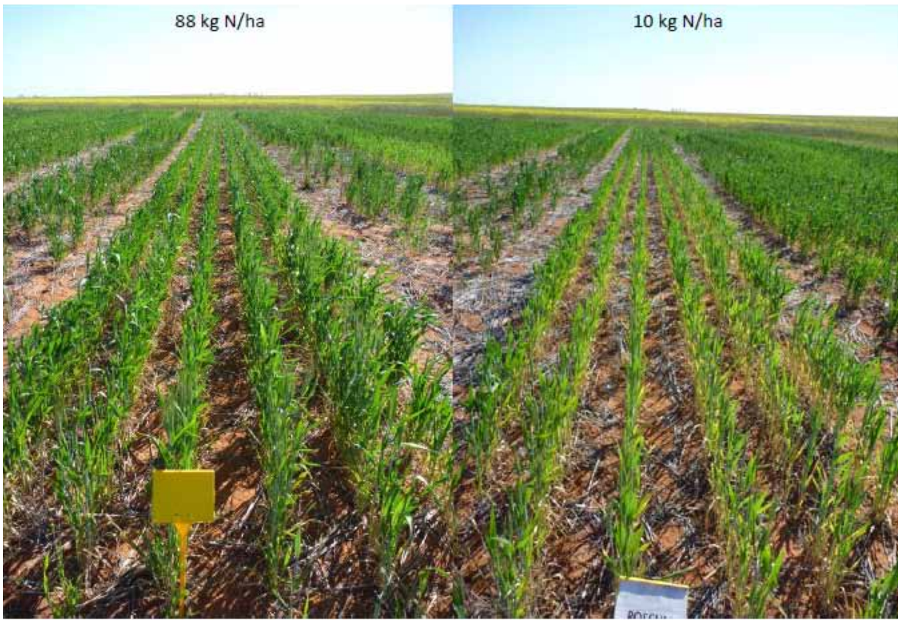
MALLEE CATCHMENT TECHNICAL BULLETIN

Technical Bulletin #29

Nitrogen management tools and strategies for the low rainfall Mallee



Above: Comparison of different nitrogen rates. Left: 88 kg N/ha. Right: 10kg N/ha. Photo: Mallee Sustainable Farming.

This technical bulletin summarises the findings from field research conducted to enhance farmer knowledge of nitrogen management decision support tools and application strategies.

Background

Farmers implementing continuous cropping systems are increasingly applying nitrogen (N) fertilisers. In the lower rainfall parts of the Mallee, applying nitrogen can be a production and financial risk, however, nitrogen deficient crops have low biomass and stubble loads, leaving the soil exposed to erosion. This project was developed to improve farmers knowledge of nitrogen management decision support tools and application strategies. The aim of the project is to increase confidence, knowledge and skills of farmers when making decisions about applying nitrogen fertiliser. This will lead to increased crop water use efficiency, enhance groundcover and improve soil health in the low rainfall Mallee region.

Method

A replicated demonstration trial was established west of Mildura, where in-crop nitrogen management is currently not widely practiced. Thirteen treatments integrating different combinations of

At a glance

- This project was undertaken to demonstrate decision support tools and nitrogen application strategies.
- High plant available water and low soil nitrogen resulted in decision support tools predicting high yield potential and high fertiliser nitrogen requirements.
- There were positive yield responses to nitrogen fertiliser, however fertiliser efficiency was low and nitrogen fertiliser alone was not enough to reach potential yield.
- High nitrogen fertiliser applications were not of benefit as they resulted in plant establishment problems when applied upfront and did not improve profitability over lower fertiliser rates.

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nitrogen management decision support tools (Mallee Calculator, Yield Prophet, Mallee Sustainable Farming (MSF) N Zone Tool and GreenSeeker) and application strategies (upfront and in-crop, Z21 (start of tillering), Z31 (start of jointing) and Z37 (jointing)) were implemented.

The trial was sown on May 9, 2011, with Clearfield wheat (var. Justica) using a no-till seeder with 6 tynes at 30 cm spacings. Nitrogen was applied to each treatment according to the nitrogen application strategy. All treatments received 50 kilograms per hectare of di-ammonium phosphate (DAP) at seeding which supplied approximately 10 kilograms per hectare of nitrogen. Urea was used to supply additional nitrogen to the treatments. Upfront treatments were applied at seeding and in-crop nitrogen was applied on:

- June 28, 2011 (Z21);
- July 29, 2011 (Z31); and
- September 27, 2011 (Z37).

The late nitrogen application occurred at flowering as there was no opportunity to apply nitrogen at the intended Z37, due to an extended period of dry weather.

Various measurements were collected during the trial, including:

- Plant establishment, tiller and head number;
- Biomass at Growth Stage Z31;
- Biomass total nitrogen and nitrate at Growth Stage Z31;
- GreenSeeker Normalised Differential Vegetative Index (NDVI) at anthesis (flowering); and
- Grain yield and quality.

Results

Nitrogen rates

Plant available soil water was very high (approximately 100 mm) while soil nitrogen was very low (18 kg N ha^{-1} to 120 cm) prior to seeding and as a result, decision support tools 'recommended' that high levels of nitrogen would be required. Yield potential predictions over

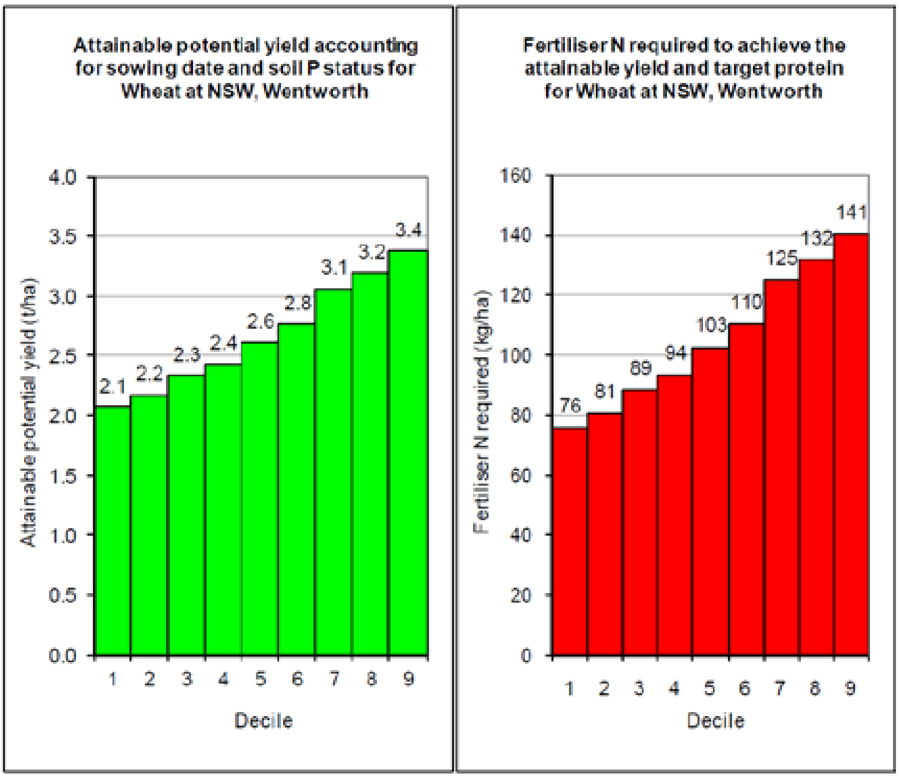

Figure 1. Mallee Calculator yield potential and nitrogen recommendations for a range of seasonal expectations and 80% Water Use Efficiency.

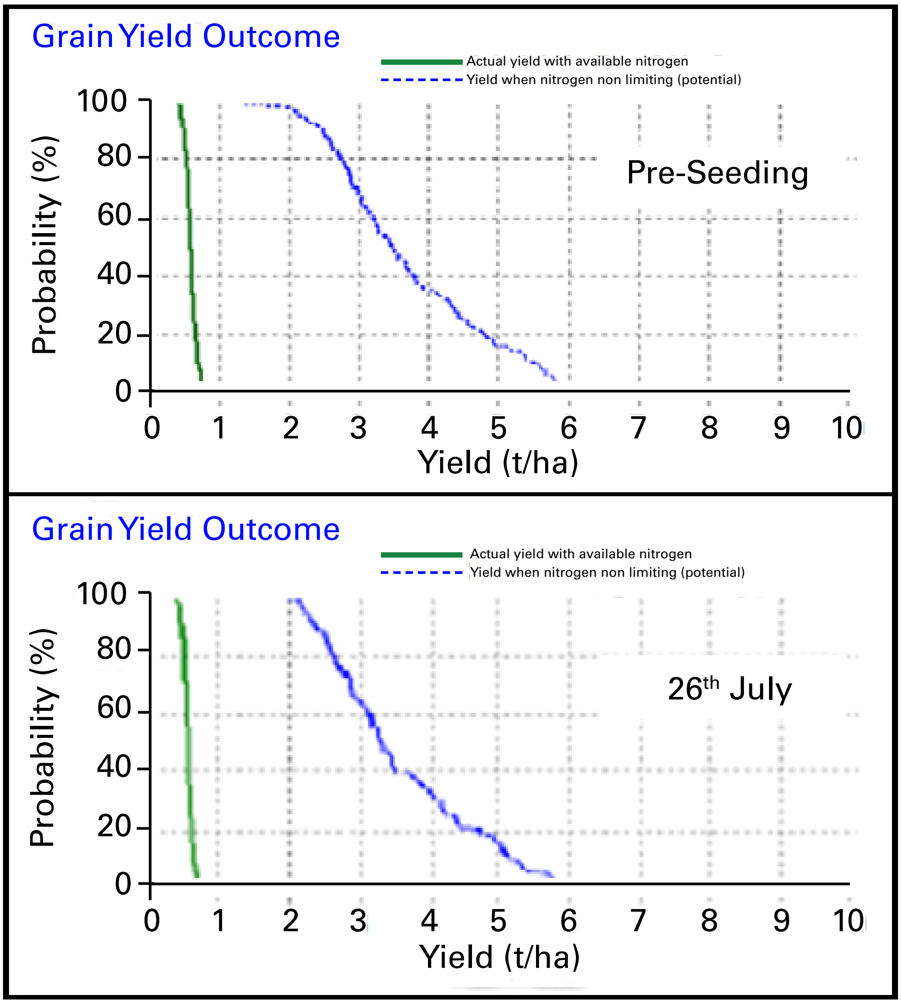

Figure 2. Yield Prophet outputs pre-seeding and on the 26th of July.

a range of seasonal scenarios for the site were 2.1- 3.4 t/ha (Figure 1 and 2). As Figure 3 shows, growing season rainfall was very low between sowing and growth stage Z31 and the season was tracking at decile 1 growing season rainfall. Therefore, decision support tools generally predicted that less fertiliser be applied in-crop than in the up-front treatments. Table 1 provides the nitrogen fertiliser rates applied to each of the treatments.

The high nitrogen rates up-front resulted in fertliser burn to the upfront only treatments. With up to 103 kg N ha^{-1} applied at sowing, deep banding of the urea was attempted however, it appears that the separation between seed and fertiliser was not adequate to prevent crop damage.

To utilise GreenSeeker as a nitrogen management tool, nitrogen rich strips were placed in buffer plots so that crop responses could be measured as an aid to determining the crop nitrogen requirement. At high nitrogen levels, there was reduced crop growth, therefore no crop response to increasing nitrogen levels could be detected with the GreenSeeker. Therefore, the treatments where GreenSeeker was selected as the decision support tool had a standard 40 kg N ha^{-1} applied upfront and at growth stages Z21 and Z30.

Crop growth

Nitrogen application increased tiller and head density (Figure 4). Tiller numbers in the GS Z21+Z31, YPZ21, MC UP+21 and YP+GS UP+31 were significantly higher than the control, thus indicating early nitrogen applications are favorable for promoting tillering. In terms of head numbers, only GS Z21+Z31 and YPZ21 were significantly greater than the control. Significant differences were found in biomass production at Growth

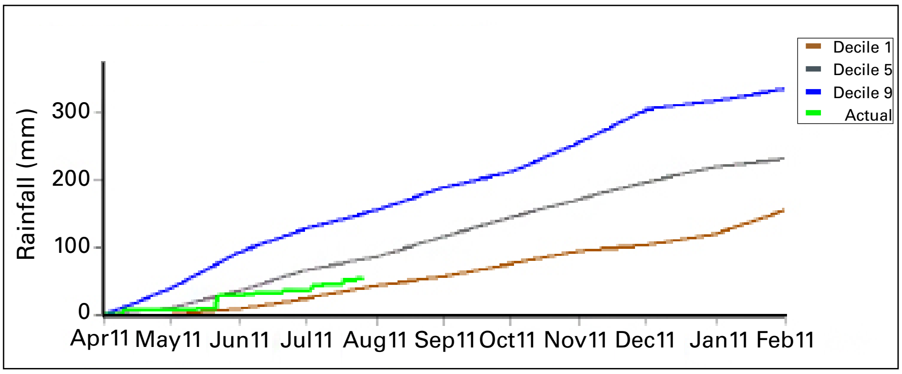

Figure 3. Growing season rainfall at the project site up-to Growth Stage Z31 nitrogen application.

Table 1. Nitrogen fertiliser application rates (kg N/ha) by time of application for each treatment.

Application Strategy	Decision Support Tool	Treatment Code	Nitrogen Fertiliser Rate (kg N/ha)			
			Upfront	Z21	Z31	Z37
Control Upfront Nitrogen (DAP 50 kg - 10 kg N/ha)	Nil	Starter	10			
Upfront	Soil test + Mallee calculator	MC-UP	103			
Growth Stage Z31	Soil test + Mallee calculator	MC-Z31	10		66	
Upfront + Growth Stage Z31	Soil Test + Mallee Calculator	MC-UP+Z31	51.5		24.5	
Upfront	MSF Nitrogen Zone Tool	MSF Tool UP	90			
Upfront	Yield Prophet	YP-UP	80			
Growth Stage Z21	Yield Prophet	YP-Z21	10	48	30	
Growth Stage Z31	Yield Prophet	YP-Z31	10		70	
Growth Stage Z37	Yield Prophet	YP-Z37	10			70
Up-front + Growth Stage Z31	Yield Prophet	YP UP+Z31	40		54	
Growth Stage Z31	GreenSeeker+ Nitrogen Rich Strip	GS-Z31	10		30	
Growth Stage Z21+ Growth Stage 31	GreenSeeker+ Nitrogen Rich Strip	GS-Z21+Z31	10	30		
Upfront+ Growth Stage Z31	GreenSeeker+ Nitrogen Rich Strip	YP+GS-UP+Z31	40			

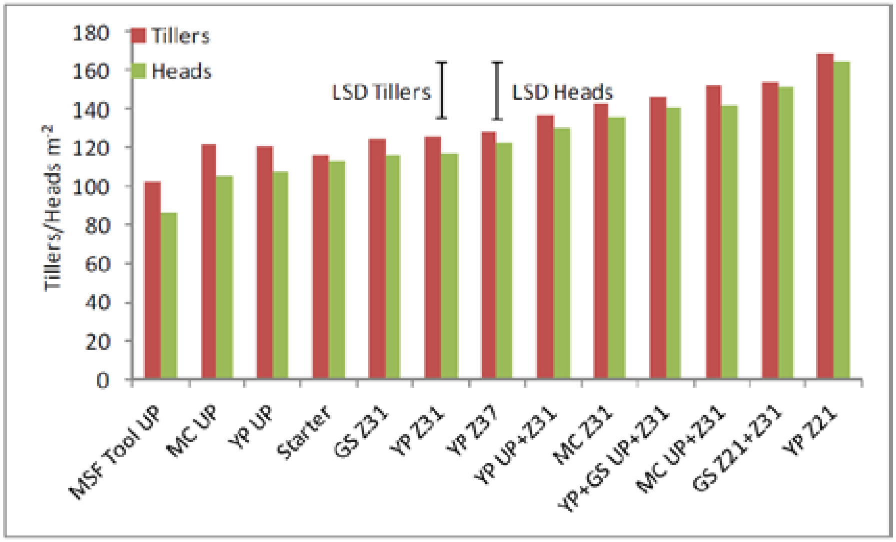

Figure 4. The number of tillers and heads density for each treatment.

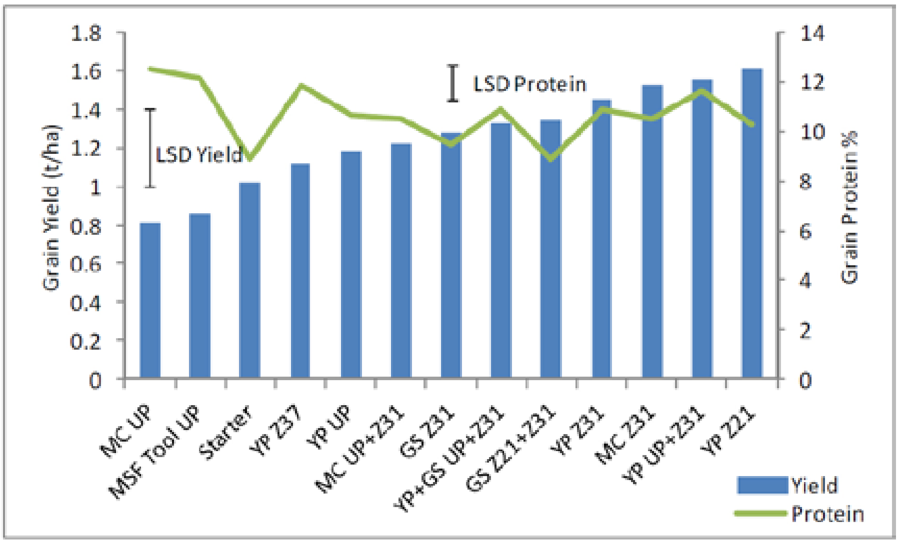

Figure 5. Grain yield (t/ha) and protein (%) measured for each treatment.

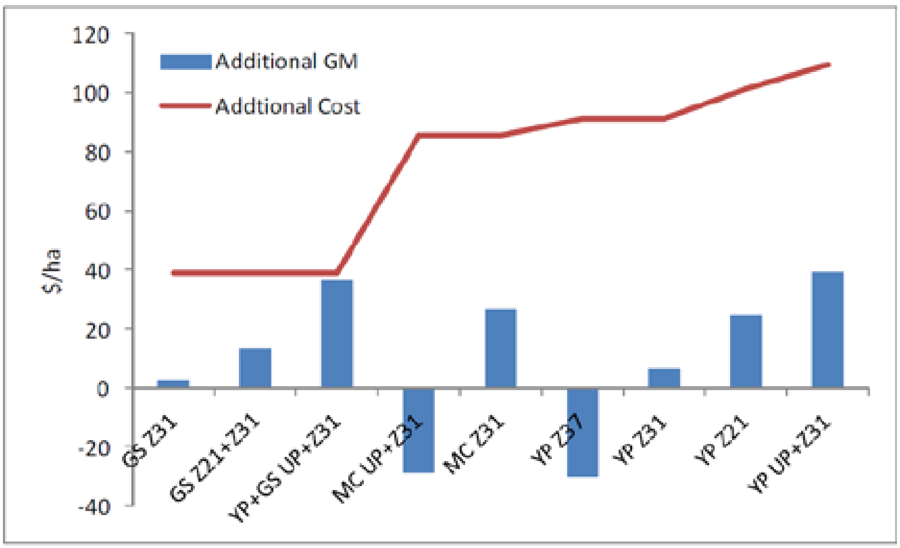

Figure 6. Additional gross margin and additional nitrogen application cost compared to the starter fertiliser treatment.

State Z31; however, these related to the poor establishment. All NDVI at flowering was also measured and there were no significant differences between treatments.

Grain yield and quality

Four treatments resulted in significantly higher yields than the starter fertiliser treatment: YP-Z21, YP-UP+Z31, MC-Z31 and YP-Z31 (Figure 5). These treatments also received the highest nitrogen rates of 88, 94, 76 and 80 kg N/ha respectively (apart from upfront only treatments). While not always significant, yields did tend to increase with increasing nitrogen fertiliser rate.

Grain quality parameters were measured; however, only grain protein was significantly different between treatments (Figure 5). Other than starter fertiliser, grain protein was lowest in the treatment with highest grain yield (YP-Z21) or the treatments where the lowest rates of fertiliser nitrogen was applied (GS-Z21+31 and GS-Z31 = 40 kg N/ha).

An interesting finding is that the late nitrogen application treatment (YP-Z37), in which nitrogen was actually applied around flowering, had a higher grain protein than other in-crop and split application treatments with similar amounts of nitrogen applied. However, this was only significant in two treatments, YP-21 and MC-UP+Z31. The highest grain protein measurements were the upfront treatments where very high nitrogen fertiliser rates combined with low grain yields; however, protein levels were still no greater than 12.5 percent.

Erosion susceptibility

Erosion susceptibility was measured for each treatment post harvest. No significant difference between treatments was found for either ground cover or dry aggregation. The mean groundcover level for the site was 63.9%, while dry aggregates were 32.4%.

Implications of the findings

The starter fertiliser treatment was able to achieve a yield of 1.02 t/ha however, decision support tools suggested that there was only enough nitrogen in the soil profile to achieve approximately 0.5 t/ha of grain yield. Even accounting for the 10 kg/ha of fertiliser N added, yields above 0.75 t/ha should not have been achievable. Therefore, additional nitrogen has been available to the crop and while we can only speculate, it is possible that this is through:

- Higher rates of mineralisation than predicated;
- Subsoil nitrogen below 120 cm that roots could access;
- Errors in soil nitrogen measurement through soil tests; or
- Non-symbiotic nitrogen fixation during the growing season.

Fertiliser nitrogen recovery in grain was calculated for all in-crop treatments excluding YP-Z37, as the difference between the treatment and the starter fertiliser treatment. Recovery was low, ranging from 10.9 – 33.5% with most fertiliser recoveries in the range of 17-20%. Therefore, although positive responses in both grain yield and grain protein were observed from increasing nitrogen application, the efficiency of the applied fertiliser was low. A question remains as to what happened to this nitrogen and further work is required to assess whether this nitrogen still remains in the soil, or if it has been lost from the system.

Another interesting finding is the high ratio of tillers to heads (94%). With the high soil water available to the crops, it is possible that plant numbers were not adequate as additional nitrogen did not over-promote tillers and decrease tiller fertility.

A basic economic analysis was undertaken to assess the profitability of applying nitrogen. A partial gross margin was calculated for each treatment, taking into account income derived from grain yield and nitrogen fertiliser costs and excluding nitrogen application and other variable costs. Figure 6 shows applying nitrogen generated additional income in all treatments other than YP-Z37 and MC-UP+Z31, compared to the starter treatment. Where additional income was positive, it ranged from $2.60 - $39.00/ha. However, expenditure was high to achieve only modest benefits. That is, there was a high risk associated with achieving additional income from applying more nitrogen in addition to the 10 kg N/ha applied as starter fertiliser. Return on investment ranges from -34-94 %, therefore each dollar spent generated less than one dollar in additional income.

Conclusion

The key points from this project are:

- Farmers in low rainfall environments can increase productivity through the use of nitrogen fertiliser, however, they may not reach yield potential with nitrogen inputs alone;
- Decision support tools can help guide farmers with nitrogen fertiliser decisions however, they must also consider non-nitrogen constraints to yield;
- Further work is required to assess why fertiliser efficiency appeared to be so low and why the crop was not able to reach potential yield, even when nitrogen inputs were more than adequate.
- This project was unable to confirm the best nitrogen application strategy but it appeared that early applications promoted greater number of tillers and heads; and
- Avoid applying very high nitrogen rates at seeding as there is potential to lead to crop damage, even with deep banding.

Further information

The information for this technical bulletin has been taken from: 'Nitrogen Management Tools and Strategies for the Low Rainfall Mallee', 2012, A report for the Mallee Catchment Management Authority (CMA) by Mallee Sustainable Farming (MSF). A copy of the report can be downloaded from the Mallee CMA website **www.malleecma.vic.gov.au**

Acknowledgments

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Project Partners

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