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Benefits, costs and risks of nutrient use in cropping in the HRZ of southern Australia

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Purpose

To equip growers and their advisors to confidently assess crop nutrient demands and pay-offs in the HRZ of southern Australia.

Overview

- Features of the problem
- Response surface analysis
  - ❖One nutrient at a time (N or P or S or K)
  - ❖Two nutrients at a time (N&P or N&S or N&K)
- Conclusions

Features of the problem

- Determine fertiliser rates and product yield that maximise net revenue (economic optimum) in the current growing season.
- Information is required at the local scale (soil type and climate).
- Growers able to fit the fertiliser to their budget.
- Assist growers to respond tactically within a season to evolving conditions.
- Risk encountered mostly relate to production outcomes:
  - ❖ Unknown season type or yield but known starting moisture
  - ❖ Fixed crop $ returns (can contract)
  - ❖ Fixed fertiliser prices at application

One-nutrient-at-a-time approaches

Optimisation – one variable input

- Method:
  - ❖ “Response surface analysis”.
  - ❖ Integrates estimated response surfaces with the marginal principle of profit-maximisation.
- The decision rule for maximising profit from using a variable input, such as N or P, is to apply the input up to where the revenue from an extra kilogram of nutrient applied just exceeds its cost.
- Assumes that other nutrients are unlimiting.
- We uses conventional response curves for the current time period:
  - ❖ Not ‘steady-state’ or maintenance curves.
  - ❖ Will also provide information on residual nutrients at end of growing season.

Price assumptions

Wheat price ($/t), net, on-farm post-harvest[1]	256
N inputs	
- Urea unit cost delivered and spread (2 applications) ($/t)[2,1]	552
- N:W price ratio	4.8
- N unit cost delivered and spread ($/kg N)	1.20
P inputs	
- DAP unit cost delivered and spread ($/t)[2,1]	722
- P unit cost delivered and spread ($/kg P)[3]	3.61
- P:W price ratio	14.3
- P:N price ratio	3.0

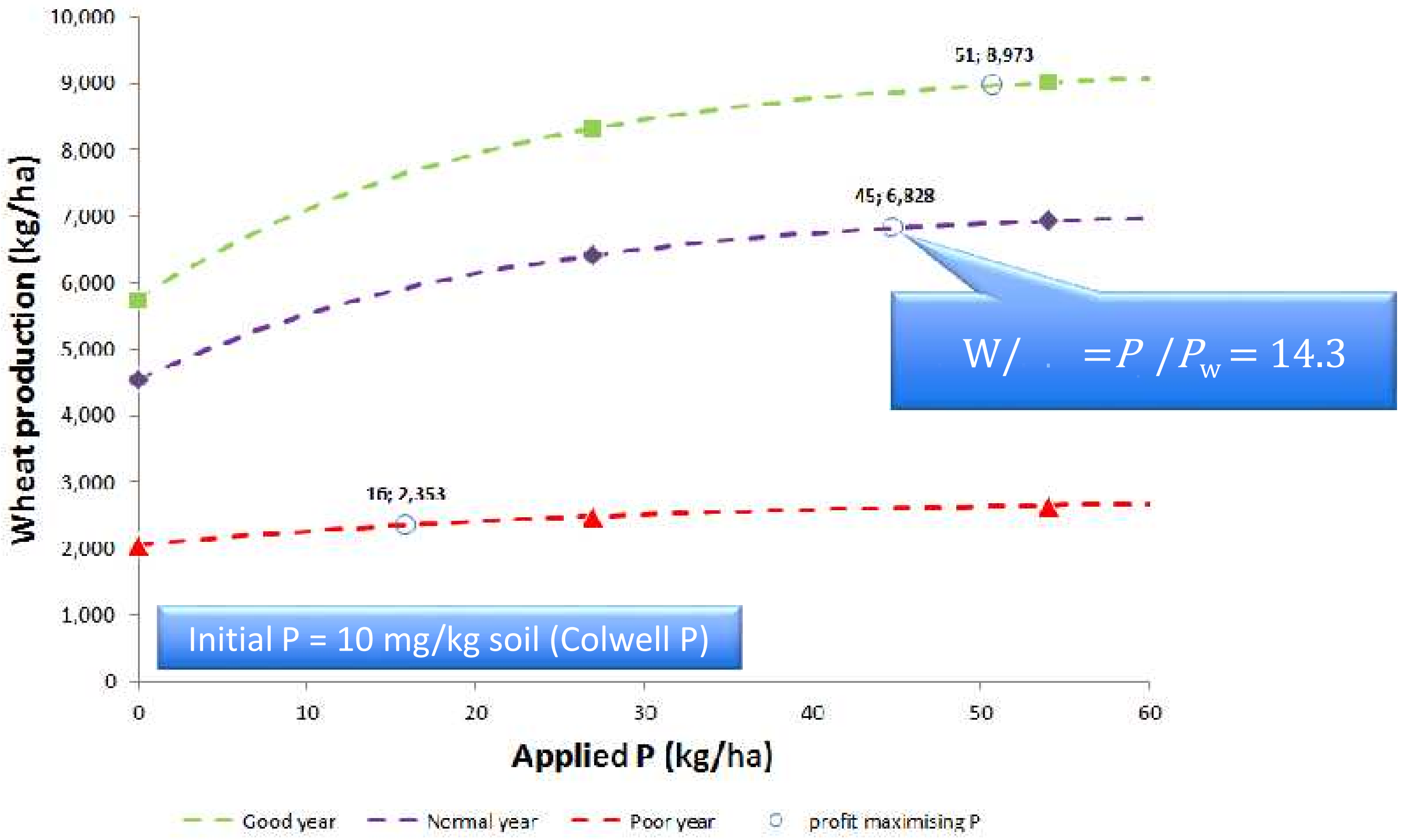
Sources:

1. 2016 Farm Gross Margin Guide (GRDC, 2016)

2. Bruce Lewis, Vickery Bros (pers. comm.)

3. Calculated from the DAP price, after accounting for the value of N as determined from the price of Urea.

Optimisation – one variable input



Two-nutrient-at-a-time approaches

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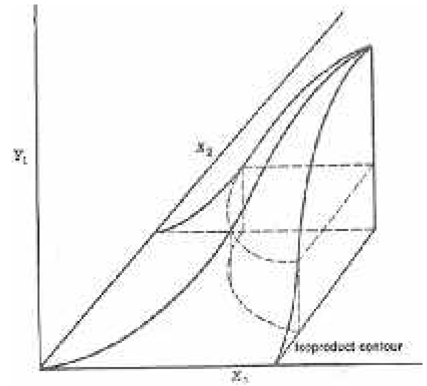
Optimisation - 2 variable inputs

- Relaxes the assumption that other nutrients are unlimiting.
- Takes into account the market as well as physical substitution between the two variable nutrients .
  - ❖ For example, that P is 3 times more expensive than N.
- The economic decision rule is to apply N and P up to where the cost of applying an extra kilogram of P is equal to the reduction in the cost from using less of N.
- Accommodates a budget constraint:
  - ❖ Can determine the optimum yield and combination of 2 fertiliser inputs, say N and P
  - ❖ OR the least cost combination of the 2 fertiliser inputs.

Optimum yield and two variable inputs (N & P) in a "good" year



Applied N (kg N/ha)	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
160	5,411	8,026	8,386	8,605	8,763	8,888	8,992	9,080	9,157	9,226	9,288	9,344	9,396	9,444	9,488	9,530	9,569
150	5,393	7,999	8,359	8,576	8,734	8,859	8,962	9,050	9,127	9,196	9,257	9,313	9,365	9,413	9,457	9,498	9,537
140	5,374	7,971	8,329	8,546	8,704	8,828	8,930	9,018	9,095	9,163	9,225	9,281	9,332	9,379	9,424	9,465	9,504
130	5,353	7,941	8,298	8,514	[illegible]	8,794	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9,344	9,388	9,429	9,468
120	5,332	7,908	8,264	8,479	8,635	8,758	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9,306	9,350	9,391	9,429
110	5,308	7,873	8,227	8,441	[illegible]	8,719	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9,264	9,308	9,349	9,387
100	5,282	7,835	8,187	8,400	8,555	8,677	8,778	[illegible]	[illegible]	9,007	9,067	9,122	9,173	9,219	9,263	9,303	9,341
90	5,254	7,793	8,143	8,355	8,509	8,630	8,751	8,817	8,892	8,958	9,018	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
80	5,222	7,746	8,094	8,305	8,458	8,578	[illegible]	8,764	8,838	8,904	8,964	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
70	5,186	7,693	8,039	8,248	8,400	8,520	8,619	8,704	8,778	8,844	8,903	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
60	5,146	7,633	7,976	8,183	8,334	8,453	8,551	[illegible]	8,709	8,774	8,833	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
50	5,098	7,562	7,902	8,107	8,257	8,375	8,472	8,555	8,628	8,693	8,751	8,804	[illegible]	8,898	8,940	8,979	9,016
40	5,040	7,476	7,812	8,015	8,163	8,279	8,376	[illegible]	8,530	8,594	8,652	8,704	8,752	8,797	8,838	8,877	8,913
30	4,966	7,366	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8,405	8,468	8,525	8,577	8,624	8,668	8,709	8,747	8,783
20	4,864	7,215	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8,233	8,294	8,350	8,401	8,447	8,490	8,530	8,568	8,603
10	4,695	6,964	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7,946	8,005	8,059	8,108	8,153	8,194	8,233	8,269	8,303
0	3,296	4,890	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5,579	5,621	5,659	5,693	5,725	5,754	5,781	5,806	5,830

Applied P (kg P/ha)

$. / . = P / P = 3$

Isoproduct contour
yield = 8.7t/ha

Isocost line
Total costs = $200/ha

Initial N = 160 kg N/ha
Initial P = 10 mg/kg soil (Colwell P)

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Least cost combination of 2 variable inputs

Applied N (kg N/ha)

160	5,411	8,026	8,386	[illegible]	8,763	8,888	8,992	[illegible]	9,157	9,226	9,288	9,344	9,396	9,444	9,488	[illegible]	9,569
150	5,393	7,999	8,359	8,576	8,734	8,859	8,962	9,050	9,127	9,196	9,257	9,313	9,365	9,413	9,457	9,498	9,537
140	5,374	7,971	8,329	8,546	8,704	8,828	8,930	9,018	9,095	9,163	9,225	9,281	9,332	9,379	9,424	9,465	9,504
130	5,353	7,941	8,298	8,514	8,671	8,794	8,897	8,984	9,060	9,128	9,190	9,245	9,297	9,344	9,388	9,429	9,468
120	5,332	7,908	8,264	8,479	[illegible]	8,758	8,860	8,947	9,023	[illegible]	9,152	9,208	9,259	9,306	9,350	9,391	9,429
110	5,308	7,873	8,227	8,441	8,597	8,719	8,821	8,908	8,983	9,051	9,111	9,167	9,217	9,264	9,308	9,349	9,387
100	5,282	7,835	[illegible]	8,400	8,555	8,677	8,778	8,864	8,940	9,007	9,067	9,122	9,173	9,219	9,263	9,303	9,341
90	5,254	[illegible]	[illegible]	8,355	8,509	[illegible]	8,731	8,817	8,892	8,958	9,018	9,073	9,123	9,170	9,213	9,253	9,291
80	5,222	[illegible]	8,094	8,305	8,458	8,578	[illegible]	8,764	8,838	8,904	8,964	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
70	5,186	[illegible]	8,039	8,248	8,400	8,520	8,619	8,704	8,778	8,844	8,903	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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40	5,040	7,476	7,812	8,015	8,163	8,279	8,376	8,458	8,530	8,594	8,652	[illegible]	[illegible]	8,797	8,838	8,877	8,913
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10	4,695	6,964	7,277	7,466	7,604	7,712	7,802	[illegible]	[illegible]	8,005	8,059	8,108	8,153	8,194	8,233	8,269	8,303
0	3,296	4,890	5,109	5,243	5,339	5,415	[illegible]	5,532	5,579	5,621	5,659	5,693	5,725	5,754	5,781	5,806	5,830
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80

Applied P (kg P/ha)

Isoproduct contour
yield = 8.3t/ha

Isocost line
Budget constraint = $130/ha

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Conclusions

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Conclusions

- "Response surface analysis" can be used to assess crop nutrient demands and predict yield potential and pay-offs associated with high input use in the HRZ environment.
  - ❖ The method distils key technical information from complex crop models such as CAT.
  - ❖ The method uses conventional response curves for current time period.
  - ❖ Accommodates risk and uncertainty in production outcomes and prices using 'what-if' analysis and tactical responses such as split N applications.
  - ❖ Requires growers to re-evaluate decisions on an annual basis, keep testing costs in their fertiliser budget, as recommended by BCG.

- The two nutrient approach is preferred.
  - ❖ Relaxes the assumption that other nutrients are unlimiting.
  - ❖ Accommodates a budget constraint.
  - ❖ Analytic solutions are simple.
  - ❖ The tool is intuitive and easy to use.
  - ❖ It can be operational at various levels of sophistication, ranging from Fact Sheets to an interactive spreadsheet model or web application.

Further Work

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Further work: for discussion

- Agree on and run a few crop modelling scenarios.
- Agree on how to define "good", "normal" or "poor" seasons.
- Do mock-ups for canola as well as wheat.
- Agree on rules on how to convert starting soil nutrient levels (or residual fertiliser) to units of applied nutrient for estimating the response functions.
- Do mock-ups for N&K and N&S as well as N&P.
- Refine P responses in CAT?
- Explore alternative functional forms for the response functions?
- Accommodate penalty for commercial v. experimental or modelled yields?
- Accommodate crop quality attributes (eg grain protein)?
- Test the preferred concept for the ’tool’ and selected scenarios with farm management consultant and/or growers.
- For another project (?): incorporating a ‘residual value function’ and quantifying dynamic “maintenance” response curves.

Spares

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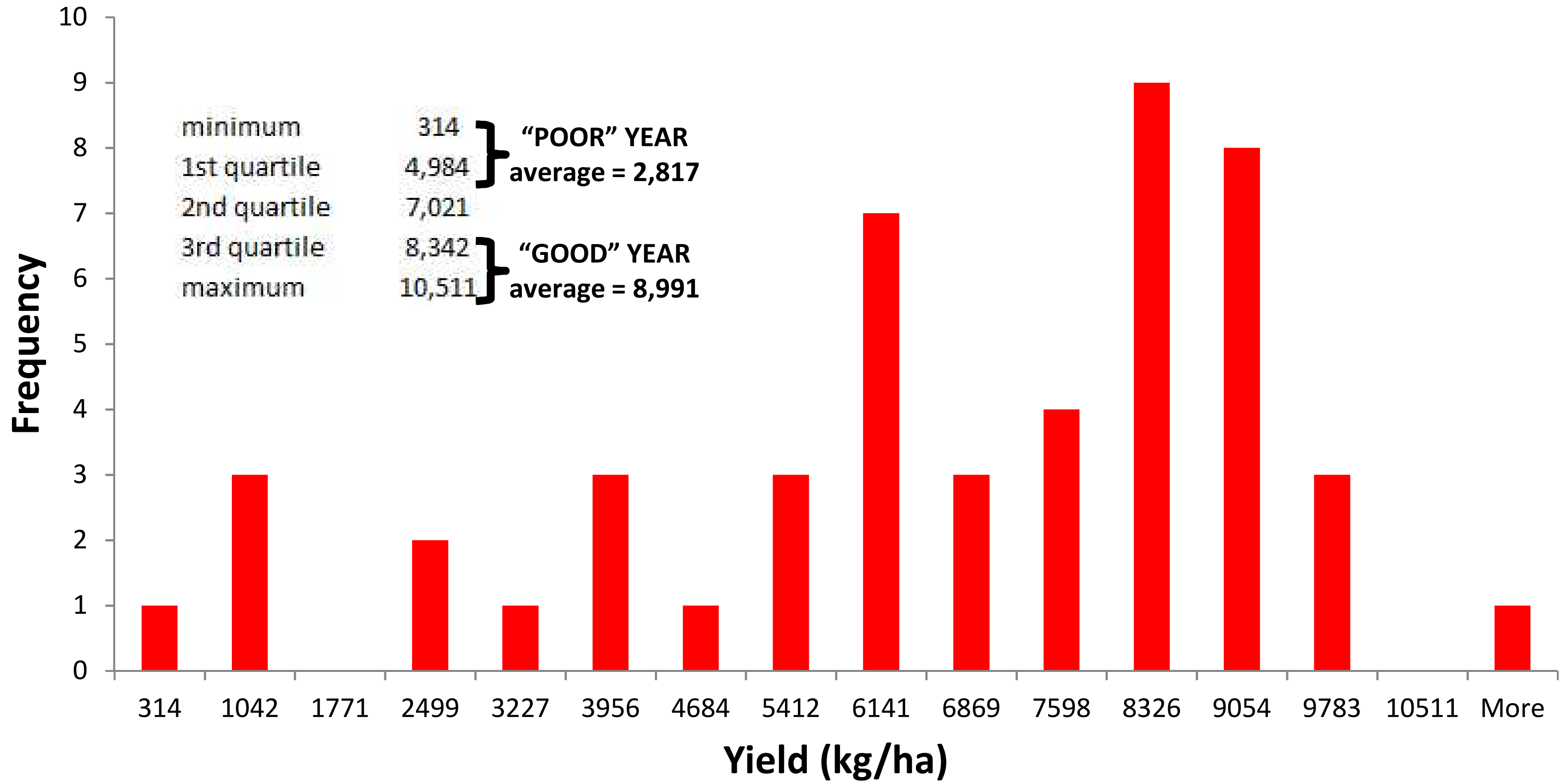
Omission trial sites

Production risk: Inverleigh, wheat, nutrients unlimiting



Source: CAT modelling

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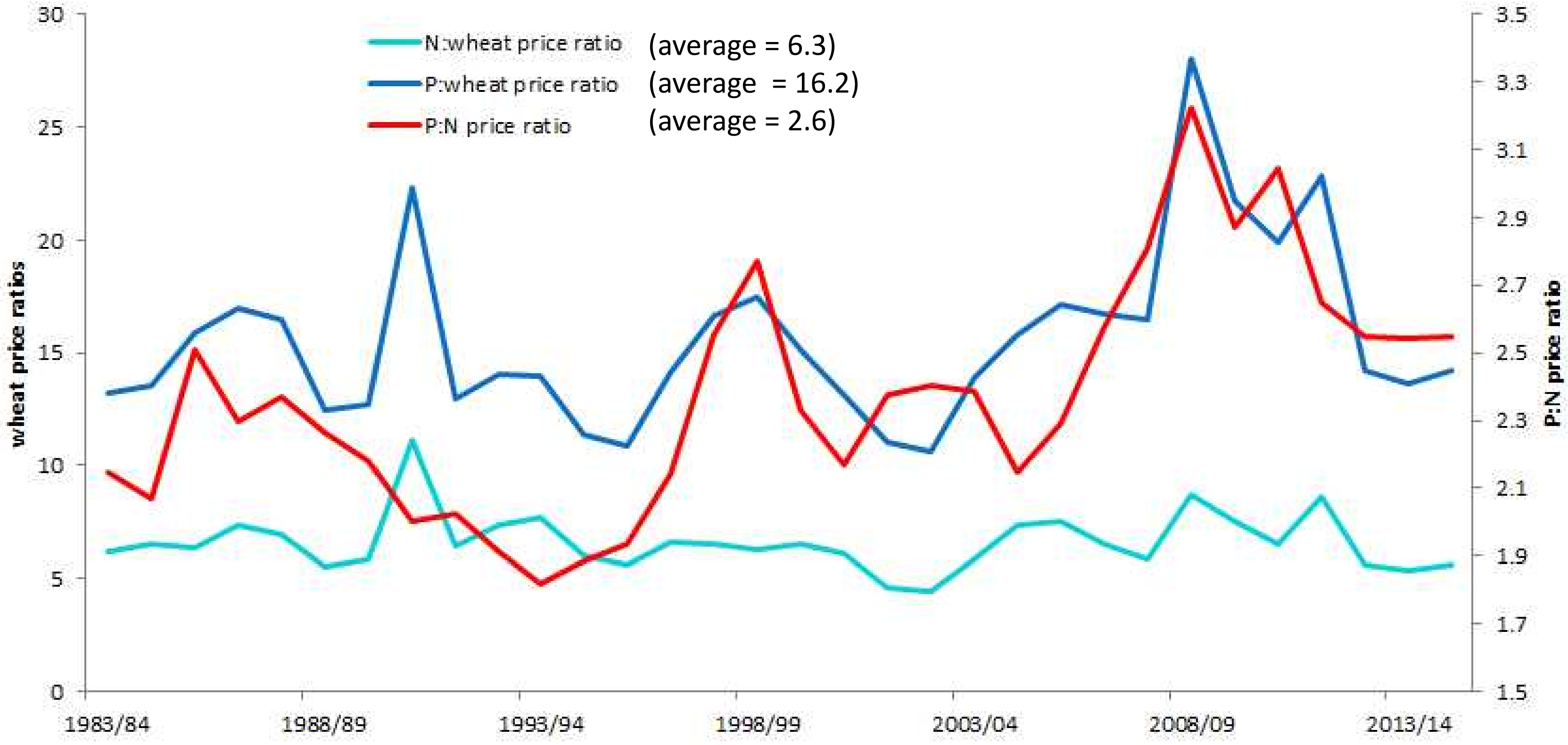
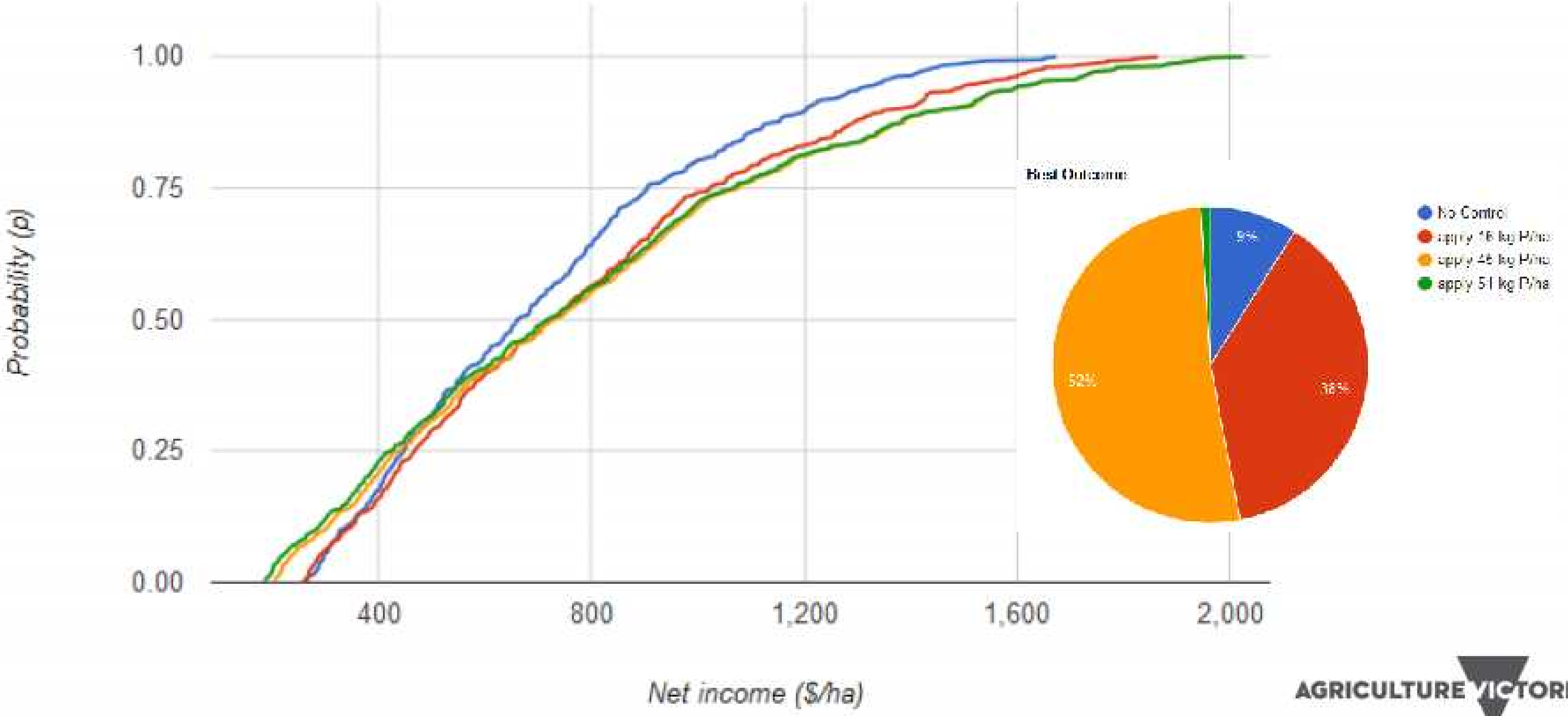
Price Risk



Source: derived from ABARES commodity price data

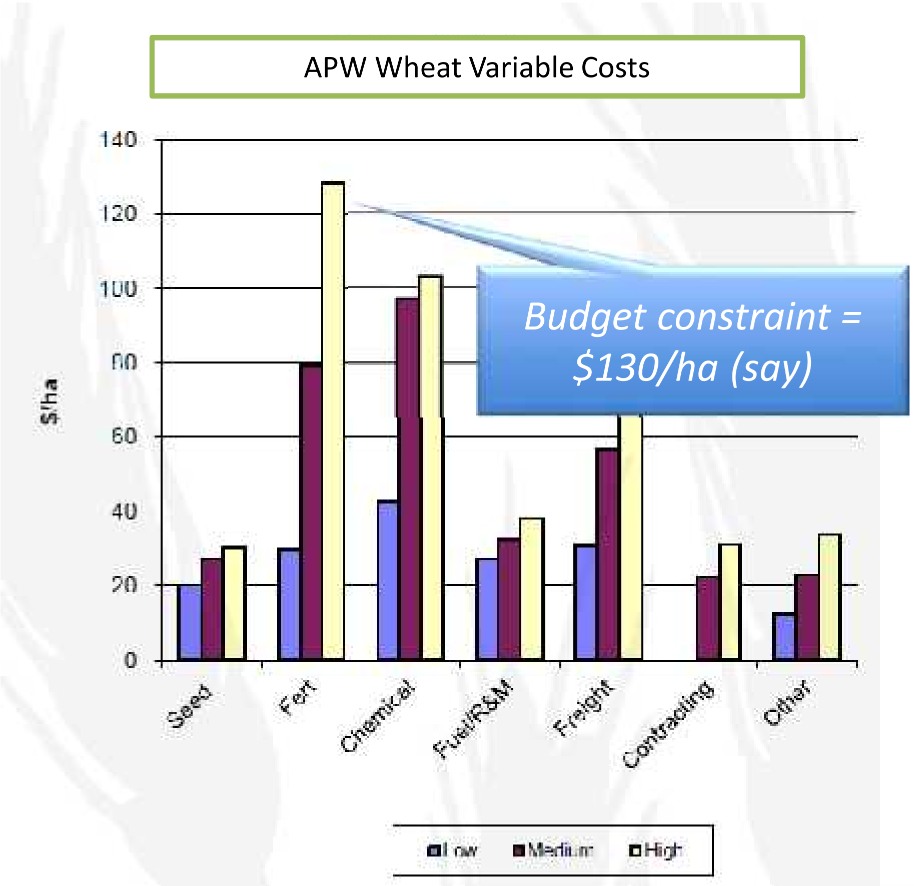
Link with existing tools: e.g. Option$ calculator

Option$ calculator inputs	**Seasonal Conditions**			**P expenditure**
	Poor	Normal	Good	($/ha)
Wheat price, net, on-farm post-harvest ($/t)	256	256	256	
Wheat yield at profit maximising P (t/ha)	2.4	6.8	9.0	
Yield penalty with ‘low’ initial soil P (10mg/kg Colwell-P) (%)				
- do nothing (control)	22	34	36	0
- apply 16 kg P/ha	11	14	15	62
- apply 45 kg P/ha	1	1	1	163
- apply 51 kg P/ha	0	0	0	184



http://www.croppro.com.au/options.php

Budget constraint



Fertiliser accounts for about 30% of variable costs in HRZ cropping and requires considerable additional working capital.

How to allocate between a range of fertiliser types where cash flow is tight?

Source: PIRSA 2015 Farm Gross Margin Guide

Quartiles: normal distribution