Fast Graphs for Slow Thinking about Nitrogen

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Farming Systems

Background

Most people will agree that agriculture is a "risky" business. Uncertainty, primarily around seasons and commodity prices, create challenges for decision making. Fortunately in Australia, we have a long history of farmer experience, combined with an excellent R, D and E system which gives us knowledge in how to deal with this uncertainty. But there still remains some decisions that are tough calls - and getting these more right, more often can be important to long term profitability of farm businesses.

GRDC have recognised this issue and have supported a program called the National Risk Management Initiative - or RiskWi$e for short, to address it. This project aims to improve growers' management of risks, by empowering them with better understanding of upside and downside of important decisions. RiskWi$e is a participatory research project involving farming systems groups and research partners from across Australia. On EP, it is being coordinated through AIR EP.

Through RiskWi$e, GRDC has recognised the importance of farmer psychology. The famous psychologist, Daniel Kahneman, in his excellent internationally best-selling book, "Thinking Fast and Slow", investigates human rationality and irrationality. He observed that "…most of our judgements and actions are appropriate most of the time… But not always." Kahneman distinguishes between fast thinking, which is instinctive, recognises patterns and jumps to conclusions, and slow thinking, which is more deliberative and logical.

The developing field of behavioural science provides us with understandings of why we may not be the pillars of rational decision making that we like to think we are - things like loss aversion, cognitive bias's, effect of stress etc. The authors also believe that there also remains a significant gap in analytics - tools which apply relatively simple techniques at a farm level to aid decision making.

Comparing the upside and downside of a decision involves weighing up a range of possible futures. This is mentally demanding to do in your head, but relatively easy in a spreadsheet. Our idea is to get the information quickly into a graph that shows the upside and downside of the decision in question (we estimate less than 20 minutes), so that we can then have a useful conversation about the judgement we need to make. This follows the advice of Professor Bill Malcolm, the Farm Management economist from the University of Melbourne: 'simple figuring and sophisticated thinking'. Below we provide an example of how this process looks.

The Nitrogen Decision Example

Figure 1 describes the decision dilemma of applying additional nitrogen to a mildly deficient crop. Investing in nitrogen is highly profitable when sufficient rainfall is received to take advantage of the additional fertiliser. The simple rule of thumb is that 40 kg of N/ha is required for an additional one tonne per ha of wheat grain. With urea at, say, $700/t (and an application cost of $10/ha) this means that investing around $70/ha (approx 40 kg N/ha) could result in a return of one tonne of wheat at, say, $350-400. But low spring rainfall would not allow this return to be realised. On the other hand, farmers are often consoled by the thought that N applied which is unused may still carry-over to other crops in subsequent years.

Estimating the supply of N can be challenging- we can use deep soil testing or look at paddock history for starting N levels then use some estimate for in-season mineralisation from organic matter. And estimating the crop demand for N is even more difficult because of the uncertain finish to the season. The traditional approach is to select a target yield, based on soil moisture, seasonal conditions to date and some guesstimate of what the season might do from now on. The N required for this target yield is then matched up against the estimate of supply to arrive at the additional N which needs to be supplied as fertiliser.

We believe that applying some simple economics and risk to this discussion does not involve a lot of extra work but can provide a rich source of information to aid the N decision question.

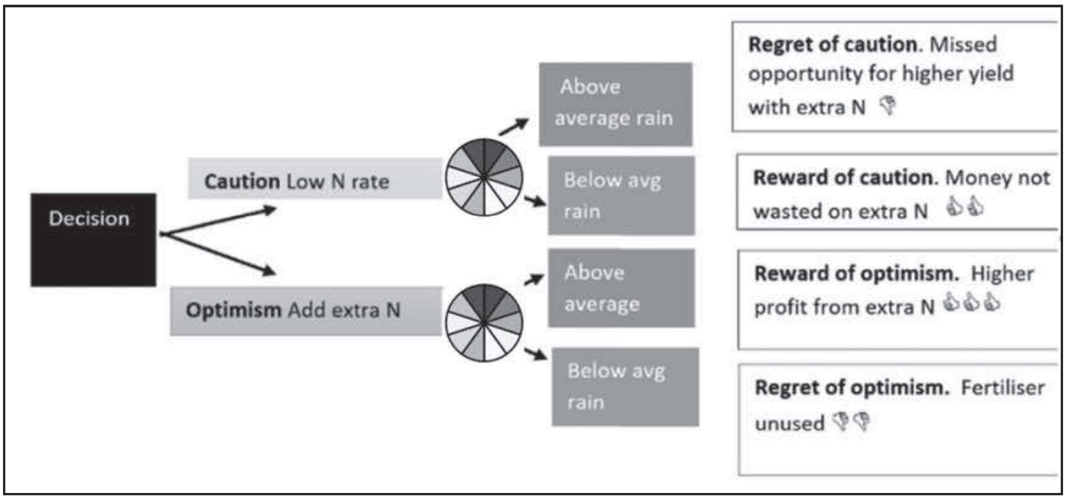


Figure 1. A simple N decision tree that considers an in season tactical decision to add extra N to a crop.

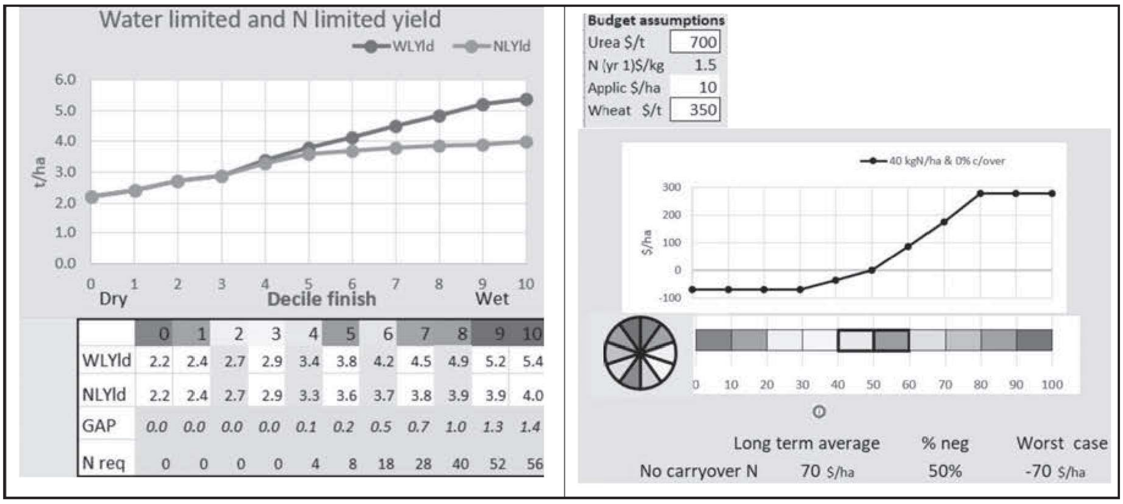


Figure 2. Screenshot of Fast Graphs for Slow Thinking. Left hand panel showing the yield with adequate N and limited by water (WL) and the yield limited by nitrogen (NL). Right hand panel shows the profit by decile graph for the application of 40 kg N/ha, which is similar to aiming for decile 8 where the gap between the water and N limited yield is 1 t/ha.

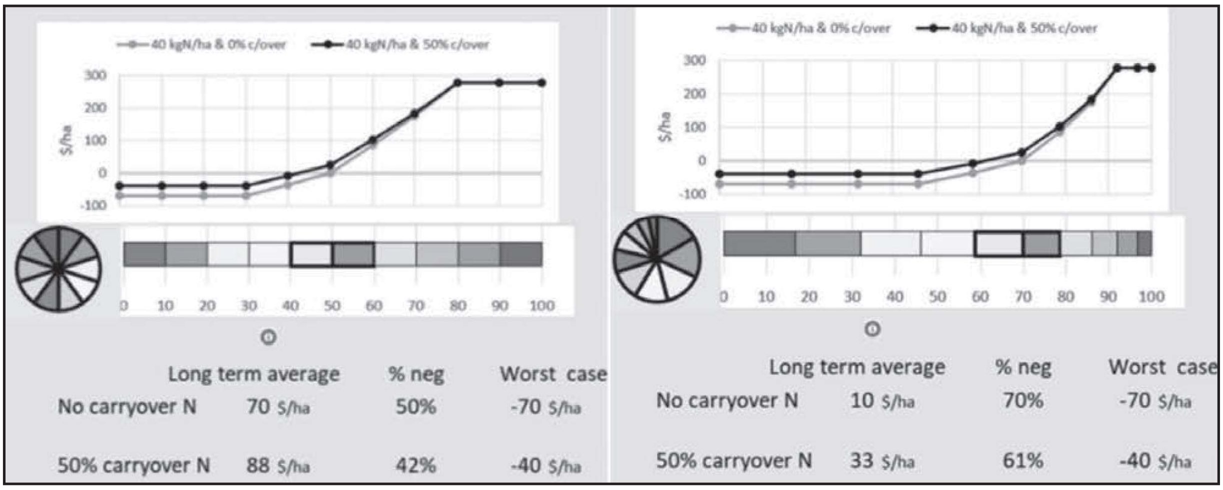
We have developed a spreadsheet which allows us to do this. This version of Fast Graphs for Slow Thinking wasn't developed as another decision support system for nitrogen; the aim was to explore how the upside, downside and probability weighted average of N decisions are changed by the cost of N and price of wheat, levels of carryover N, and seasonal climate forecasts. In doing this, we were testing the usefulness of a simple decision analysis to run the N budget across deciles, rather than pick a single target yield.

Figure 2 shows that the long-term average return from adding 40 kg N/ha to this crop is assessed at $70/ha with a break even at around Decile 5. If a farmer was to have a similar crop over a long period, then applying 40 kg/ha of N would result in an average gain of $70/ha/year and the result would be positive in 50% of the years.

As indicated earlier, we can also look at changes in seasonal outlook probabilities along with the considerations for carry over N.

A forecast doesn't change the future, it changes the likelihood of different future outcomes occurring. Figure 3a and 3b show the result when the probability of receiving above average rainfall is shifted from 50% to 30%.

Figures 3a and 3b show the return (profit/ha y axis) from adding 40 kg N/ha assuming urea is $700/t, urea spreading is $10/ha and wheat is valued at $350/t. In Figure 3a the rainfall decile outcomes (coloured rectangles on the x-axis) are equally distributed. In Figure 3b the probability of receiving above average rainfall (coloured rectangles on the x-axis) is shifted from 50% (equally distributed deciles) down to 30% (skewed distribution of deciles to the dry end). In both graphs the lighter line with lighter circles shows returns ($/ha) from each decile assuming no N carryover into subsequent years. The black line with black circles shows the impact of 50% of applied N carrying over into the following year.



Figures 3a and 3b showing the return (profit/ha y axis) from adding 40 kg N/ha assuming urea is $700/t, urea spreading is $10/ha and wheat is valued at $350/t. In Figure 3a, the probability of achieving above average rainfall is set at 50% (i.e. historic climatology). In Figure 3b, this probability is shifted down to 30%. The % neg is the probability of making a loss.

In assessing the value of N carry-over, the assumptions are that (i) a proportion between 0% and 90% (as selected) of the unused N will be available for subsequent crops, and (ii) the N carried forward to the next crop is valued as a saving in N fertiliser for the subsequent crops. Figure 3a and 3b show how carryover N of 50% reduces the loss in poor seasons but has no impact in rainfall deciles 8 and above because all the N applied in the first year is used by that crop. Including a 50% carryover of unused nitrogen changes the probability weighted average from $70 to $88 where there is an equal distribution of rainfall deciles (Figure 3a) and from $10/ha to $33/ha where there is skewed distribution of rainfall deciles toward drier outcomes (Figure 3b).

Conclusion

The RiskWi$e project is about better understanding risk and reward in all parts of the grain farm and is therefore more than an initiative about N risk-reward. It does however provide a rich opportunity for conversations about the risk and reward of N use in our grain production systems. Because getting N topdressing exactly right is almost impossible due to the variable climate, it is better to consider the consequences of erring on the side of applying a bit extra N or too little N. Budgeting tactically across deciles takes a bit longer than budgeting for a single target yield, but we have found that once growers see the graph showing the upside and downside, decision making becomes more informed and easier.

The end point is more complete conversations about risk and reward which are improved by insights from the behavioural sciences. Our contention is that the applied economic tool of decision analysis has a role, not so much in the answer it provides, but in the conversations it generates about probability, recency bias, loss aversion and allowing for range of outcomes rather than planning for a single, most likely future. Fast Graphs for Slow Thinking is one approach to stimulate thinking for improved decision making.

A short video describing the use of the Fast Graphs for Slow Thinking N tool in one situation in SA can be accessed through the following link: https://youtu.be/G8nUHXOLR90

Acknowledgements

RiskWi$e (the National Risk Management Initiative), is a 5-year national initiative of around $30 million that will run from 2023 to 2028. It seeks to understand and improve the risk-reward outcomes for Australian grain growers by supporting grower on-farm decision-making.

RiskWi$e was established through an investment of the Grains Research and Development Corporation (GRDC).