Nitrogen management: a key driver of farm business profit and risk in the low rainfall Mallee

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Abstract
The use of cereal-intensive rotations in the low rainfall Mallee region has resulted in nitrogen (N) fertiliser inputs becoming an increasing cost and risk for farm businesses. Five years of on-farm research near Karoonda in the South Australian Mallee has demonstrated advantages in shifting N fertiliser investment from some soil types to others but farm level profit-risk analysis was required. The impact of N fertiliser and residue based management practices on the profitability and the exposure to risk of a 'model' farm business was evaluated with local farmers, consultants and researchers over two workshops using a profit-risk decile calculator. Increasing N fertiliser inputs on all soil types dramatically increased annual farm profit in the better seasons (decile 6-9, 254-33 mm growing season rainfall), however in poorer seasons (decile 1-3, 159-201 mm rainfall) losses were greater. When N inputs were adjusted according to soil type, profit upsides were captured without increasing exposure to downside risk. Further analysis of the Karoonda model farm showed that the move towards more intensive cereal cropping in low rainfall (<350 mm) environments increased business risk when compared with a sequence including a pasture phase, even when risk management practices such as soil-specific N application were practiced. At higher cropping intensity, financial losses in poor seasons were more. While high cropping intensity increased potential business profitability in better seasons, the maximum fertiliser rates (~80 kg urea ha^{-1}) that workshop participants were willing to apply are likely to constrain yields, and therefore profitability, in higher rainfall seasons. This risk-related constraint to the amount of fertiliser that can be applied is important when evaluating the role for legume based breaks to supplement or replace N inputs from fertiliser.

Key words
Soil specific, sequence, break, legume, nitrogen, fertiliser, profit

Introduction
Farmers have widely adopted the use of intensive cereal based rotations in south-eastern Australia's low rainfall (<350mm) Mallee region. While these rotations were shown to be profitable (Sadras and Roget 2004), paddocks are now increasingly suffering from declining water use efficiency following a lengthy sequence of cereals. In the south Australian Mallee at Karoonda (337 mm of annual rainfall), a range of N management strategies have been compared across variable soil types in the dune-swale landscape. Volunteer medic based pastures increased subsequent wheat production for two years, and was largely related to N inputs from the legume (McBeath *et al*, 2015a, b). In an intensive cereal sequence, additional N (applied as urea) at sowing increased yields compared with district practice across the sandy mid-slope and dune soil types, while on the constrained 'heavy' swale soil increased yield from additional N inputs were not observed (McBeath *et al*, 2015b). A similar conclusion was reached in a profit-risk modelling study conducted for the same region (Monjardino *et al*., 2013) These data provide strong support for the use of soil-specific N management practices (e.g. variable rate application) in Mallee paddocks. However, even with efficient N fertiliser management practices in place, local farmers and consultants are concerned about the long-term viability of business employing intensive cropping systems with high input costs and local research has indicated that legume based breaks can provide significant N related benefits (McBeath *et al*, 2015a). In 2014, we worked with farmers and consultants from the South Australian Mallee to evaluate the impacts that the N management research undertaken at Karoonda would have on farm business profitability and exposure to downside risk.

Methodology

Two workshops were held in 2014 with farmers and advisors from the southern South Australian Mallee region. During the workshop, participants developed a model farm that was representative of the Karoonda region. The key physical attributes of the model farm developed by the participants included:

- Total arable farm size of 2400 hectares
- Enterprise mix of 85% cereal, 15% canola (intensive cropping)
- Two labour units drawing $50,000 per unit plus $20,000 allocated to casual labour
- Farm equity of 72%
- Plant and machinery inventory of $780,000
- Total fixed costs of $77,000

The profit-risk decile calculator developed by Ouzman et al (2015) was used to compare N management scenarios on business profitability and risk of the Karoonda model farm. A key feature of the calculator is the ability to compare alternative strategies across the full range of growing season deciles (here defined as decile of growing season rainfall plus 0.25 fallow rainfall) using a range of financial and economic measures in the same analysis. We conducted scenario analysis to investigate the effects of site-specific N management and the level of cropping and pasture intensity on farm business profit and risk. The first analysis compared three N fertiliser management scenarios on the default farm based on intensive cropping, farm with an enterprise mix of 85% cereal and 15% canola (including fixed low input (30 kg urea/ha) on all soils, fixed high input (80 kg urea /ha) on all soils, and soil-specific input (80 kg urea/ha on the dune (deep sand), 40 kg urea/ha on the mid-slope (sand over clay), and 20 kg urea/ha on the swale (loam over clay)). Canola was sown to the heavier soil types (45% mid and 55% swale). The N management scenarios were applied only to the cereal enterprise of the model farm. All other inputs, including phosphorus fertiliser, were kept constant across each scenario. A combination of trial data, bio-economic modelling as well as farmer and consultant experience was used to develop a matrix of cereal crop yields for each combination of N management practice x soil type x season decile (Table 1)

Table 1. Wheat yield (t/ha) in response to N management strategy, soil and season type (decile) for the Karoonda model farm producing 2040 ha of wheat and 360 ha of canola. Yields were developed using farm records, local trial data and APSIM outputs.

N management	Soil	Decile 1	Decile 3	Decile 5	Decile 7	Decile 9
Fixed Low Input	Dune	0.2	0.4	0.8	1.2	1.8
30 kg urea/ha all	Mid	0.5	1.1	1.9	2.1	2.5
	Swale	0.1	1.1	2.0	2.9	4.0
Fixed High Input	Dune	0.2	0.8	1.6	2.2	2.8
80 kg urea/ha all	Mid	0.5	1.1	2.2	3.1	3.5
	Swale	0.1	1.1	2	3.5	4.5
Soil Specific Input	Dune	0.2	0.8	1.6	2.2	2.8
80 Dune, 40 mid, 20 swale	Mid	0.5	1.1	2.2	2.6	3.1
kg urea/ha	Swale	0.1	1.1	2.0	2.9	4.0

The second analysis compared the soil-specific input scenario of the high-intensity cropping (default) farm with a similar soil-specific strategy of a lower crop intensity model farm, which involved producing 720 ha of self-regenerating annual legume pasture (largely allocated to lighter soil types, 30% dune, 60% mid, 10% swale) and a 750 ewe self-replacing merino sheep enterprise. In the pasture situation 720 ha of the wheat was assumed to follow a medic based pasture and yield benefits aligned with research outcomes at Karoonda were assumed (McBeath et al. 2015 a,b) and no urea was applied.

Results and Discussion

By increasing N fertiliser inputs from 30 to 80 kg urea/ha on all soil types, there is the potential to dramatically increase annual farm profit in the better seasons (Decile 7-9). However, in poorer seasons (decile 1-3) farm losses were approximately $60,000 greater under the high N input strategy (Figure 1a). Therefore adopting a high input fixed N strategy would increase financial risk of the model farm in poor seasons. When the soil-specific N input strategy was compared to the low N input scenario, the analysis showed that potential profit upsides were able to be captured without increasing the exposure to downside risk.

Soil Specific N was more profitable than Low N in all season types except for a decile 1 season (-$14,000). Importantly, the soil specific N management strategy was still able to capture large profit advantages of $110,000 – $183,000 over the low input fixed N strategy in decile 5-9 seasons (Figure 1a). While the ability of a business to accommodate a given level of loss will vary between businesses, a key finding in this analysis was that margins for profit could be quite small, even in a decile 5 season (eg. 93,000 to 203,000, Figure 1a). Therefore the ability of the business to recover from losses is heavily reliant on above average rainfall and any strategy that minimises downside risk in lower rainfall seasons is important for business resilience.

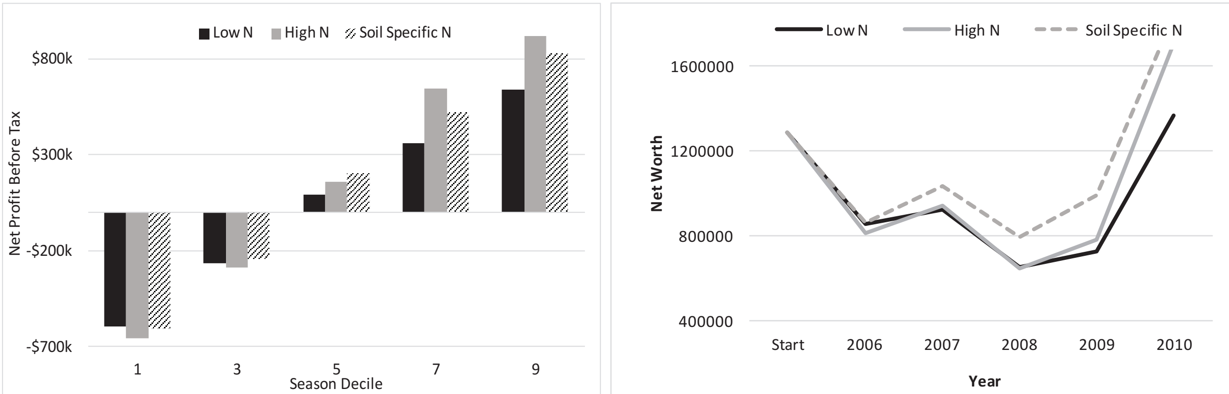

Figure 1.a (left) Annual farm net profit before tax across season type and b. (right) on farm net worth across a selected run of seasons for fixed low urea input (30 kg/ha in all soils), fixed high urea input (80 kg/ha in all soils) and soil-specific urea input (80 kg/ha on the dune, 40 kg/ha on the mid-slope, and 20 kg/ha on the swale) nitrogen management scenarios on a 2400 ha farm producing 2040 ha of wheat and 360 ha of canola. Growing season rainfall deciles were 2 (2006), 5 (2007), 3 (2008), 5 (2009), 10 (2010).

The three N input scenarios were compared across a period of five seasons (2006-2010), where a wide range of growing season rainfall deciles was experienced at Karoonda (Figure 1b).. The farm net worth of the model farm implementing the fixed low and high N input scenarios tracked similarly over this period. However the net worth of the farm adopting the soil-specific N management strategy was higher due to its ability to capture increased profits in good years and minimise losses in poorer seasons. At the end of the five year period, the farm implementing soil-specific N management had increased its net worth by $548,000 while the fixed low N input farm gained only $80,000 over the same period (Figure 1b). The high N scenario increased net worth by $419,000 over the five year period but was performing well below the soil specific N scenario in the lower rainfall seasons of 2008 and 2009 ($147,000 to $207,000 less) (Figure 1b).

Analysis of the Karoonda model farm also showed that the move towards intensive cereal cropping in low rainfall environments increased business risk, even when risk mitigation practices such as soil-specific N application were practiced. The losses made by the intensive cropping farm were $195,000 greater in a decile 1 season than the losses incurred on the farm with pasture. While the returns are greater in better seasons, the income forgone in a decile 9 year by the pasture-based systems ($99,000) is less than the losses saved in a decile 1 season (Figure 2).

The results shown in Figure 2 suggest that there is scope to re-evaluate the role of regenerating pasture phases to manage profit-risk and farm level fertiliser N requirements. During the workshops, farmers highlighted the fact that they were not comfortable with the risks associated with the high inputs required to sustain continuous cropping and that many were not willing to apply more than 80 kg/ha of urea in any season, which is likely to constrain crop yields in higher rainfall seasons. This analysis demonstrates that while the upside (profit in the higher rainfall years) is higher with intensive cropping, incorporating a pasture phase does not necessarily result in an unprofitable business and arguably it is a strategy that improves business resilience by reducing losses in lower rainfall seasons.

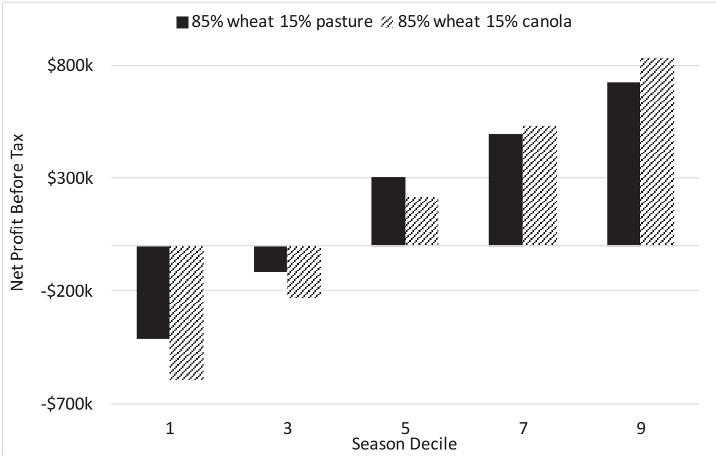

Figure 2. Annual farm net profit before tax in response to season type for a farm with 720 ha of Pasture and 1680 ha of wheat where no N fertiliser is applied to the 720ha of wheat that follows pasture and soil specific inputs of 80 kg/ha urea on the dune, 40 kg/ha urea on the mid-slope, and 20 kg/ha urea on the swale applied to 960 ha of wheat compared with the intensive cropping scenario of 2040 ha of wheat and 360 ha of canola with soil specific inputs of urea.

Conclusion

We have demonstrated that it is possible to analyse the potential effect of implementing research outcomes as farm practices at the farm level using a profit-risk decile analysis in a workshop setting. This analysis delivered outputs that are meaningful to growers and advisers, in terms of their motivation to adopt a practice on farm. A uniform increase in N fertiliser rate increased annual farm profit in the better seasons (decile 6-9), however losses were greater in poorer seasons (decile 1-3). When N inputs were adjusted according to soil type, profit gains were captured in better seasons without increasing exposure to downside risk in poor seasons. Analysis of the Karoonda model farm also showed that a more cropping intensive system carried a higher level of business risk, even when risk mitigation practices such as soil-specific N application were practiced. Consequently, there is an opportunity to re-evaluate the role for legume pasture phases to manage N inputs and business resilience in low rainfall Mallee farming systems.

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