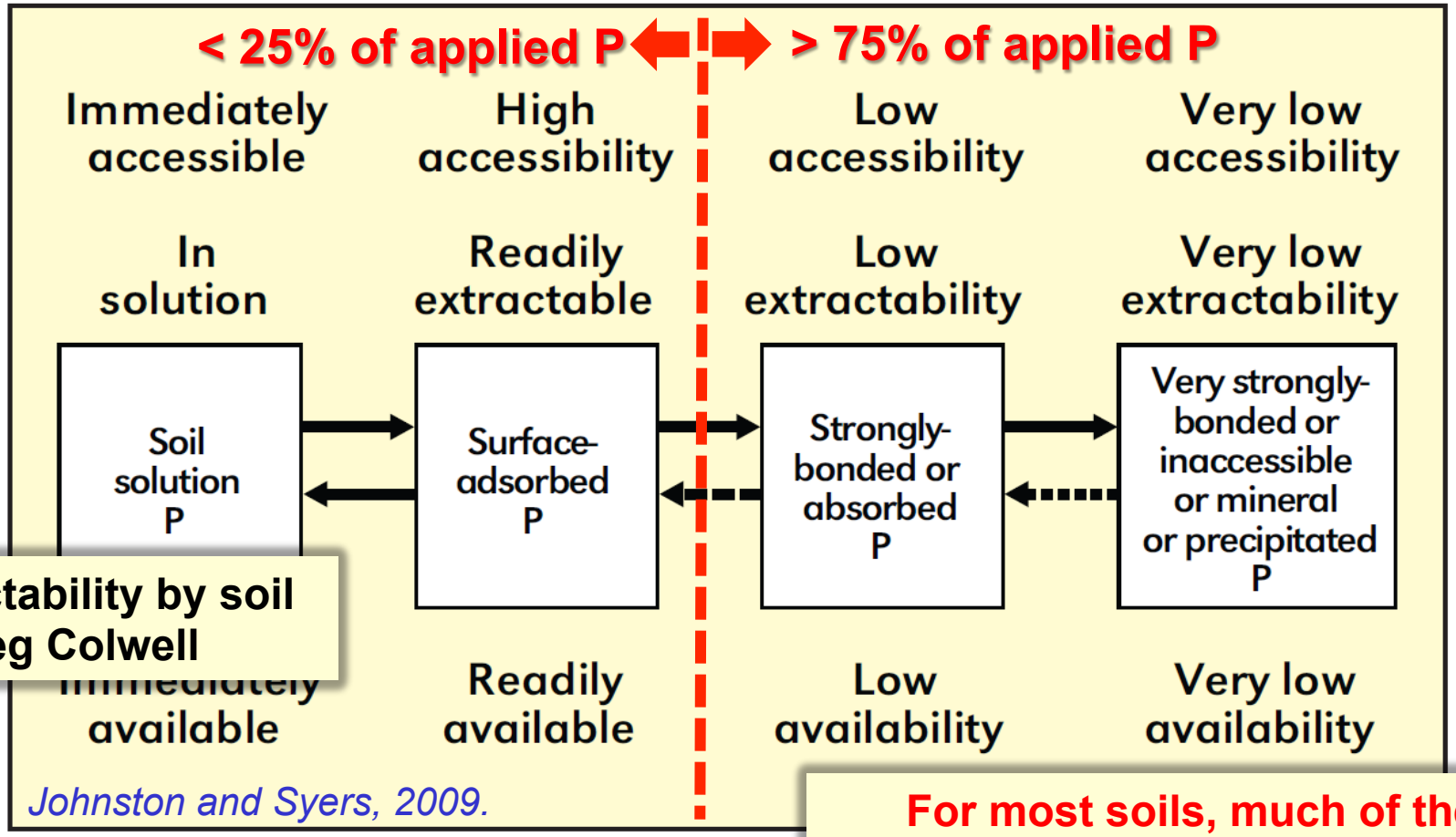
Email: lab.feedback@incitecpivot.com.au

Phosphorus fertilizer and the soil

- Plants take up P from solution as orthophosphate
  - primary orthophosphate ion: $H_2PO_4^-$ (pH < 7.0) and secondary orthophosphate ion: $HPO_4^=$ (pH > 7.0)
  - Form most common depends on pH
- P chemistry in soils is complex — P may become sparingly available to plants in some soils due to formation of reversion products
  - High or low pH in particular
- Appreciable organic P is also present – 20% to 70% of total P – mineralised before becoming plant available.



Availability and extractability of soil P pools



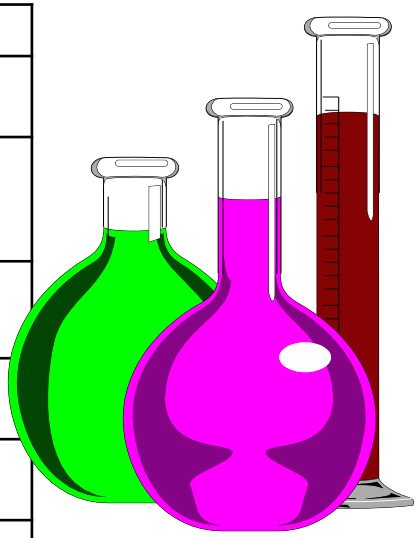
Extractability by soil tests eg Colwell

Recovery by balance method accounts for fertilizer P that enters the less available pools

For most soils, much of the <u>applied</u> P enters the lower availability pools….
<u>Phosphate Buffering Index</u>
… can be available over time

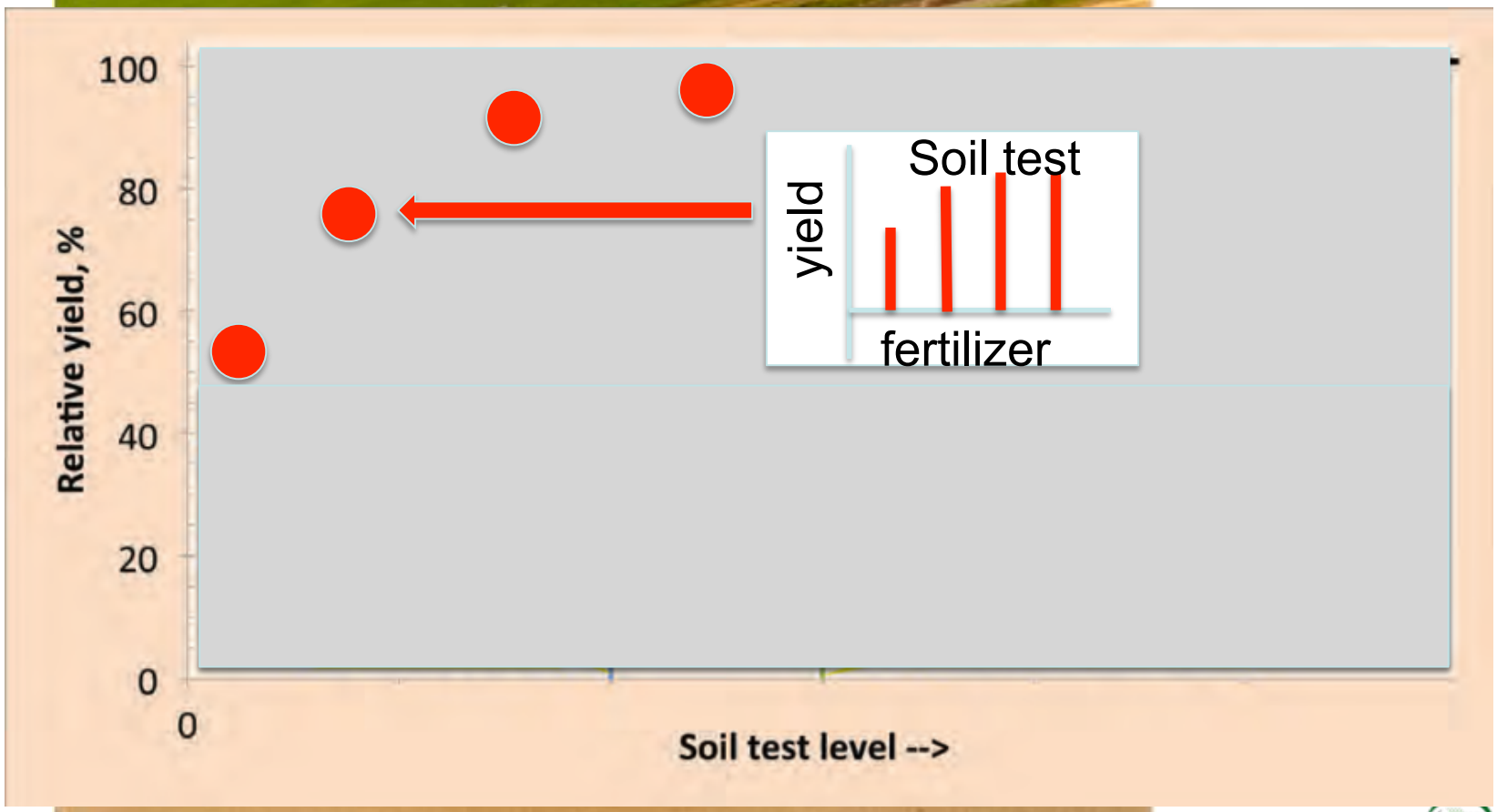
Soil Tests for P……

Test Name	Extractant & conditions	Reference
Olsen P	0.5M sodium bicarbonate (pH 8.5) 0.5 h extraction in 1:20 soil:solution.	Olsen et al. 1954. USDA Circular No.939.
Colwell P	0.5M sodium bicarbonate (pH 8.5) 16 h extraction in 1:100 soil:solution.	Colwell 1963. Aust.J.Exp.Agric.Anim.Husb. 3, 190-198.
Lactate P	0.02M calcium lactate 1.5 h extraction in 1:50 soil:solution	Colwell 1970. Aust.J.Exp. Agric.Anim.Husb. 10, 774-782.
Bray 1 P	0.03M Ammonium Flouride in 0.025M HCl 1 min. extraction in 1:7 soil:solution	Bray & Kurtz 1945. Soil Sci. 59, 39-45.
Mehlich 3	"weak" acids – Amm Flouride, Nitric Acid EDTA, AmmNitr.	Mehlich 1984. CSSPA. 15, 1409-1416
Dilute $CaCl_2$ P	0.005M Calcium chloride in 18 h extraction for 1:5 soil:solution	Moody et al. 1988. Aust.J.Exp.Agric. 23, 38-42
Acid extractable P	0.005M sulphuric acid for 16 h extraction in 1:200 soil:solution	Kerr & von Steiglitz 1938. BSES Tech.Comm. No 9.
DGT-P	Estimates exchangeable + extractable using an ion-exchange method	Mason et al. 2010. Plant Soil. 337, 243-258.

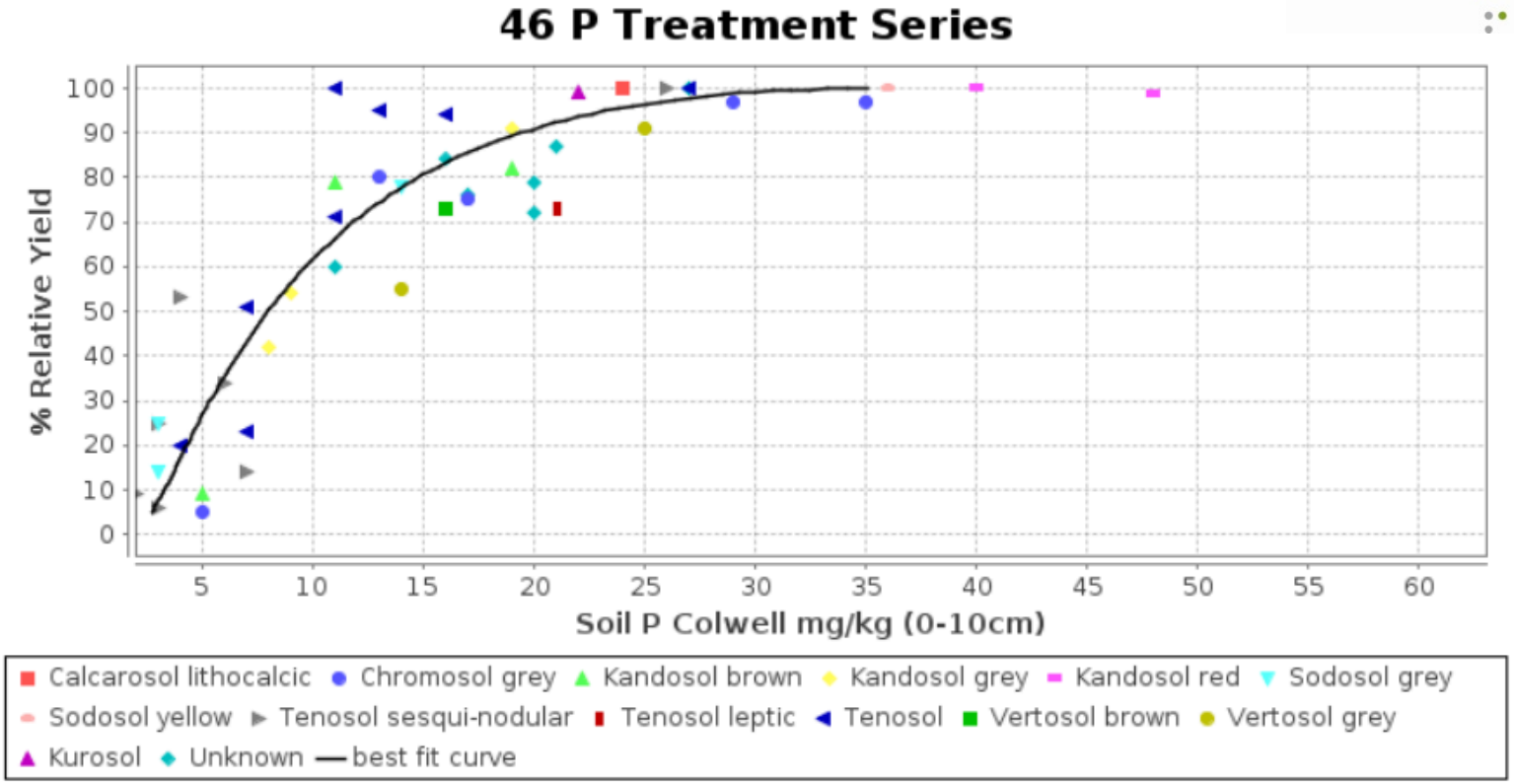


What does the soil test value mean?

- Compare to the critical value.



From Better Fertilizer Decisions for Crops



Soil test calibration:

80% Relative Yield: 15.0 (13.0 - 17.0)

90% Relative Yield: 19.0 (17.0 - 22.0)

95% Relative Yield: 23.0 (20.0 - 27.0)

Correlation R: 0.89

Slope RY(50-80): 4.3 (3.6 - 5.0)

Regression equation: $x = e^{(1.9182(\arcsin(\mathrm{sqrt}(y/100))) + 0.56952)}$

70% confidence limit at 90% Relative Yield: 19.0 (18.0 - 21.0)

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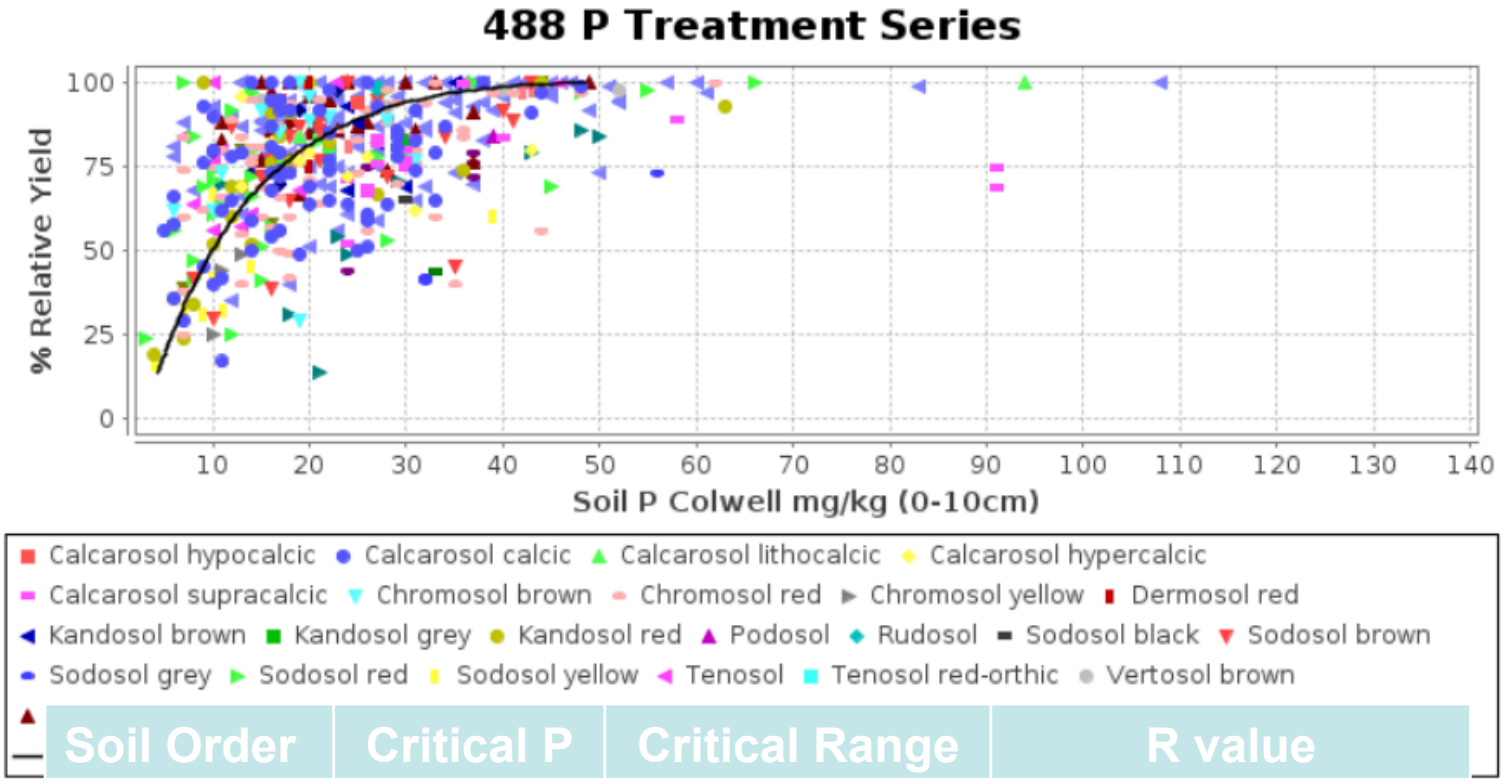
For wheat in Southeastern Australia



Soil Order	Critical P	Critical Range	R value
All	26	23-29	0.45 (488)
Chromosol	27	19-38	0.39 (79)
Sodosol	30	21-45	0.44 (78)
Vertosol	20	14-27	0.35 (41)

Critical Colwell P values – BFDC project

Crop	Soil Type	Critical Value (mg/kg)	Critical Range (mg/kg)
Wheat & Barley	Vertosol	17	12-25
	Chromosol/Sodosol	22	17-28
	Calcarosol	34	26-44
	Brown/Red Chromosols	25	18-35
Barley	Ferrosol	76	46-130
Canola	All soils	18	16-19
Field Pea	All soils	24	21-28

- Canola – less responsive to P than cereals (soil type)
- Wheat –
- Peas – about the same response to P as cereals
- Incomplete data on all crops and soils.

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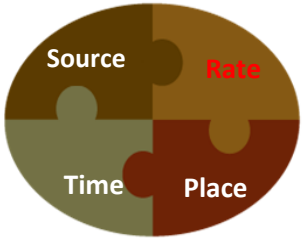
Selecting the Right Rate



- Soil Test & PBI
  - Build up = replacement + (build up + fixation)
  - Maintenance = replacement + a little if PBI is low
  - Maintenance = replacement + soil fixation if PBI is moderate

- Dahlen Long Term Cropping N&P Experiment (est. 1996)
  - Four rates of P (TSP 0/9/18/36) * Five rates of N (Urea 0/20/40/80/160)
  - Each year the site sown to a single crop.
  - Canola, wheat, barley, pulse.
  - Direct drilled, zero cultivation, stubble retained.
  - Soil samples, grain harvest, nutrient content.

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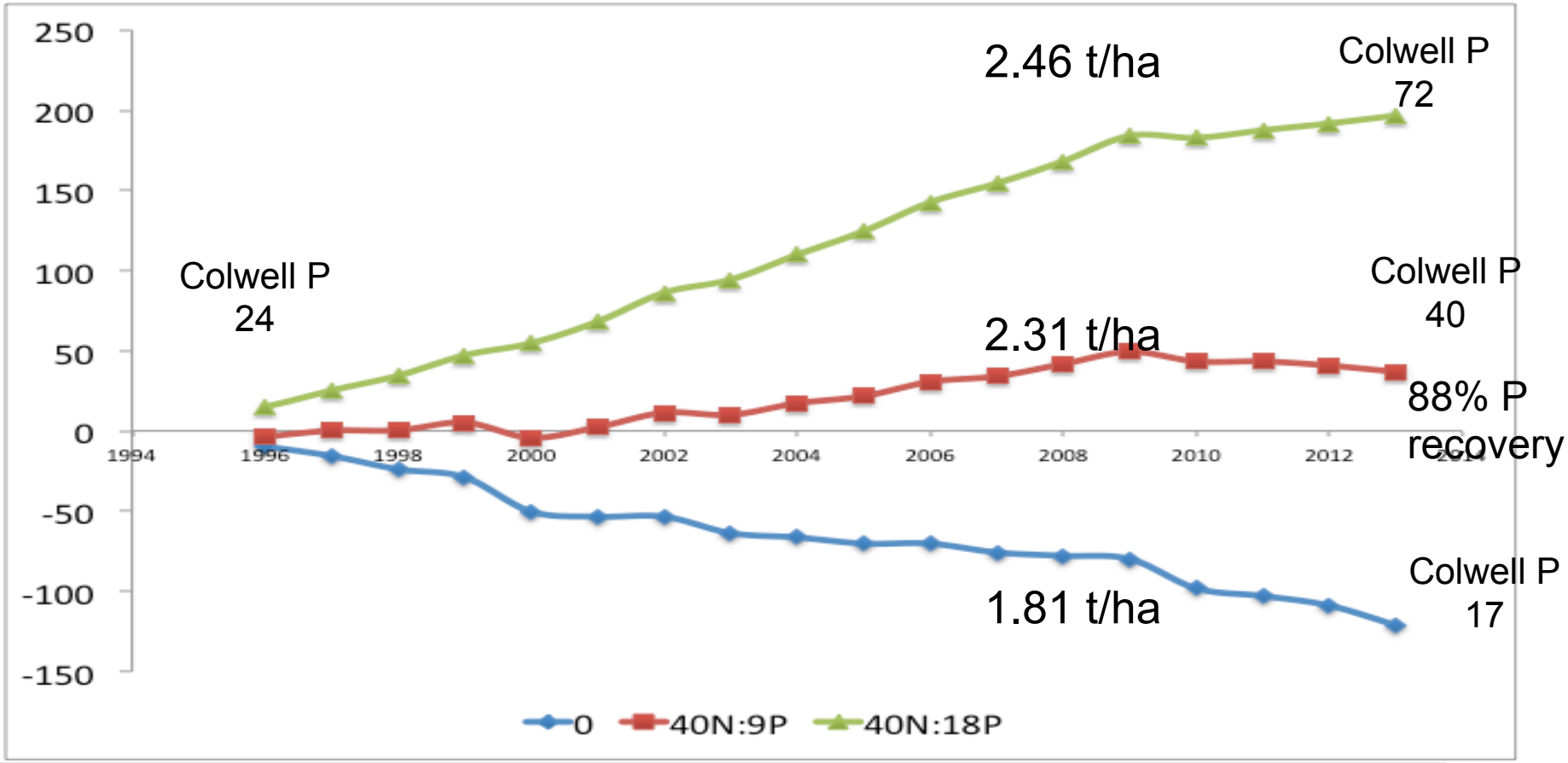
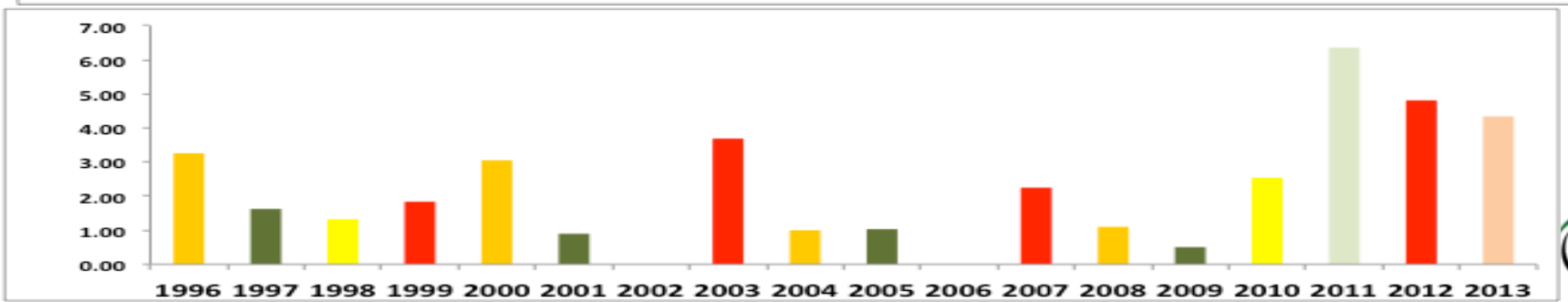
Dahlen progressive P balance





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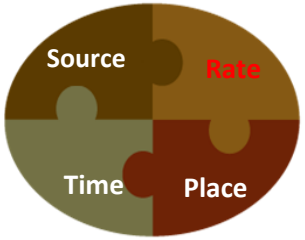
Selecting the Right Rate



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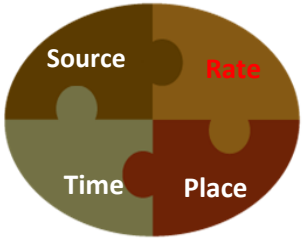
- At Dahlen PBI ~ 100 (low)
  - Maintenance + 40 kg surplus gave 16 Colwell soil test increase.
    - 2 kg P to raise Colwell 1 unit (some loss to soil fixation)
- If PBI higher (eg Chromols)
    - 3-5 kg P to raise Colwell 1 unit (larger loss to fixation)

Selecting the Right Rate



- Soil Test & PBI
  - Build up = replacement + (build up + fixation)
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- Allocate P to the most responsive situations
  - Wheat on wheat – Critical Colwell = 34 mg/kg
  - Wheat on canola – Critical Colwell = 49 mg/kg (PBI 70)
  - Clean paddocks
  - Following canola – wheat has a somewhat higher P demand.

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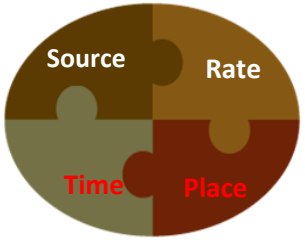
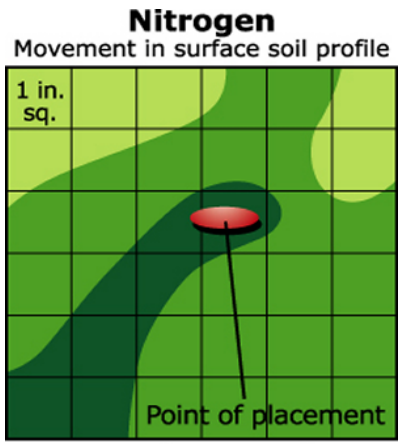
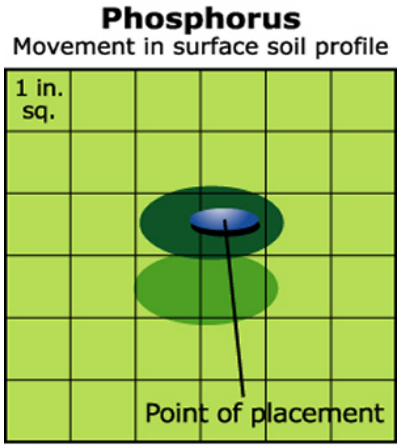
Right Place/Time for P





Nitrogen location 17 days after application



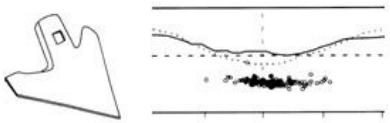
Phosphorus location 17 days after application

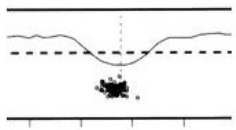
High concentration

Medium concentration

No effect

- Low mobility
- Placement at seeding
  - Banded
- Potential for seed damage – MAP/DAP
  - Wide rows.
  - High rates
  - Narrow points





Safe Rate	Soil Type	Point & Spacing			
		Share		Spear Point	
		15cm	30cm	15cm	30cm
Canola & DAP	Sandy Moist	100	50	30	15
	Loam Moist	150	70	50	30

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http://seed-damage-calculator.herokuapp.com

South Dakota Cooperative Extension Service
SDSU

IPNI International Plant Nutrition Institute

Calculator | Definitions | Theory | Disclaimer

Calculation successful.

Seed Damage Calculator

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This calculator can be used as a guide to the maximum amount of fertiliser that can be applied in the same furrow as seed. It is a guide only.

Input

Measurement unit
Metric

Crop
Wheat

Fertiliser
DAP (18-20-0)

Soil moisture
Borderline

Soil texture
Medium

Seed furrow opening width (cm)
5

Row spacing (cm)
45

Tolerated stand loss (%)
10

☑ I agree to the terms of use for this web site

Calculate

Output

Maximium kg/ha of fertilizer product with seed
46.0

seed bed utilization (%)
11

litres/ha

kg/ha of Nitrogen (N)
8.3

kg/ha of Phosphorus (P)
9.2

kg/ha of Potassium (K)

kg/ha of Sulphur (S)

kg/ha of Magnesium (Mg)

Download (PDF)

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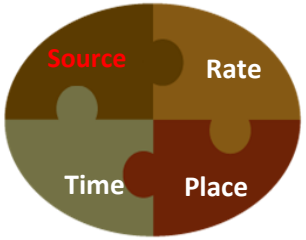
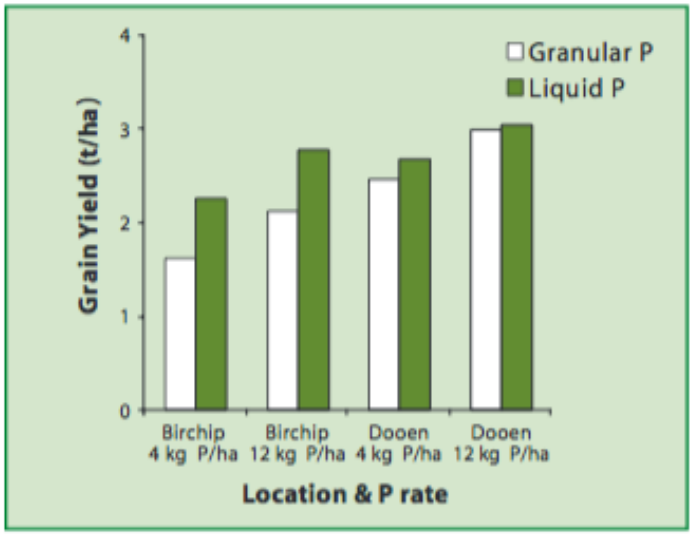
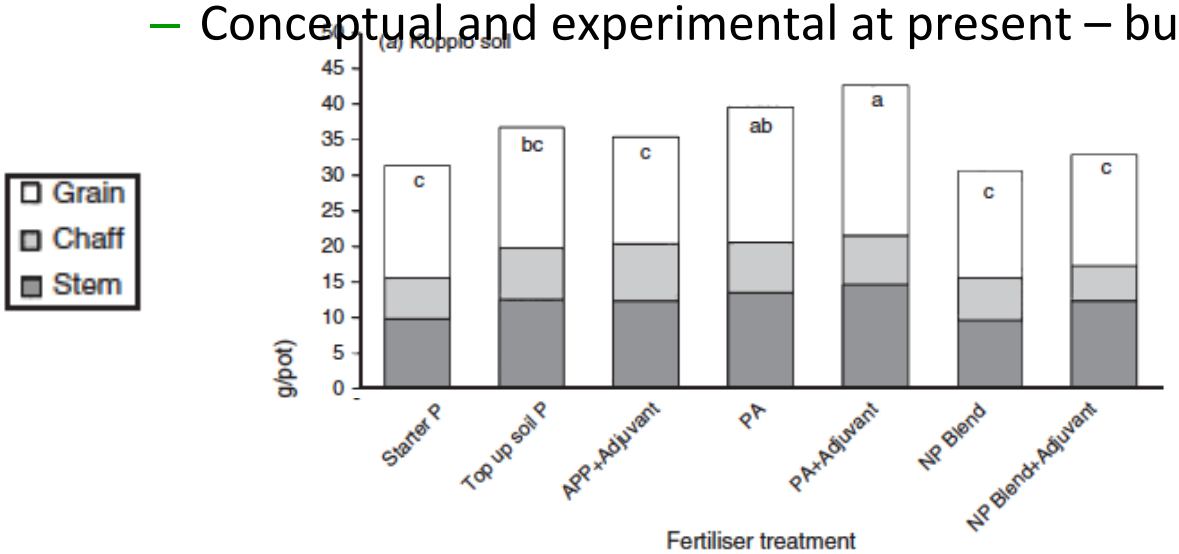
Options opening up



- Co-granulation (Zn, S)
- Fluid P sources
  - Benefits on calcareous soils
  - Less fixation (Ca, Fe, Al)
- Foliar P
  - Opportunity to "top-up" P, becomes a tactical decision
  - Conceptual and experimental at present – but some interest.





McBeath et al, 2011, CPS

- phosphoric acid +/- Adj
- NP blend +/- adjuvant

#3……..there are no silver bullets

"Frankly, I don't know what to believe. They say if it sounds too good to be true, it usually is."

Summary

- Get the foundation correct (esp. pH).
- Colwell P is still a reliable test – sampling critical
  - Understand what it is telling you.
- Allocate fertilizer dollars to the most responsive situations.
  - Soil tests help identify responsive areas
  - Yield potentials/replacement
- Maintain a soil P test near the value critical value.
- The development of new products and technologies are promising but not yet mature.