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Dahlen Long Term Fertilizer Experiment

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Taylors Lake, September 2011

Long term trial site – established 1996

- Four rates of P (TSP)
  - 0, 9, 18, 36
- Five rates of N (Urea)
  - 0, 20, 40, 80, 160
  - No N in legume phase
- N applied either
  - All at sowing/split 50:50
- Each year the site sown to a single crop.
- Soil samples, grain harvest, nutrient content.

Direct drilled, zero cultivation, stubble retained.

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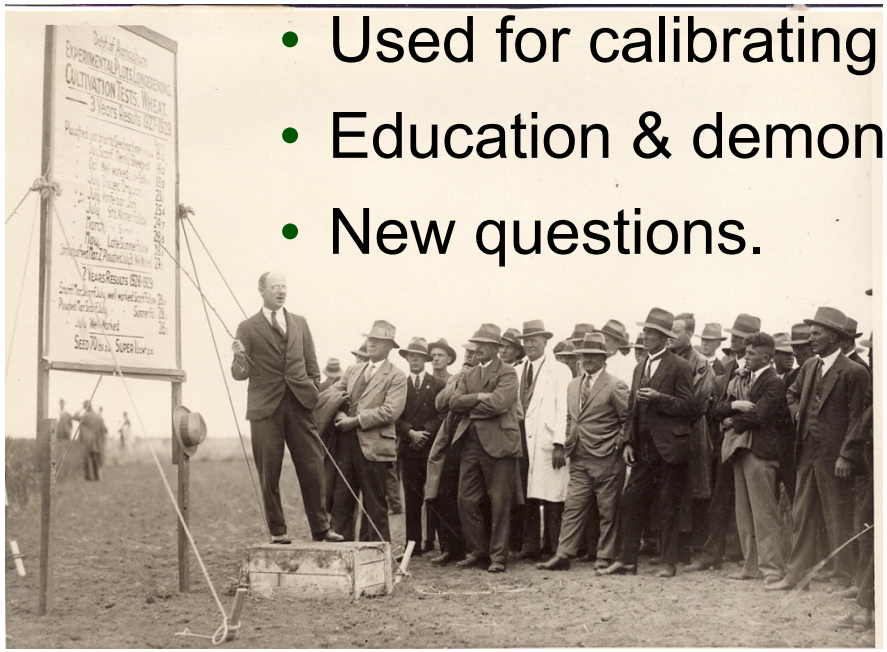
Why have a long term experiment?

- Use to document trends in yield and quality over time.
- Follow the build up or depletion of nutrients in soil.
- Used for calibrating soil tests (*eg* DGT-P).
- Education & demonstration.
- New questions.



Longerenong Rotation 1 – 1916

Broadbalk, Rothamstead, 1843

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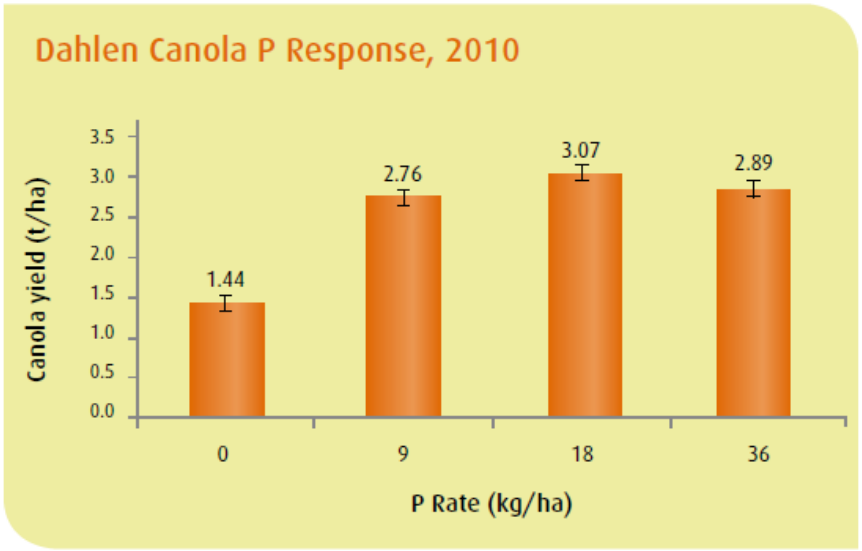
Crops Grown

- Barley -1996, 2000, 2004, 2008
- Chickpea -1997, 2009
- Lentil – 2001 , 2005
- Canola -1998, 2002, 2006 , 2010
- Wheat - 1999, 2003, 2007
- 2011 in fodder oats (weed control)

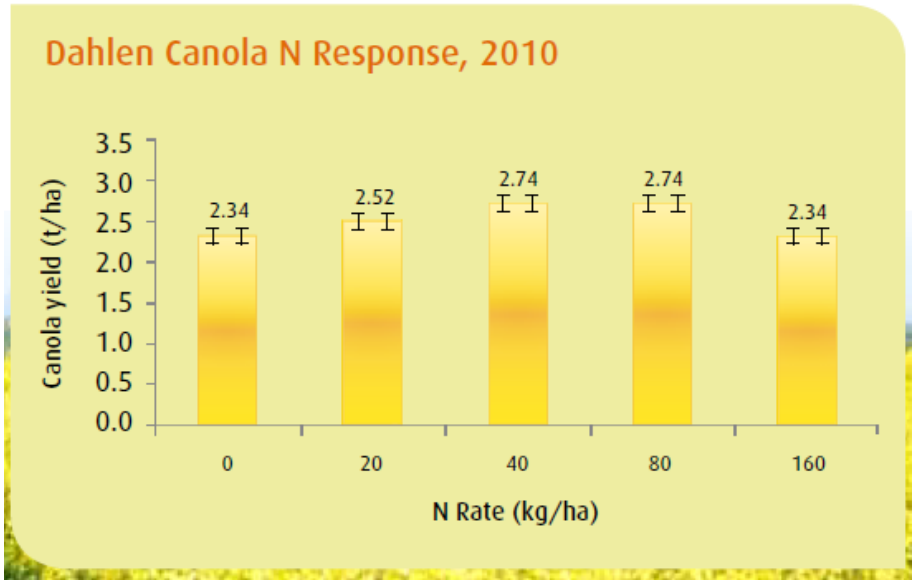
2010 Canola

- Good year for responses
  - 0 N 0 P = 1.38 t/ha
  - 80 N 18 P = 3.45 t/ha
- Relatively small N response
  - Poor Barley 2008
  - Poor Chickpea 2009
    - Still fixed N
  - Some small benefit to splitting N

Graph 1

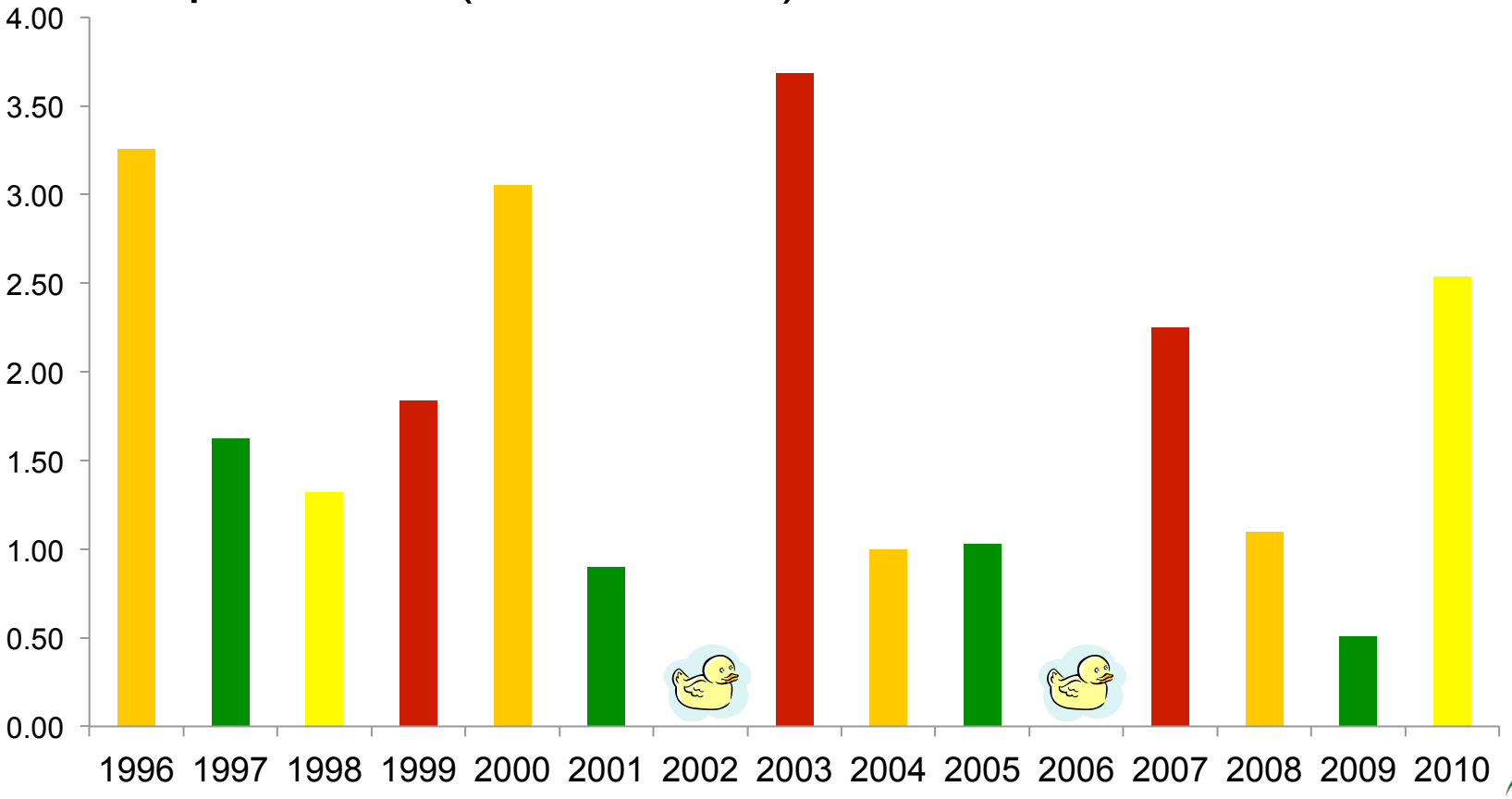


Graph 3



Mean yields 1996 to 2010 (t/ha)

- Not the greatest set of years!!!
- 2 complete fails (both canola)



Main effects 1996 to 2010

Year	1996	'97	'98	'99	'00	'01	'03	'04	'05	'07	'08	'09	'10
Crop	Barl	Cpea	Cano	Whea	Barl	Lent	Whea	Barl	Lent	Whea	Barl	Cpea	Cano
Site Mean Yield (t/ha)	3.26	1.62	1.32	1.84	3.05	0.90	3.69	1.00	1.03	2.25	1.10	0.51	2.54
N	***	***	***	***	***	***	***	***	ns	**	***	***	***
P	***	***	***	***	***	***	***	***	***	**	ns	***	***
T	***	ns	ns	ns	ns	ns	ns	ns	**	ns	ns	ns	*
N*P	***	ns	***	ns	***	***	***	***	ns	ns	***	ns	ns

- 12/13 sign N response
- 12/13 sign P response
- 6/13 sign Timing response
- 7/13 sign N*P interaction

How to evaluate these experiments

- Yields ?
- Profitability
  - Annual v Long term
- Efficiency – Many ways to do this
  - Partial Factor Productivity – Yield divided by Fertilizer applied
    - (If interested in straight production – how to get the most)
  - Agronomic Efficiency – Yield increase divided b fertilizer applied
    - If interested in efficiency of use of fertilizer
  - Partial Nutrient Balance – kg nutrient removed per kg fertilizer applied
    - If interested in the efficiency of nutrient use
- Nutrient Balance over time

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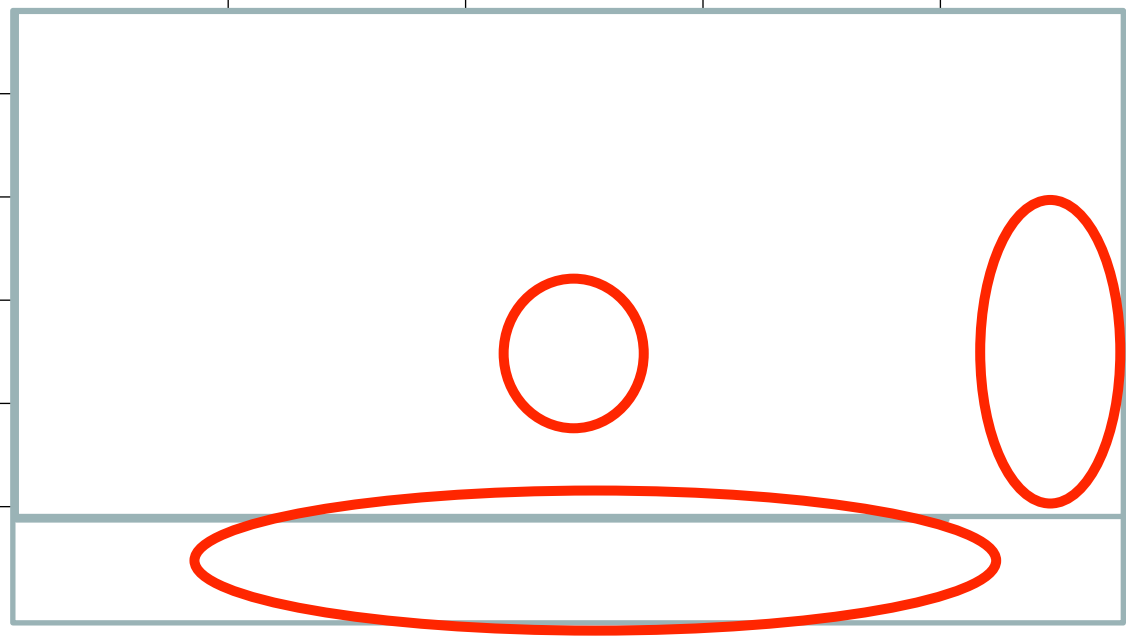
Across all years – mean of treatments

Average Grain Yield (t/ha)

N	0	9	18	36
0				
20				
40				
80				
160				



Year by Year best treatment ($/ha)

Year	Crop	$/ha	N	P
1998	Barley	952	160	36
1997	Chickpea	504	*20*	18
1998	Canola	534	80	9
1999	Wheat	250	20	9
2000	Barley	573	80	18
2001	Lentil	286	*0*	9
2003	Wheat	668	20	9
2004	Barley	48	20	18
2005	Lentil	267	*160*	9
2007	Wheat	329	20	9
2008	Barley	116	20	9
2009	Chickpea	1	*40*	0
2010	Canola	1319	40	18

Average Best Treatment – 15 crops

- Based on gross margins
  - Yields as harvested
  - Costs
    - Wheat – $183 /ha
    - Barley - $171/ha
    - Pulse - $273 /ha
    - Canola - $222/ha
  - Prices
    - Wheat - $220/t
    - Barley - $200/t
    - Pulse - $400/t
    - Canola - $500/t
    - Urea – $460/t
    - TSP - $430/t

Profitability $/ha/y

N	0	9	18	36
0	118	202	196	159
20	120	**244**	**246**	160
40	141	**229**	**243**	199
80	89	**235**	**254**	170
160	25	141	145	101

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Agronomic Efficiency

- When 9 or 18 kg P
  - First 20 kg N gets an extra 16 kg grain per kg N
  - More N gives more but not a lot more – diminishing returns!
- At 9 kg P
  - Some N gives about 50 kg grain per kg P
  - Additional P does not give a higher grain return

Nitrogen AE
(kg increase in yield per kg fertilizer applied)

N	0	9	18	36
0				
20	5.0	**16.0**	**17.1**	5.8
40	4.0	8.0	10.7	9.2
80	2.0	6.0	7.8	5.0
160	1.4	2.1	2.6	2.2

Phosphorus AE
(kg increase in yield per kg fertilizer applied)

N	0	9	18	36
0		31.1	17.7	9.5
20		**49.1**	27.6	9.8
40		**36.7**	24.9	11.8
80		**57.2**	36.5	14.4
160		40.3	25.4	12.1

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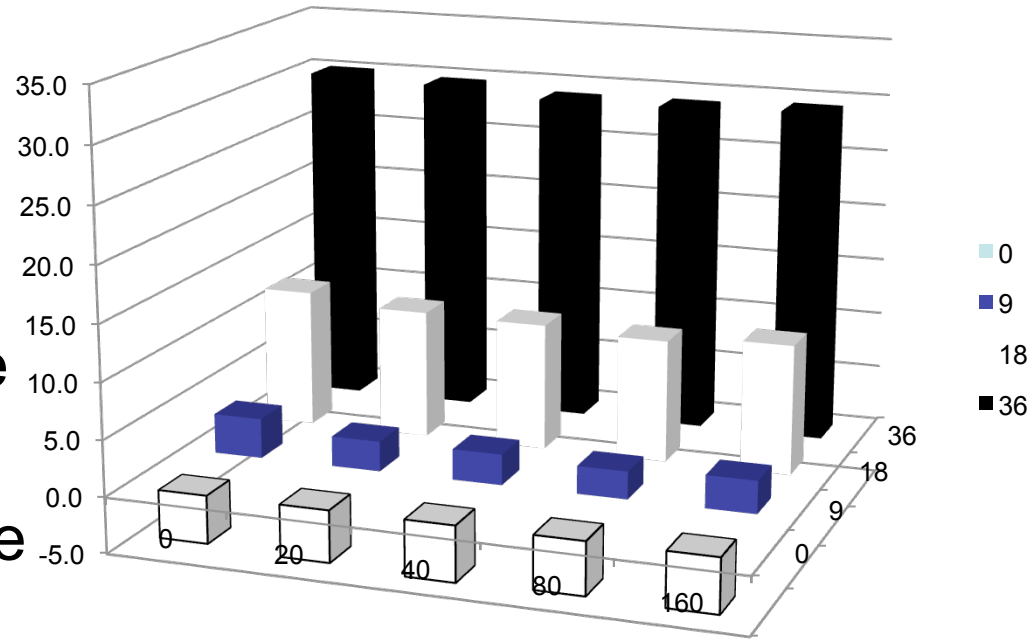
What about nutrient balance?

- Around 5 kg P removed if no P applied
- 9 kg P has about 3 kg P more P applied than removed
- 18 kg P has 11 kg P more applied than removed
- 36 kg P has 30 kg P more applied than removed.
- N had little impact on P removal



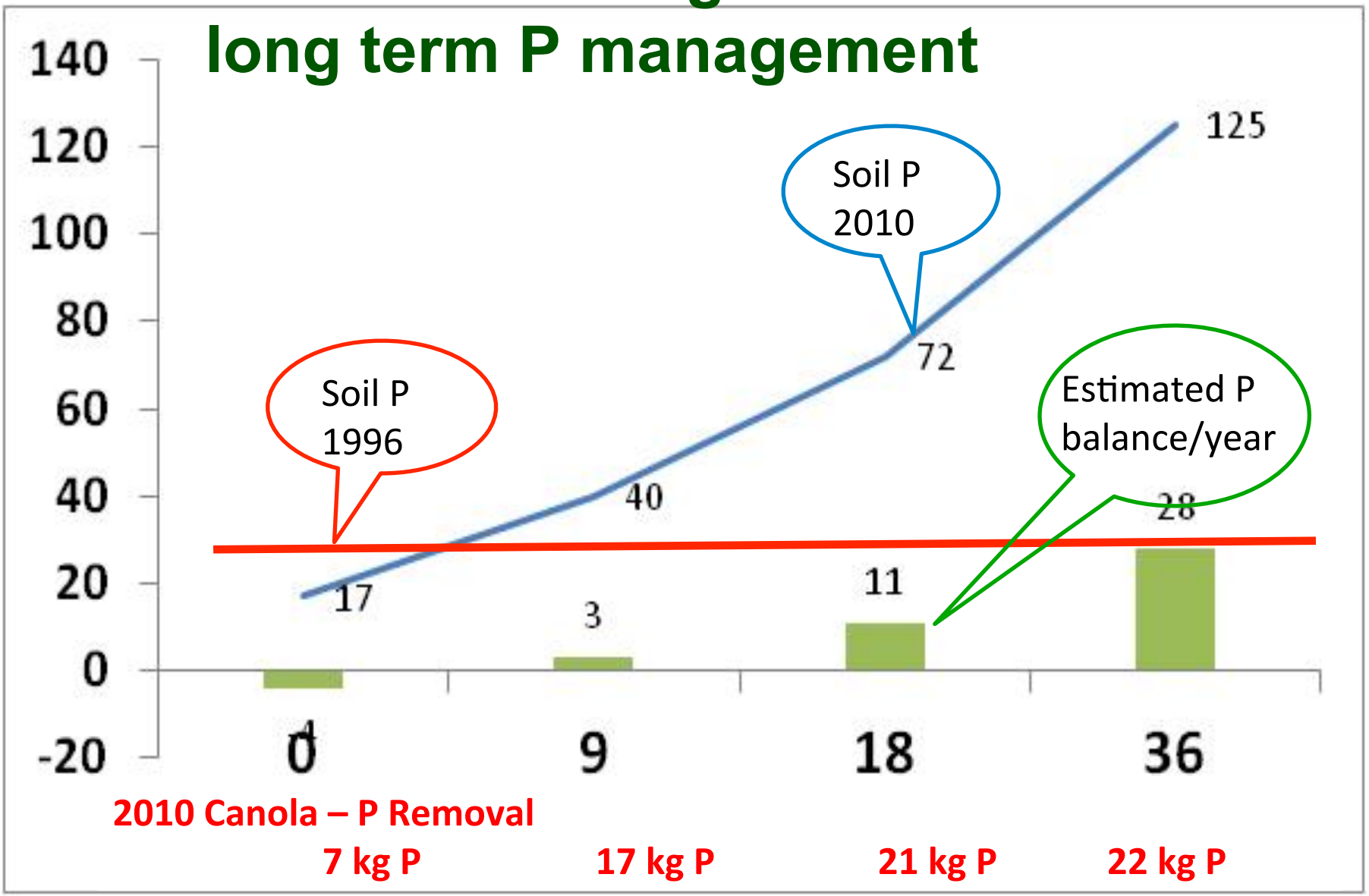
Phosphorus

Fertilizer applied - Grain removal

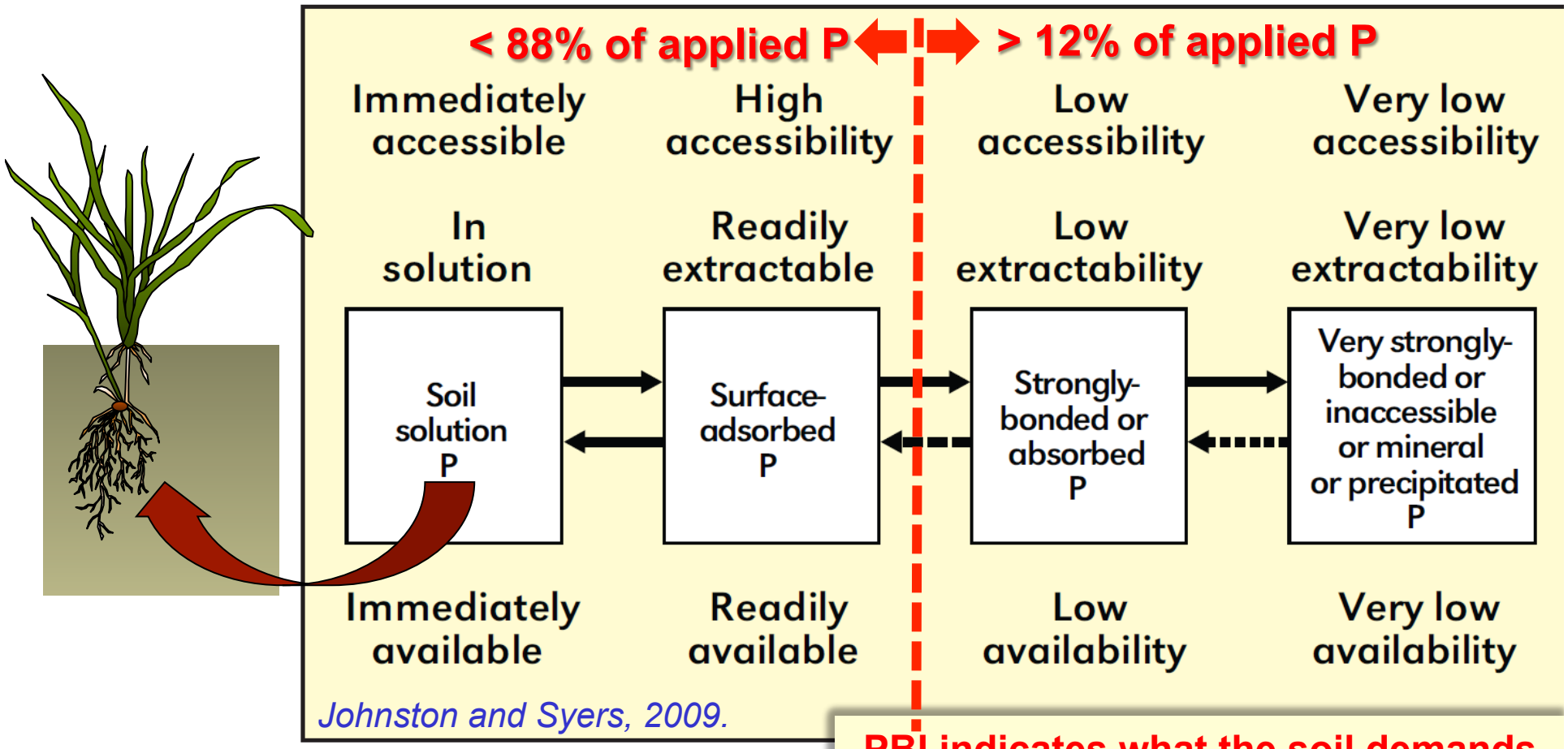
Effects on soil P levels (top 10 cm only)

- Long term P strategy:
  - Site started at 20 mg/kg Colwell P
  - (PBI = 115 (low) *Critical P = 35 mg/kg*
  - Now
    - 0 P = 17 mg/kg — total P = 250 kg/ha = *responsive*
    - 9 P = 40 mg/kg — total P = 300 kg/ha = *near critical*
    - 18 P = 72 mg/kg — total P = 384 kg/ha = *above critical*
    - 36 P = 125 — total P = 528 kg/ha = *well above critical*

Dahlen IPL Trial Long Term P – long term P management



Availability and extractability of soil P pools



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

PBI indicates what the soil demands from the fertilizer & enters the low availability pool … becomes plant available over time

So what do we conclude

- In the long term annual application of 9 kg/ha P
  - has kept the soil test near critical
  - Is about in P balance of input and output

- Relatively poor years
- Top soil P only
- Does not show the whole P story

- BUT
  - **MESSAGE IS THAT IF YOUR SOIL TEST VALUES ARE AT OR NEAR CRITICAL, REPLACEMENT P IS A GOOD STRATEGY.**

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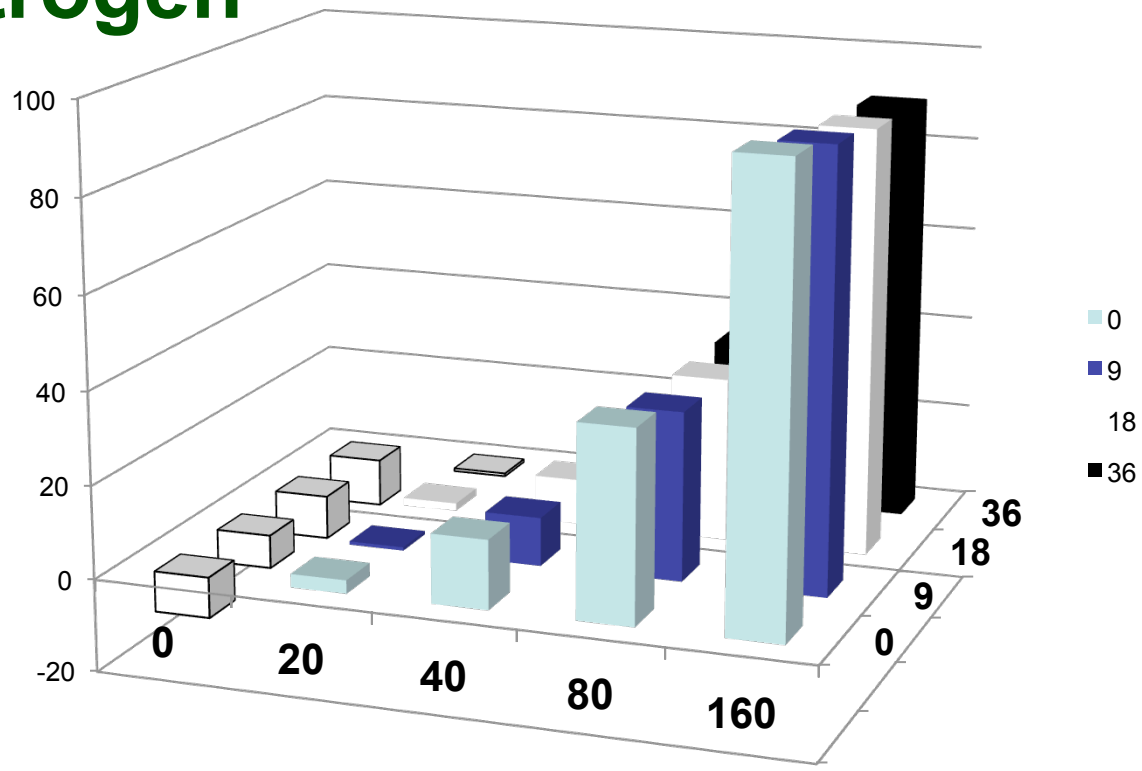
What about Nitrogen

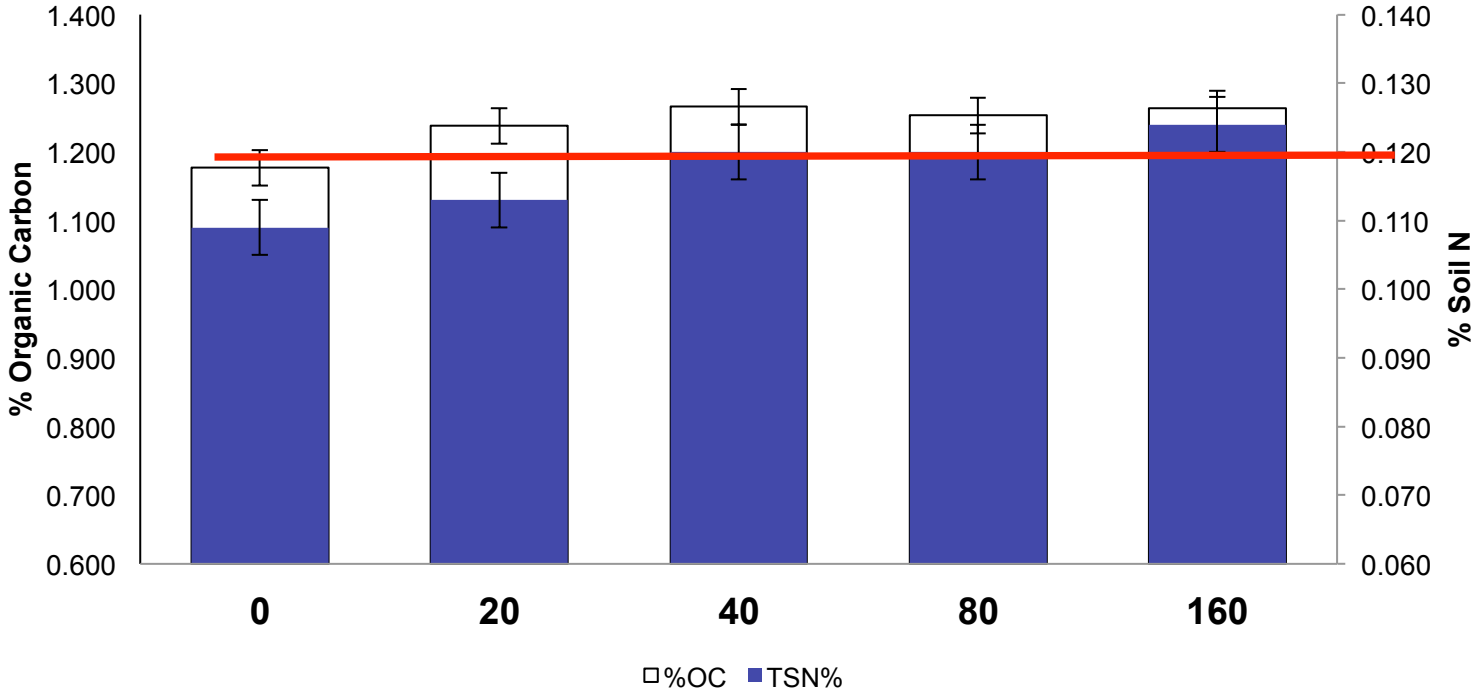
- Similar story to P
- Includes legume N contribution about 75 kg N/ha/legume crop
- Nil N is drawing down on the soil reserves.
- 20 to 40 N is about equal to N removal



- More than 40 N applied means that more N is applied than removed.

What happens to the excess N?

- 1996 organic C level – 1.14%, TSN = 0.096
- Top 10 cm 2011 pre-sowing
  - N alone had no significant effect on OC (*p*=0.114)
  - TSN did show significant (p=0.015) increases with N
  - Difficult to compare 1996 with 2011 (bulk density).



P also increased the OC level!

- The increase in Total Soil N was due to P stimulating legumes and therefore N fixation.
- N fixation study on lentils in 2005

P	TSN%	%OC
0	0.108	1.089
9	0.116	1.249
18	0.124	1.330
36	0.125	1.290
se	*0.003*	*0.027*

P Rate	Biomass	Yield	Nfixed kg/ha	kg/t
0	3.06	0.60	**37.6**	13
9	4.39	1.13	**53.6**	11
18	5.08	1.20	**65.5**	12
36	4.76	1.06	**72.3**	13
LSD	*0.52*	*0.12*	***10.2***	*ns*

Splitting N – what did that show?

- Only two years when splitting was significantly different from an at-sowing N application
- Averaged across all N treatments
- But no interaction
- Splitting is a risk management strategy.

		At Sowing	Split	p
Barley	**1996**	***3.47***	***2.99***	***Sign***
Chickpea	**1997**	*	*	
Canola	**1998**	*1.34*	*1.30*	*ns*
Wheat	**1999**	*1.88*	*1.80*	*ns*
Barley	**2000**	*3.08*	*3.02*	*ns*
Lentils	**2001**	*	*	
Wheat	**2002**	*0.00*	*0.00*	*ns*
Wheat	**2003**	*2.68*	*2.69*	*ns*
Barley	**2004**	*1.00*	*0.99*	*ns*
Lentil	**2005**	*	*	
Canola	**2006**	*0.00*	*0.00*	*ns*
Wheat	**2007**	*2.18*	*2.26*	*ns*
Barley	**2008**	*1.10*	*1.10*	*ns*
Chickpea	**2009**	*	*	
Canola	**2010**	***2.45***	***2.63***	***0.05***

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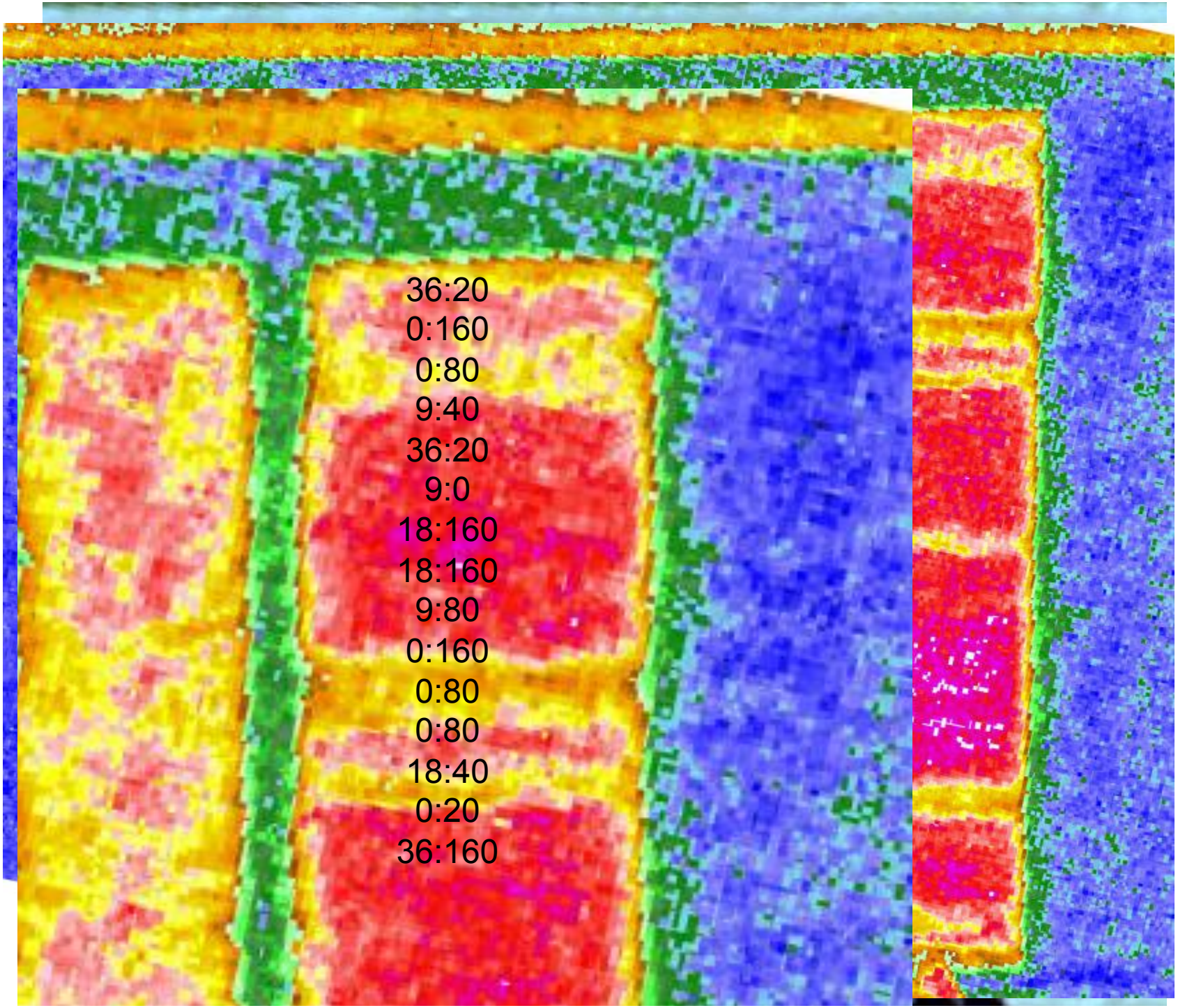
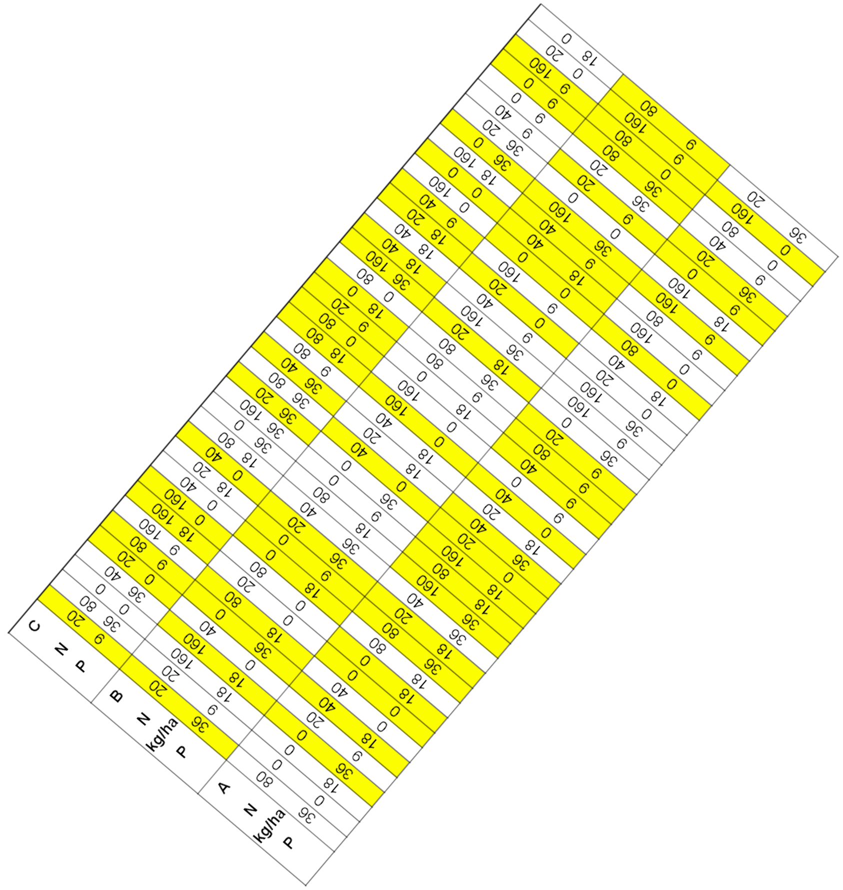
So what worked out best?

- 20:9 or 40:9
  - About the most profitable
  - About in nutrient balance of input and output
    - Soil tests kept at about the same level
  - BUT
    - Relatively poor string of years
      - In better years more P and N pay off
  - BUT
    - Need to set the P status with at-sowing – maybe up P rate to meet higher demand in better years – monitor with soil tests.
    - Match N supply to season – with moderate N at sowing, little penalty with splitting.


36:20
0:160
0:80
9:40
36:20
9:0
18:160
18:160
9:80
0:160
0:80
0:80
18:40
0:20
36:160


A
N
kg/ha
P
B
N
kg/ha
P
C
N
P

Effect of N & P on Ndfa

- 2005 site in lentil
- N had no effect:
- P affected growth & yield

P Rate	Biomass	Yield	Score	Nodule Wt	%Ndfa	%N	Nfixed kg/ha	kg/t
0	3.06	0.60	1.1	0.023	80	1.7	**37.6**	13
9	4.39	1.13	2.3	0.057	68	1.7	**53.6**	11
18	5.08	1.20	2.3	0.064	67	1.8	**65.5**	12
36	4.76	1.06	2.4	0.060	64	2.0	**72.3**	13
LSD	*0.52*	*0.12*	*0.4*	*0.010*	*ns*	*ns*	***10.2***	*ns*

- Affected nodulation,
- not %N derived from atmosphere (fixed)

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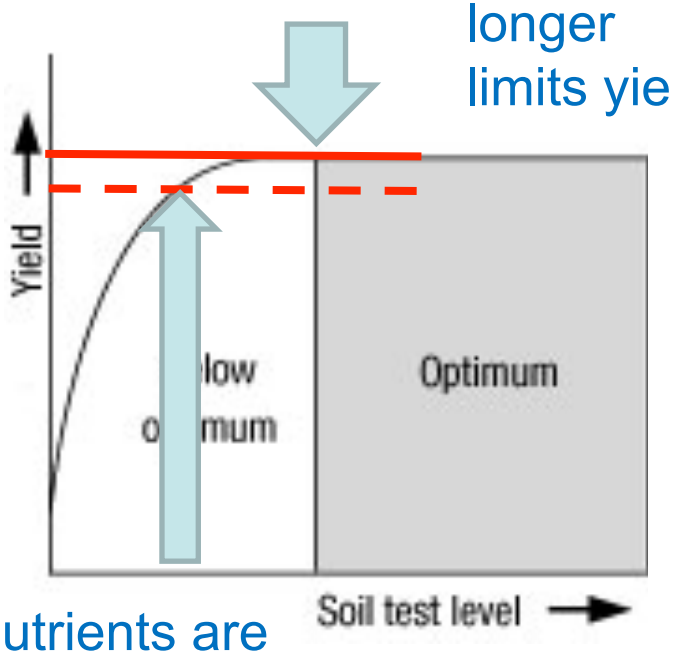
Critical P value

- A critical soil test value is based on achieving 95% of maximum yield at that value.
- Olsen P = 15 mg/kg but poor predictability
- Colwell P = value depends on soil type – better predictor of response than Olsen
- Better fertilizer decisions for crops



Colwell P and PBI

- A critical P test value depends on soil chemistry – P buffering capacity
- PBI is a measure of how much applied P is transfered to the low availability pools
- Scale 0 to 1000
- Dahlen = 115
- Critical Colwell = 35 mg/kg

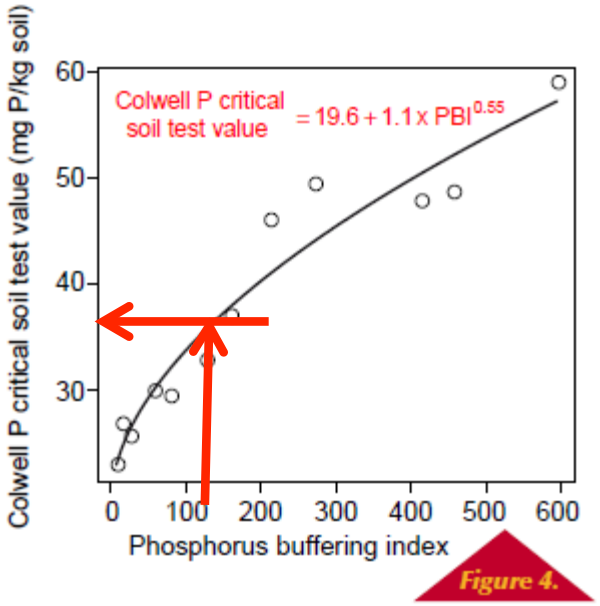


Figure 4.

The relationship between critical Colwell P value and soil P buffering index. The critical Colwell P value is the soil test value predicted to produce 95% of maximum pasture yield.

PBI Category		Critical Range
<15	Extremely Low	20-24
15-30	Very very low	24-27
36-70	Very low	27-31
71-140	Low	31-36
141-280	Moderate	36-44
281-840	High	44-64

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N & P interaction – as per model system?

- Wheat Phases analysed.
- In two of three years N*P interaction
- Nature is that @0P = little N response
- Also see that timing of N had no significant effect.

Three-Way ANOVAR P values – Grain Yield t/ha

	1999	2003	2007
Site Yield	*1.84*	*3.69*	*2.25*
N	0.000	0.000	0.017
P	0.011	0.000	0.003
Timing	0.131	0.437	0.178
N*P	0.079	***0.000***	0.201
N*Time	0.289	0.781	0.290
P*Tm	0.763	0.302	0.366
N*P*Tm	0.464	0.913	0.599

Frost 1999

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What set strategy was best?

	0N	20N	40N	80N	160N	*mean*
0P	241	244	265	218	188	***231***
9P	311	391	347	317	281	***329***
18P	294	353	327	339	262	***315***
36P	247	283	337	291	219	***275***
Mean	***273***	***318***	***320***	***291***	***238***	

- 9P
- 20N

Nitrogen	0N	20N	40N	80N	160N	mean
0P	-8	3	15	42	96	*30*
9P	-7	4	13	41	97	*30*
18P	-9	1	14	41	97	*29*
36P	-9	0	13	38	98	*28*
mean	*-8*	*2*	*14*	*41*	*97*	

Phosphorus	0N	20N	40N	80N	160N	mean
0P	-4	-4	-4	-4	-5	*-4*
9P	5	4	4	4	4	*4*
18P	13	13	13	13	13	*13*
36P	32	31	30	31	31	*31*
mean	*11*	*11*	*11*	*11*	*11*	

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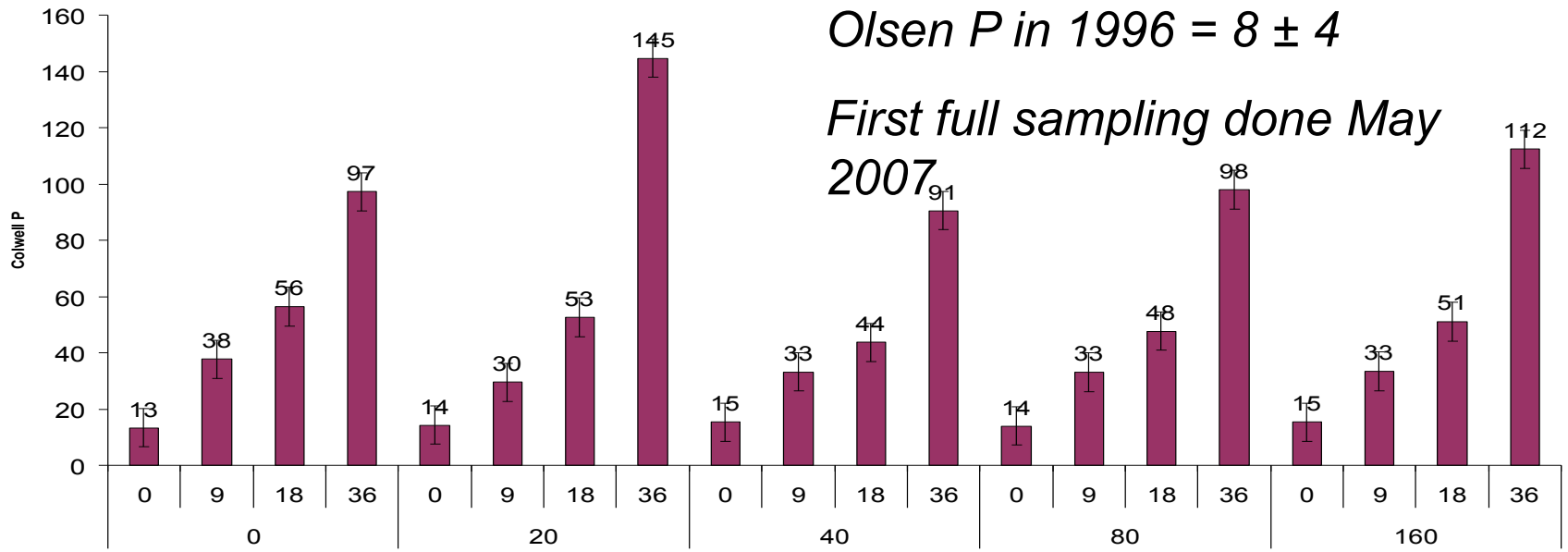
Long term effect on Colwell P



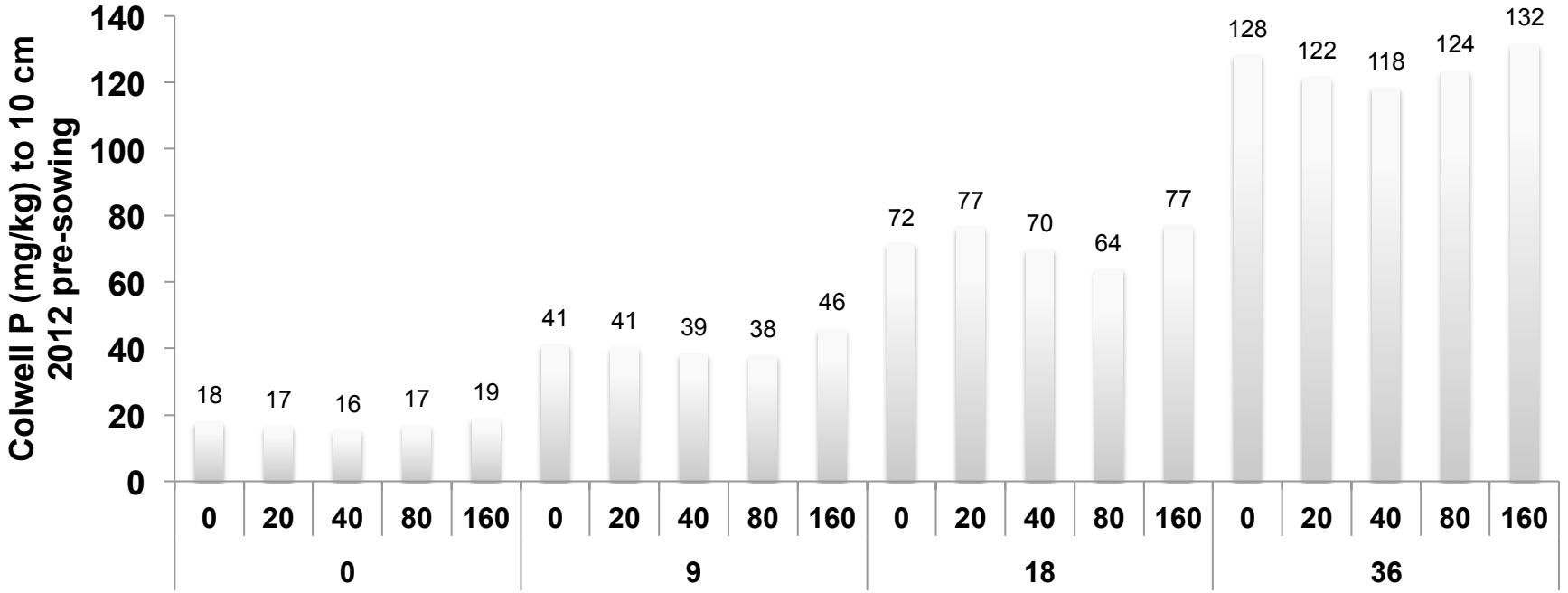
Olsen P in 1996 = 8 ± 4

First full sampling done May 2007

- Interaction between N & P - @ high N, Colwell P is less than at lower N – less P offtake @ lower N??
- N did not increase OC, +P took OC from 0.93±0.02 to 1.01±0.02
- N decreased soil pHCaCl2 from 7.3±0.1 to 6.9±0.1
- Both N and P increased soil S levels.

Long Term Colwell P

- Starting Colwell = 24 mg/kg
- Interaction between N & P - @ high N, Colwell P is less than at lower N – less P offtake @ lower N??



P balance and soil test changes

- Rotation in P balance will be at about 32 Colwell
- Colwell P rises 0.2 mg/kg for each kg P over balance