Nitrogen Fertiliser- weighing up risk and return

Rick Llewellyn¹, Therese McBeath¹, Marta Monjardino, Jackie Ouzman¹, Bill Davoren¹, Vadakattu Gupta¹, Damian Mowat¹, Michael Moodie²

¹CSIRO, ²Mallee Sustainable Farming (MSF)

Presented at the GRDC Grower Updates, 13th August 2014, Waikerie, SA

GRDC project code: CSA00025

Keywords: Nitrogen, fertilisers, risk, economics, variable rate.

Take home messages

- There is strong support from mallee research and economic risk analysis for the use of soil-specific N management to improve profitability and reliability of returns from fertiliser N on mallee crop paddocks.
- The highest yielding part of the paddock is not necessarily where the return on extra N fertiliser is highest – aim for where returns on each dollar of N applied are likely to be greatest.
- Applying extra N at seeding rather than at GS31 has usually been the best option.
- Shifting fertiliser inputs from heavy constrained soils to sandy topsoils can have significant profit and risk benefits over several years but nutrient reserves need to be monitored.
- The gross margins of break crops are usually riskier than for cereals but the effect of a legume-based break on cumulative wheat yield over the next couple of years has been relatively reliable.

Background

There has been widespread use of continuous cereal on mallee soils over the past decade with these practices generally productive and relatively water use efficient. Although this has been profitable on average, it can involve increasing levels of risk as input requirements increase. There is an increasing number of these crop paddocks suffering from declining nutrient and water use efficiency following lengthy sequences of cereal. Weighing up the best N investment strategies in terms of profit and risk for different soil types becomes particularly important. In this paper we look at findings from some SA Mallee research over the past 5 years that looks at what have been the best N strategies for growers based on a range of measures that take into account yield, profit, return on investment and exposure to potential losses. The economics of a single year crop or pasture break to reduce reliance on N fertilizer is also evaluated across the typical range of Mallee soils.

Methodology

Trials were established in 2009 at a Mallee Sustainable Farming on-farm research site near Karoonda (Lowaldie) to test soil-specific strategies and tactics for reducing risk and increasing profitability in cereal-based rotations. Various treatments reflecting potential management practices were applied across soil types covering a dune-swale system. Field results and crop & economic modeling are used to identify the best long-term options and likely risk. Field trials involved N x P, break crops, and
pasture and cereal management strategies including N timing. All experiments are designed to examine soil-specific effects and cover a range of soil types. Average annual rainfall at Karoonda is 337mm and 2012 rainfall was 352mm. During the 2013 growing season rainfall was close to the average at 228mm.

Break crops including legume, rye, brassica and pasture were grown in 2009 and 2010 and followed by consecutive wheat crops until 2013. Wheat yield following these breaks were compared with a continuous wheat treatment. All treatments were applied at four positions in the landscape: hill (deep sand), mid-top, mid-slope and swale (heavy flat).

Several economic methods have been used including the use of crop simulation to test how well different N fertilizer practices perform over a wide range of season types. This is used to test the riskiness of different strategies by also including a range of N and grain prices in the analysis.

Results and discussion

Over 5 years of continuous wheat, additional N (urea) at sowing has increased returns across the mid-slope and dune but most markedly in the dune (Figure 1). Nil fertiliser has been the most profitable strategy on the heaviest most constrained flat in all years but N reserves are now getting low (as suggested by a high protein response to N in 2013). Applying N upfront gave a better gross margin than a late split application with most N applied at tillering-stem elongation across most of the landscape. Applying in-season N earlier than GS31 appeared to improve responsiveness in 2013. Pasture produced in 2009 resulted in one of the best gross margins across the landscape (swale through to crest). Growing pasture in 2010 resulted in a gross margin penalty as it meant missing very high wheat yields in the swales in that year.

**Figure 1.** Cumulative gross margins ($/ha 2009-2013) in response to a range of agronomic treatments across the swale to dune system. Treatments have been applied since 2009. District
practice is 50kg DAP (9kg N). High N is an additional 67kg/ha Urea (total of 40 kg N). Pasture was a volunteer medic-based pasture with lower levels of medic on sand.

**What about the risks?**

We evaluated different N strategies and rates in terms of a range of potential profit, variability, downside risk and investment return measures (Table 1). Assuming other constraints are managed, there are both risk and profit advantages in shifting N investment from some soil types to others. Even when considering that a farmer may want to forego some potential average profit to reduce the variability in returns (aversion to risk) there were benefits from increases in the level of N fertiliser application on the sandy dune soils above what is currently considered district practice.

**Table 1.** Indicators of profit and risk for N for each soil type.

<table>
<thead>
<tr>
<th>Sowing fertiliser N (kg/ha)</th>
<th>Mean Return ($/ha)</th>
<th>Standard Deviation ($/ha)</th>
<th>Probability of Break-Even (% of years)</th>
<th>Mean return of bottom 10% of cases ($/ha)</th>
<th>Return on N ($ return/$N invested)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dune</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>-30</td>
<td>24</td>
<td>11</td>
<td>-68</td>
<td>1.9</td>
</tr>
<tr>
<td>30</td>
<td>22</td>
<td>49</td>
<td>69</td>
<td>-67</td>
<td>2.6</td>
</tr>
<tr>
<td>60</td>
<td>106</td>
<td>109</td>
<td>82</td>
<td>-84</td>
<td>2.7</td>
</tr>
<tr>
<td>Mid-slope</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>7</td>
<td>57</td>
<td>57</td>
<td>-94</td>
<td>2.2</td>
</tr>
<tr>
<td>30</td>
<td>55</td>
<td>92</td>
<td>72</td>
<td>-111</td>
<td>2.7</td>
</tr>
<tr>
<td>60</td>
<td>105</td>
<td>165</td>
<td>68</td>
<td>-143</td>
<td>2.1</td>
</tr>
<tr>
<td>Swale</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5</td>
<td>55</td>
<td>133</td>
<td>67</td>
<td>-175</td>
<td>2.1</td>
</tr>
<tr>
<td>15</td>
<td>66</td>
<td>154</td>
<td>68</td>
<td>-200</td>
<td>1.7</td>
</tr>
<tr>
<td>30</td>
<td>74</td>
<td>188</td>
<td>66</td>
<td>-260</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Assumed sowing Soil N: Dune 18 kg/ha; Mid-slope 36 kg/ha; Swale 52 kg/ha. Based on simulation of potential weed, disease and frost-free wheat yields and the range of prices from recent decades.

**What about N from breaks?**

Other trials at the site have shown that break crops (e.g. lupins, peas, and pasture) have led to a cumulative yield gain of approximately 1 t/ha of wheat over the next 2-3 wheat crops compared to continuous wheat. About 2/3 of this is gained in the first year after the break.

Pasture (and other legume breaks) have been shown to lead to an important and timely supply of N in subsequent crops with major wheat yield benefits. The benefits of a legume-based break to N supply in the next crops go beyond starting N levels. Figure 2 shows a comparison from a low disease year (2011) where N supply was likely to be a major driver of the differences in yield. Here the dotted lines show readily available N (fertiliser N + mineral N) for high fertiliser input (40 kg N) vs. 2010 pasture (in which the 2011 crop received 9 kg fertiliser N). The solid lines show yields and that having a volunteer medic-based 2010 pasture in 2010 still caused a wheat yield boost compared with the high N input treatment, despite the high N input treatment having more readily available N.
Figure 2. Wheat yields in 2011 (solid lines) following a 2010 pasture vs. high input of fertiliser N plotted with the readily available N at sowing (fertiliser + soil N 0-60cm; kg N/ha). Fertiliser in 2011 wheat following 2010 pasture was 50kg DAP (9kg N) with an additional 67kg/ha Urea (total of 40 kg N) on the 40 fert N treatment. 2010 pasture was a volunteer medic-based pasture.

Conclusion

The potential N benefits of a legume break go beyond what is evident in starting mineral N levels and can greatly reduce fertiliser requirements. Given that the risk and return characteristics for the range of mallee soils on a farm or in a paddock usually vary greatly, soil-specific N practices allow growers to invest their N budget according to risk & return preferences. In the absence of other major constraints, this can typically involve more lower-risk/higher-return N investment on sands and less higher-risk/lower-return N investments on constrained heavier soils.

Acknowledgements

Thanks to the Loller family for their generous support in hosting the trial, the Karoonda Mallee Sustainable Farming advisory group, Jeff Braun and Anthony Whitbread. Funding for this work was from the GRDC and CSIRO Agriculture Flagship.

Contact details
Rick Llewellyn
CSIRO, Waite Campus
08 8303 8502
rick.llewellyn@csiro.au