Are farmers in low rainfall cropping regions under-fertilising with nitrogen? A Mallee risk analysis.

RESEARCH

Marta Monjardino, Therese McBeath, Lisa Brennan and Rick Llewellyn
CSIRO Ecosystem Sciences

Key messages

- **There are opportunities to increase profit with increased N input in sandy Mallee soils. However, the risk aversion of the land manager is an important consideration. The use of probability graphs at different levels of risk aversion can support decision making and practice change.**

Background

Fertiliser is a major variable cereal production cost in Australia (ABARE, 2010) and costs are expected to increase in the future (FAO, 2010). In the face of high climatic and spatial variability, low nutrient use efficiency and market volatility, identifying the most profitable rate of nitrogen (N) fertiliser presents a challenge to dryland farmers. N deficiency is one of the main causes of a gap between actual and potential yields in the wetter seasons, but because N is such a significant investment, farmers often seek to minimize the risk of a loss in poor seasons by applying low standard rates of N to their cereal crops. In doing so, their fertiliser management reflects recommendations for average seasons. Part of the reason for the conservatism in this management strategy is the perception that excess N supply in dry seasons increases their exposure to risk. We ask the question: could those farmers in the Australian wheat belt who adopt a low-input strategy to minimize economic risk in fact be missing out on greater returns overall because of under-fertilising with N in the more favourable seasons ?

We used simulation modelling to test wheat response to a range of N management strategies at sites that are the location of field based N management trials. The output of the crop simulation modelling was used in economic modelling to evaluate the combined impact of yield and price risk on long-term performance of N fertiliser strategies, including tactical N application within the growing season. We then considered the best profit and risk scenarios according to the risk aversion preference of the land manager.

How was it done?

A combination of agronomic and economic tools were used to evaluate the combined impact of yield and price risk on long-term performance of N fertiliser strategies on 3 different soil types, including the application of extra in-season N when growing season conditions are favourable. The results were then re-scaled according to the farmer's level of risk aversion. The main outcome is a response scale associated with adding N which is intended to help inform farmers in their fertiliser decisions.

To test N response for a given site we applied 0-90 kg N/ha at sowing with a further 0-90 kg N/ha applied in-season at GS31-39 (applied if simulated soil N was less than 100 kg N/ha at the time and a >10 mm rainfall event occurred) on three soil types common in the Karoonda district of the SA mallee (av annual rainfall 342 mm); the dune (starting N 103 kg/ha), mid-slope (starting N 72 kg/ha) and flats (starting N 36 kg/ha). Outputs were modelled over 60 different growing seasons using the climate data of 1950-2010. Due to co-location of our modelling with sites where N response trials have been undertaken we were able to closely monitor the model output with field data.

In addition to the 60-year time-series wheat yield data sets generated in APSIM, two farm-gate-price datasets were also created, one for Australian Standard White (ASW) wheat and the other for N fertiliser (urea, 46% N) from a range of data sources including historical pool returns (AWB 2010), commodity statistics (ABARE, 2010) and farm budget guides (Rural Solutions SA, 2009; 2010; 2011). To quantify variability in net returns for each scenario, we used @RISK (Palisade Corporation, 2002) to generate outputs of net returns based on the probability density functions for yields and the price parameters based on the distributions of prices over the defined period.

A number of economic and risk performance indicators were used to rank the best performing N management strategies including:

- Net return greater than district average practice.
- A co-efficient of variation of less than 30%.
- A greater than 50% probability of a net profit and a net return greater than district practice.
- A net return better than a loss of $150/ha in the bottom 10% of seasons.
- A net return of greater than $1 per $1 invested N fertiliser.

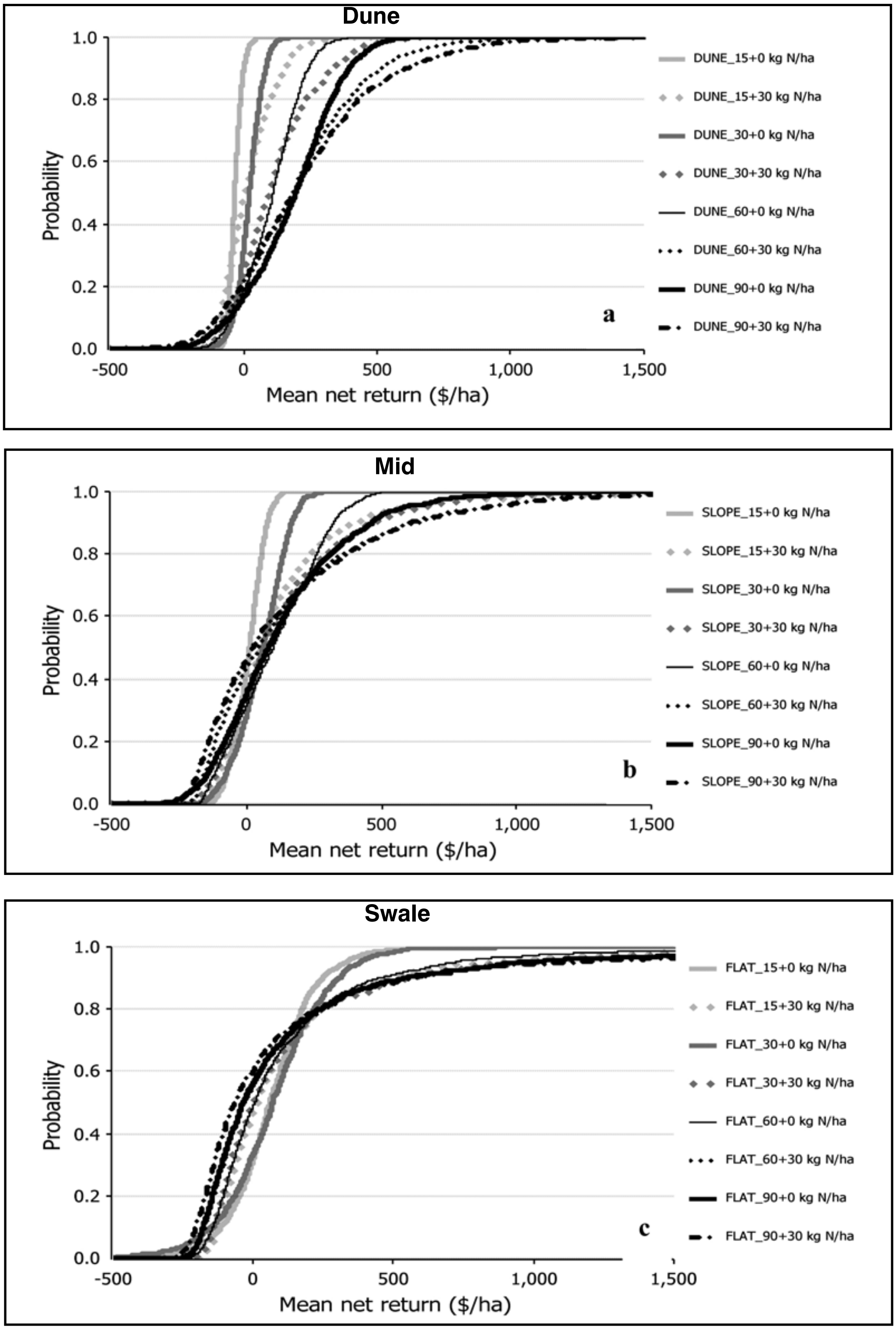

Figure 1. The probability of a mean net return ($/ha) on a. Dune, b. Mid-slope and c. Swale in response to a subset of the treatments evaluated. *To read the graph, a mean net return of $0/ha with a probability of 0.2 means that in 80% of seasons a net return of >$0/ha will be achieved.

What happened?

District practice at Karoonda is 10-20 kg N/ha at sowing. A comparison of district practice with alternative N management strategies on the three soil types of dune, mid-slope and swale suggested that net returns may be improved through altering N input strategies. District practice had a mean net loss of $30/ha in the dune, a low net return of $7/ha in the mid-slope, and a relatively higher net return of $66/ha in the flat over the 60 year simulation runs. While the mean net return on the flats is high, this value has a high standard deviation due to variable performance. The upside of this soil is that due to a relatively deep soil profile it can produce very good yields in high rainfall seasons and this outcome is reflected in the mean value.

The analysis indicated that there is scope to use more N within the dune and the slope zones of a Mallee paddock. The best strategies included mid to high N rates applied at sowing, with low rates of additional N applied in-season when required on both the dune and slope (Figure 1a. and b.). The best performing upfront rates are lower for the more fertile mid-slope (starting N 72 kg/ha) zone compared to the poorer dune (starting N 36 kg/ha) soil.

For the swale (starting N 103 kg/ha), very few management strategies offered an economic-risk better than district practice (Figure 1c.).

Whilst a range of tactical N applications performed well across the dune and slope, those including a sowing input of 30 to 90 kg N/ha in the dune and 15 to 60 kg N/ha in the mid-slope, with in-season application of 0 to 30 kg/N ha in both zones, were the best treatments.

One of the best net returns on the dune was in response to a sowing application of 90 kg N/ha, which, compared to the standard 15 kg N/ha, increased mean net return by $213/ha, while reducing some of the risk by increasing break-even probabilities by 73%, increasing the return in the bottom 10% of seasons by $56/ha and increasing net return on fertiliser investment $0.7 per $ of invested N fertilizer (but also increased the coefficient of variation by 1.74). A similar, though slightly higher risk strategy was applying the same total N but with 60 kg N/ha at sowing followed by 30 kg N/ha tactical N.

In the mid-slope and compared to district practice, 30 kg N/ha at sowing followed by 30 kg/N ha in-season when required tactically, increased mean net returns by $130/ha, reduced the coefficient of variation of mean net returns by 6.54, increased the probability of breaking even by 8%, increased the mean return in the worst 10% of seasons by $52/ha, increased the return on total N fertilizer investment by $0.5 and increased the return on tactical N fertilizer invested by $1.8.

The least attractive management options (measured as a combination of economics and risk) were under-fertilising with zero/low N inputs in the dune and mid-slopes and over-fertilising in the swale (especially in-season).

The analysis was extended to include a specialised form of analysis (SERF-stochastic Stochastic Efficiency with Respect to a Function) that alters the ranking of different N management strategies using a range of risk aversion preferences from very risk averse through to neutral risk aversion (where risk does not control decision making). As expected the analysis suggested a more risk-averse farmer would be more likely to select an upfront N application strategy due to the lower risk on return when compared to tactical fertilisation with mid to high N rates (i.e. 60 + 30 kg N/ha in the dune), despite a lower net return for this practice. In general, risk-averse farmers prefer consistent returns and are thus willing to take a somewhat lower, but less variable, expected payoff (Kingwell, 2011).

What does this mean?

The most useful aspect of this analysis is to provide a picture of the range of outcomes for a given N management strategy at a given site. When this study is complete, the analysis will include three South Australian sites (Hart, Tarlee and Karoonda), and other sites from all of the Australian grain growing regions. The analysis will be completed at each site to include a range of starting (deep soil test N) conditions so that the analysis includes the likely range of starting soil N conditions for the soil type, and the analysis will be incorporated in a framework that considers the risk preference of the land manager. Given that the model can only predict the response to N addition by soil water conditions with variation in prices accounted for it is not designed to be a perfect predictor of the outcome in a given season but rather to provide an opportunity to compare a range of treatments and potential outcomes, with risk aversion preference incorporated.

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