Soil-specific Nitrogen Strategies and Upfront N Application on Sands Continue to Pay at Karoonda

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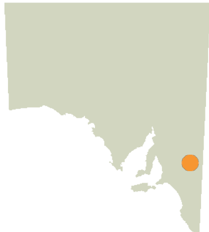

Why was the trial/project done?

To identify opportunities to reduce risk and increase profitability by evaluating the soils and conditions where continuous cereal systems perform best and where inputs can be most cost-effectively targeted.

How was the trial/project done?

Trials were established at Karoonda (Lowaldie) to test soil-specific strategies and tactics for reducing risk and increasing profitability in cereal-based rotations over the 2010-2014 growing seasons. Potential management practices including nil fertiliser, district practice, increased sowing N, increased N applied in-season and pasture breaks in 2009 and 2010 were applied on 150m long plots running across a range of soil types covering a dune-swale system. Simulation modeling was also used together with field results to identify the best long-term strategies for soil zones.

Key Messages

- The trial provides strong support for the use of soil-specific N management to improve profitability and risk management on Mallee dune-swale paddocks.
- Sandy soil types have consistently shown yield responses to increased inputs of N, while the heavy swale soils have not shown a yield benefit of increased N inputs.
- Nil fertiliser (N & P) has been the most profitable fertiliser treatment on the heaviest swale soil and the least profitable elsewhere.
- Upfront N at a higher rate still appears to generate the most consistent yield increase and profit outcome on the sandy soil types.

About the trial

The trial was established in 2009 on a paddock that had been under continuous cereal for several years, with a design established to test the response to agronomic treatments over the range of dune to swale soil types, at long plots (150 m) running across a wide range of production potentials. The 2014 continuous wheat treatments were the 9th consecutive cereal grown on the trial site. Corack wheat was sown on May 13 at 70 kg/ha seeding rate with fertiliser rate according to treatments (Table 1) applied below the seed, and different treatments were applied throughout the season. The in-season N treatment was applied by top-dressing urea at GS22 (early tillering; June 25).

__Table 1.__ Treatments for the Soil-Specific Strategies Trial 2010-2014

Treat	Description	2014 Fertiliser
1	Pasture 2009-Cereal 2010-2014	10P, 9N (50 kg DAP)
2	Cereal 2009-Pasture 2010- Cereal 2011-2014	10P, 9N (50 kg DAP)
3	Continuous cereal- district practice fertiliser	10P, 9N (50 kg DAP)
4	Continuous cereal- no fertiliser	0P, 0N
5	Continuous cereal- high sowing N inputs	10P, 40N (50 kg DAP, 67kg Urea)
6	Continuous cereal- extra N in-season	10 P, 40 N (50 kg DAP, 67kg Urea)

The collection of data at the trial site (not all reported in this article) included;

- Proximal sensing with EM 38
- Pre-sowing soil tests-plant available N and plant available water (PAW)
- Pre-sowing assessment of stubble load
- Plant biomass at anthesis
- NDVI at late tillering
- Grain yield and protein concentration
- Daily rainfall and max/min temperature
- Soil water at harvest

Results

Rainfall

There was 114 mm of rainfall in the December 2013 to March 2014 summer fallow period. Trials were sown on the 13th of May after approximately 65 mm of opening rain in April to early May. During the growing season rainfall was below average at 182 mm (average 237mm) with a particularly dry spring reducing the potential yields. The trial was harvested on November 26th.

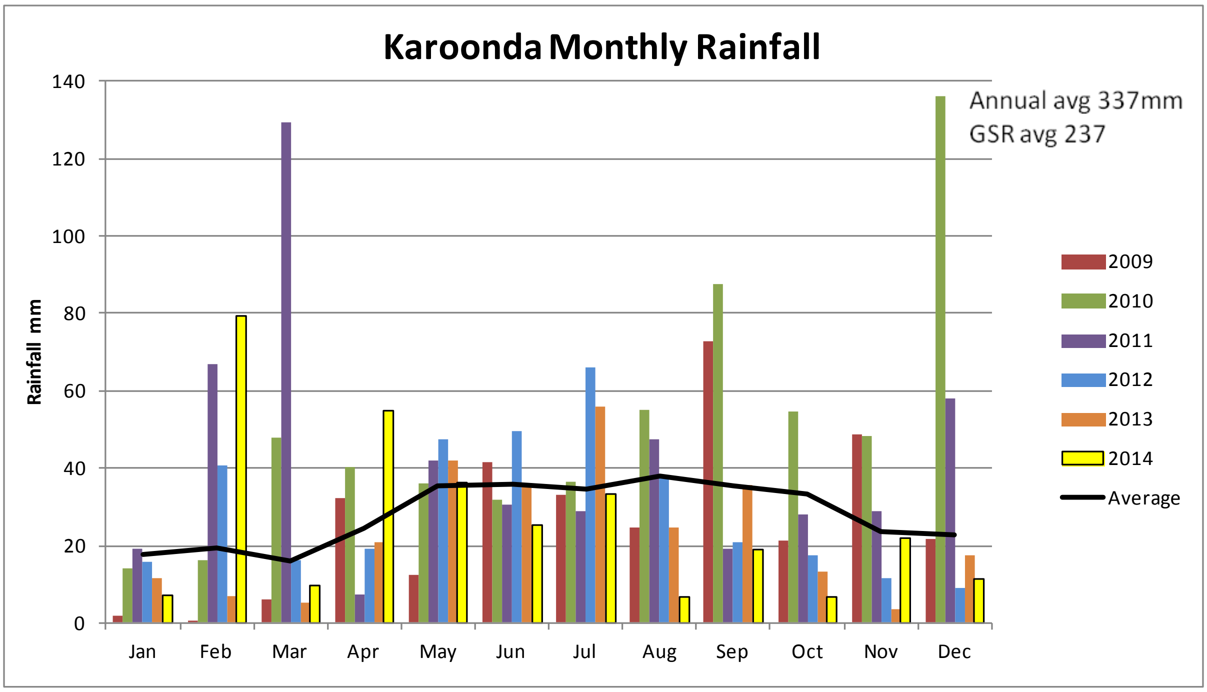

***Figure 1.** Karoonda long term average and monthly rainfall at the trial site.*

Soil Tests

As funding formally ceased in June 2013 only a select few soil measurements were made in 2014. Mineral N was highest in the swale as had occurred in previous seasons but the mineral N levels were considerably lower than 2011 and 2012 (approximately 1/3 of 2012 value) (Table 2). There was 78mm of plant available water in the swale, with more water available in the mid-slope and dune (Table 2), though much of this soil water was stored at depth (data not shown).

Table 2. *Pre-sowing 2014 mineral N (kg/metre depth) and plant available water in the swale (2), mid-slope (5) and dune (8) for the district practice treatment.*

Position	Mineral N (kg/ha)	Plant Available Water (mm)
Swale (2)	60.2	78
Mid-slope (5)	30.8	133
Dune (8)	15.4	101

Grain Yield

Grain yield was analysed according to position along the dune-swale system to capture the effect of soil type on treatment response, with position 1 being at the base of the trial in the swale and position 9 being in the sand dune (Figure 2). Table 3 displays the data in Figure 2 to indicate the significance.

As in 2013 there was no effect of treatment on grain yield at positions 1 and 2 in the swale. Pasture breaks and high N treatments were the best treatments at position 3 in the transition from swale to mid-slope, while high N treatments were superior at the mid-slope positions 4-5 and crest (6) (Figure 2, Table 3). The negative effect of 5 years of nil fertiliser on yields is apparent. From positions 7 to 9 on the dune, the benefits of increased N inputs either at sowing or in-season were substantial (up to 1.3 t/ha over nil fertiliser and 1 t/ha over district practice), while nil fertiliser was the poorest performing treatment at 0.5-0.8 t/ha (Figure 2, Table 3). In most cases applying the higher rate of N all upfront out yielded a split application with 32 kg N/ha top dressed during tillering. For the most part there were no further yield benefits from including a pasture in the sequence 4-5 years prior.

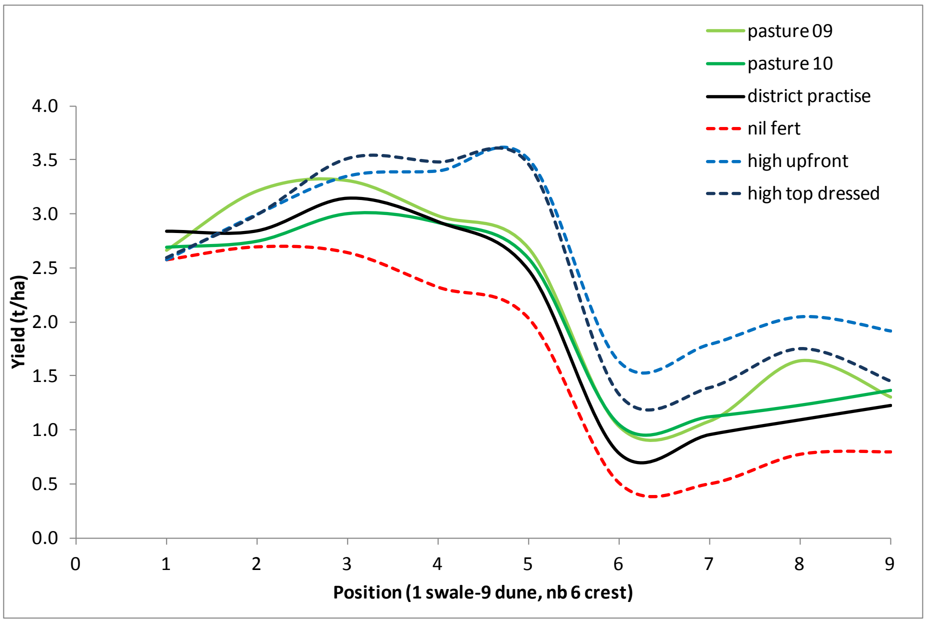

Figure 2. *Corack wheat yields across the landscape positions for each treatment in 2014. Landscape positions are 15 m apart.*

Table3. *Yield (t/ha) in response to treatment within 9 landscape positions, 2014. Within a position (column), a treatment appended by a different letter is significantly different.*

	1 Swale	2 Swale	3 Swale	4 Mid	5 Mid	6 Crest	7 Dune	8 Dune	9 Dune
Pasture 2009	2.67	3.22	3.31 ab	2.99 b	2.69 b	1.03 bc	1.08 c	1.64 abc	1.31 b
Pasture 2010	2.69	2.75	3.00 bc	2.92 b	2.59 b	1.05 bc	1.12 bc	1.23 bcd	1.37 b
District practice	2.84	2.84	3.14 ab	2.93 b	2.48 b	0.79 cd	0.96 c	1.1 cd	1.23 bc
Nil fert.	2.58	2.69	2.64 c	2.32 c	2.03 c	0.51 d	0.50 d	0.77 d	0.80 c
High N upfront	2.58	3.00	3.35 ab	3.40 a	3.50 a	1.63 a	1.79 a	2.05 a	1.92 a
High N topdress	2.60	3.00	3.51 a	3.48 a	3.46 a	1.33 ab	1.39 b	1.75 ab	1.45 b
***L.S.D**	*NS*	*NS*	0.40	0.24	0.43	0.42	0.30	0.60	0.44

*L.S.D-least significant difference

Soil testing results from 2011 and 2012 demonstrated the reason for the lack of further yield response to legume based pastures grown 4-5 years prior. In the first year following pasture, N supply potential was between 8 and 16 kg N/ha/season more than where N inputs at sowing were increased to 40 kg/ha (Figure 3). The benefits from the legume pasture decreased with time, and in the second year after pasture the benefit against 40 kg N/ha at sowing was 0.4-9 kg N/ha/season (Figure 3). Therefore, in the absence of another pasture break in the sequence, increased inputs of N fertiliser are required to maintain soil N fertility and yield at the levels observed in the high N input treatments.

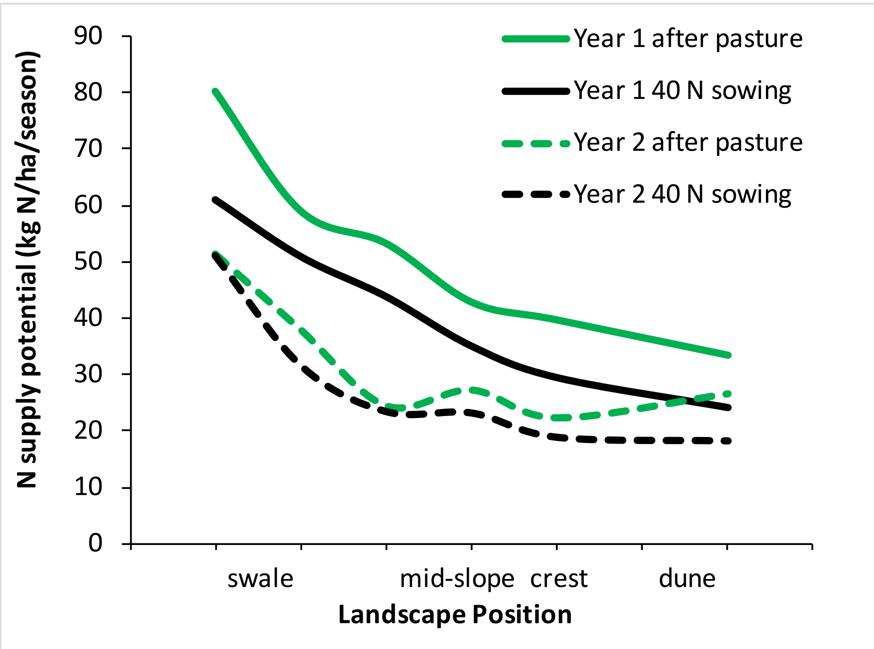

Figure 3. *Soil N Supply Potential (kg N/ha/season) in the first and second year following 2010 pasture compared with the first and second year of increased inputs of fertiliser N (40 kg N/ha at sowing compared with 7-9 kg N/ha at sowing in previous seasons).*

Grain protein

Analysis of grain protein showed an improved level from feed grade to APW at positions 3-4 (mid-slope) and 6-9 (dune) in response to increased N input above district practice (Figure 4).

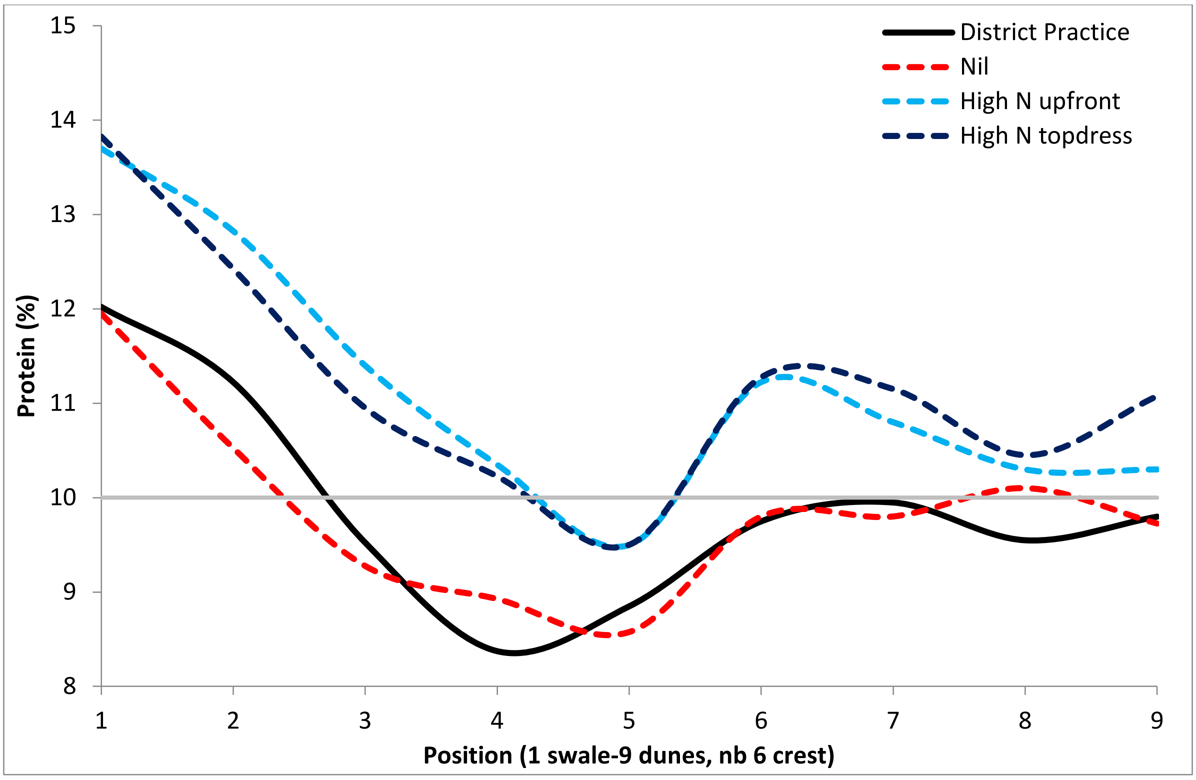

Figure 4. *Corack wheat grain protein across the landscape positions for each treatment in 2014. Landscape positions are 15m apart. The grey horizontal line denotes the 10% protein requirement for APW classification.*

Gross Margins

Analysis of gross margins over the six year trial period highlighted some interesting differences across the landscape (Figure 5). Additional N input at sowing increased returns across the mid-slope and dune, but most markedly in the dune. Applying N upfront gave a better gross margin than a split application with most N applied at tillering-stem elongation across most of the landscape. Pasture produced in 2009 resulted in one of the best gross margins across the landscape (swale through to crest) (Figure 5). 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 5).

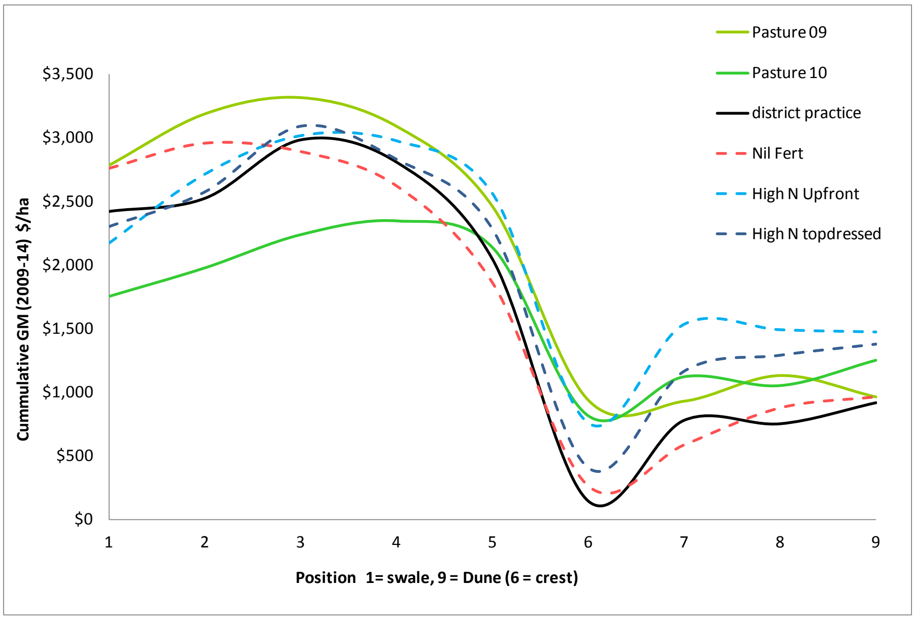

Figure 5. *Cumulative gross margins ($/ha 2009-2014) in response to a range of agronomic treatments across the swale to dune system.*

Implications for commercial practice

- The trial provides strong support for the use of zoning and soil-specific N management to improve profitability from Mallee dune-swale paddocks and improve the reliability of returns from fertiliser N.
- Upfront N at a higher rate still appears to generate the most consistent yield increase and profit outcome on the sandy soil types.
- The highest yielding part of the paddock is not necessarily where the return on extra N fertiliser is highest – knowing starting soil N and considering yield potential is valuable.
- If it is more than three years since a legume break, increased inputs of N are required to maintain soil N fertility and crop productivity.
- Sandy soil types showed consistently profitable yield responses to increased inputs of N, while the heavy swale soils did not show a yield benefit of increased N inputs.

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Links and references

http://msfp.org.au/wp-content/uploads/2014/02/MSF1323.pdf

http://msfp.org.au/wp-content/uploads/2013/10/Farming-to-soil-type-in-the-Mallee-to-improve-water-use-efficiency-and-reduce-risk.pdf

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