Nitrogen decisions for cereal crops: a risky and personal business

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Objectives, to investigate..

- Dryland (rainfed) wheat production in Australia
- Look at crop yield responses to N fertiliser
  - Using a crop simulator
- How important is economics in N decisions?
- Predictions from an economic model or framework
- What growers actually do
- Decision Support Systems?
- Extension to Myanmar
Yield responses

• John Kneipp (Tamworth District Agronomist)
  – ‘To grow wheat you need Nitrogen and water’
  – Hence the WNMM (and APSIM)
• We expect yields to increase with more N
• What do these responses look like?
  – A lot of variability in yield response (seasons)
• Crop simulations at Cunderdin, Rutherglen, Wagga Wagga & Tamworth
In Wiradjuri language: Wagga Wagga ‘place of many crows’
Aside (footprints)
• Diminishing returns responses are common in biology and elsewhere
• Linear Response and Plateau for individual plants (Law of the Minimum)
• But concave responses across a field
  – Variation in seed germination and flowering dates
• Mitscherlich \( Y = a(1 - \exp(-bN)) \)
Including variability

- 10\textsuperscript{th}, 50\textsuperscript{th} & 90\textsuperscript{th} percentiles of yield distributions, to represent
- ‘Poor’, ‘Medium’ and ‘Good’ seasons
- We fitted Mitscherlich functions
- How do these percentiles move?
- Just up and down (North-South) or also across (East-West)?
- This might affect the N use decision
Risk aversion and N decisions

![Graph showing the relationship between wheat yield (t/ha) and N (kg/ha) with critical points N_{ra}, N^*, N_{max}.

- N_{ra} is the point of risk aversion.
- N^* is the point of optimal balance between yield and risk.
- N_{max} is the maximum yield point.

The graph illustrates how increasing N affects the wheat yield, highlighting the trade-off between yield and risk.
Economic model predictions.
North-South movement, little change in decision between season type
North-South and East-West, N decision varies with season
Actual farmer decisions

• We asked agronomists at each location about typical grower decisions
• Grower decisions at or below the economic rates
• But growers seem to have the yield responses and prices in mind
• Economic framework is ‘roughly right’
## Predicted & Actual decisions

<table>
<thead>
<tr>
<th>Location</th>
<th>Theoretical economic N rates</th>
<th>Typical grower decisions</th>
<th>MRR for ‘Medium’ 100% ROI</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Season type</td>
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<tr>
<td></td>
<td>‘Poor’ (10th)</td>
<td>‘Medium’ (50th)</td>
<td>‘Good’ (90th)</td>
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<td></td>
<td>Kg N/ha</td>
<td>Kg N/ha</td>
<td>Kg N/ha</td>
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<tr>
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<td>87</td>
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<tr>
<td>Tamworth</td>
<td>52</td>
<td>85</td>
<td>87</td>
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</tbody>
</table>
• Growers may be averse to (prefer to avoid) the chance of bad outcomes
• If so they may be cautious in their decisions
  – Avoid spending extra money with a greater chance of failure
• Risk aversion is a friction to decision making
• N decisions are also personal decisions
• ‘Cereal growers and agricultural consultants in Australia do not seem to use a formal N optimising economic framework when advising clients’

• Dr. Rob Norton, International Plant Nutrition Institute
Conclusion

• The shape and variability in crop yield responses to N make using an economic framework for precise N recommendations an ‘absurdity’, (Jock Anderson 1975)

• N decisions are risky and growers make their own personal (or subjective) decisions

• But the economic framework is ‘roughly right’
  – The yield max N rate is too high
  – Best N rates vary between Good and Poor seasons at some locations (soil types)
  – Adding risk aversion reduces the rates further
In Myanmar

• Myanmar farmers (smallholders) are
  – Poor, indebted, risk averse, less educated, and have high borrowing rates
• Add an extra requirement for a 100% Return on Investment (ROI) in developing fertiliser recommendations (CIMMYT 1988)
• They will resist us recommending a big investment in fertiliser to increase yield if the higher potential yield comes with a higher risk of bad outcomes
• We don’t decide what is optimum for them