Department of
Primary Industries and
Regional Development

GOVERNMENT OF
WESTERN AUSTRALIA

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GRAINS RESEARCH &
DEVELOPMENT CORPORATION

Nitrogen management for wheat protein and yield in Bonnie Rock

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Key messages

- There was no protein or yield penalty in delaying all nitrogen to four weeks after emergence.
- Delaying all nitrogen application to 10 weeks after emergence resulted in reduced grain yield due to little follow-up rain.

Background

Despite extensive research on nitrogen (N) fertiliser strategies, uncertainty still exists regarding the timing and effectiveness of tactical N application. Tactical N application involves delaying the application of N to a time when application rates can be better matched to the crop yield potential. The aim is to reduce costs in poor seasons and maximise yield in good seasons.

Results from the past 3 seasons of Tactical Wheat Agronomy trials (DAW00249) suggest that by delaying N application to 6 or 12 weeks after sowing (WAS), yield is not impacted but grain protein levels increase. The trial reported here was aimed at replicating these findings in Bonnie Rock to provide understanding for current recommendations, as well as economic and farm logistics of varying N decisions to later in the growing season.

Materials and methods

Site description

A small plot trial was conducted at Bonnie Rock (30.5739916S, 118.5591666E) starting May 2018. The soil at the site was a shallow loamy sand duplex, with the loamy sand transitioning into clay at a depth of 30cm. The soil was acidic at the 0–20 cm depth (pH_{ca} of 4.8, 4.5) and alkaline at depth. The top 10 cm had 0.78% organic carbon (Table 1). The area received approximately 156 mm of rainfall during the 2018 growing season (April–November), characterised by a dry September (5.6 mm).

Prior to seeding, the risk of various root diseases was assessed using the DNA-based PREDICTA® B test. Sampling of soil for PREDICTA® B was conducted as recommended by SARDI. Eighteen of the 23 soil-borne pathogens tested were not detected while four (rhizoctonia, bipolaris, pythium root rot and charcoal rot) were found at densities presenting a low disease risk. Root lesion nematodes were detected at levels presenting a medium disease risk (Table 2).

Table 1: Soil characteristics at the Bonnie Rock trial site

Soil Property	Sampling depth (cm)					
	0-10	10-20	20-30	30-40	40-60	60-80
Colour	LTBR	BROR	BROR	BROR	BROR	LTBR
Gravel (%)	0	0	0	0	0	0
Texture	1.5	2	2.5	2.5	2.5	2.5
Ammonium Nitrogen (mg/kg)	8	1	3	2	2	1
Nitrate Nitrogen (mg/kg)	30	2	5	4	3	5
Phosphorus Colwell (mg/kg)	43	14	11	9	6	4
Potassium Colwell (mg/kg)	348	218	235	508	558	598
Sulfur (mg/kg)	42.5	21	42.2	39.1	44	52.4
Organic Carbon (%)	0.78	0.48	0.43	0.36	0.33	0.29
Conductivity (dS/m)	0.313	0.086	0.193	0.252	0.411	0.377
pH Level ($CaCl_2$)	4.8	4.5	5.4	6.8	8.1	8.4
pH Level (H_2O)	5.4	5.8	6.5	8	9.1	9.4
DTPA Copper (mg/kg)	1.21					
DTPA Iron (mg/kg)	16.59					
DTPA Manganese (mg/kg)	29.86					
DTPA Zinc (mg/kg)	2.51					
Exc. Aluminium (meq/100g)	0.114					
Exc. Calcium (meq/100g)	2.61					
Exc. Magnesium (meq/100g)	1.4					
Exc. Potassium (meq/100g)	0.74					
Exc. Sodium (meq/100g)	0.76					
Boron Hot $CaCl_2$ (mg/kg)	1.32					
PBI	57.2					

Experimental design

Different amounts of nitrogen were applied to plots at either seeding, four weeks after emergence (early tillering), 10 weeks after emergence (early stem elongation) or split-applied at these times resulting in 12 treatments (Table 3). Each of the 12 treatments was replicated four times in 1.54 × 10 m plots in a fully randomized, latin square block design.

For plots receiving nitrogen, urea was hand-applied at seeding, four weeks after emergence (26th June 2018; 2–3 leaf stage) and 10 weeks after emergence (8 August 2018; Z30–Z32).

Seeding and plot management

The plots were dry-seeded with wheat (Scepter) on 17 May 2018 using a cone seeder. Each plot consisted of seven rows, 22cm wide and 10m long. Approximately 4.6mm rain was recorded in the area on the 25/05/2019 and germination followed thereafter.

Table 2: Levels of various soil-borne pathogens at Bonnie Rock in 2018 as determined using PREDICTA® B

Test	Result	Disease Risk*
CCN eggs /g soil	0	ND**
Stem nematode (nematodes/100 g soil)	0	ND
Take-all (wheat + oat strains) log(pgDNA/g+1) Sample	0	ND
Take all (Gga) pgDNA/g Sample	0	ND
Rhizoctonia (*R. solani*) AG8 log(pgDNA/g+1) Sample	1.0	Low
Crown rot (*F. pseudograminearum*) test 1 pgDNA/g Sample	0	ND
Crown rot (*F. pseudograminearum*) test 2 pgDNA/g Sample	0	ND
Crown rot (*F culmorum / graminearum*) pgDNA/g Sample	0	ND
Pratylenchus neglectus nematodes /g soil	3	Medium
Pratylenchus thornei nematodes/g soil	0	ND
Blackspot (*Didymella pinodes/Phoma pinodella*) pgDNA/g Sample	0	ND
Blackspot (*Phoma koolunga*) pgDNA/g Sample	0	ND
Under evaluation	**Result**	**Pop. density*** **
Bipolaris (common root rot) pgDNA/g Sample	14	Low
Pythium root rot (*Pythium* clade f) pgDNA/g Sample	3	Low
White grain (*Eutiarosporella tritici-australis*) Copies / g sample	0	ND
Eutiarosporella darliae/pseudodarliae Copies / g sample	0	ND
Eyespot log(kDNA copies/g soil)	0	ND
Pratylenchus penetrans nematodes /g soil	0	ND
Pratylenchus quasitereoides nematodes/g soil	0	ND
Phytophthora root rot- chickpeas (*Phytophthora medicaginis*) Copies / g sample	0	ND
Charcoal rot (*Macrophomina phaseolina*) Copies / g soil	7	Low
Ascochyta blight (*Phoma rabiei*) pgDNA/g Sample	0	ND
Pyrenophora tritici-repentis (YLS) Copies / g sample	0	ND

* risk categories should only be used as a guide only, may be subject to regional and seasonal differences, and may be revised over time
**ND= below detection
***population densities are based on the distribution of pathogen levels detected in the PreDicta samples over several years. These are not risk categories

Data collection and statistical analysis

Plant establishment was assessed four weeks after emergence (WAE). At anthesis, biomass cuts were obtained using standard procedures, dried at 60°C and weighed. These were then subsampled and nutrients analysed through CSBP laboratory. At crop maturity, the plots were harvested using a plot harvester, grain weighed and yield calculated as kg/ha. The protein content of grain was estimated using Near Infra-Red.

Comparison between treatments was conducted using an analysis of variance (ANOVA) in Genstat (18th Edition). ANOVA was preceded by a test for normality and equal variances (Levene's test). LSD test was run to identify differences between groups when ANOVA was found to be significant (a p-value of < 0.05 was considered significant).

Table 3: Amounts of N applied either at seeding, four weeks after emergence (4 WAE) or ten weeks after emergence (10 WAE)

	Kg N/ha applied			
Treatment	**Seeding**	**4 WAE**	**10 WAE**	**Total N**
1	0	0	0	**0**
2	25	0	0	**25**
3	0	25	0	**25**
4	0	0	25	**25**
5	50	0	0	**50**
6	0	50	0	**50**
7	0	0	50	**50**
8	25	0	25	**50**
9	25	25	0	**50**
10	0	25	25	**50**
11	100	0	0	**100**
12	10	0	0	**10**

Results and discussion

Plots achieved a plant density of 80-100 plants per m^2. Grain yield ranged between 1.05 and 1.39 t/ha (Figure 1), with significant differences observed among treatments (ANOVA (F (11, 47) = 6.43, p = <.001))).

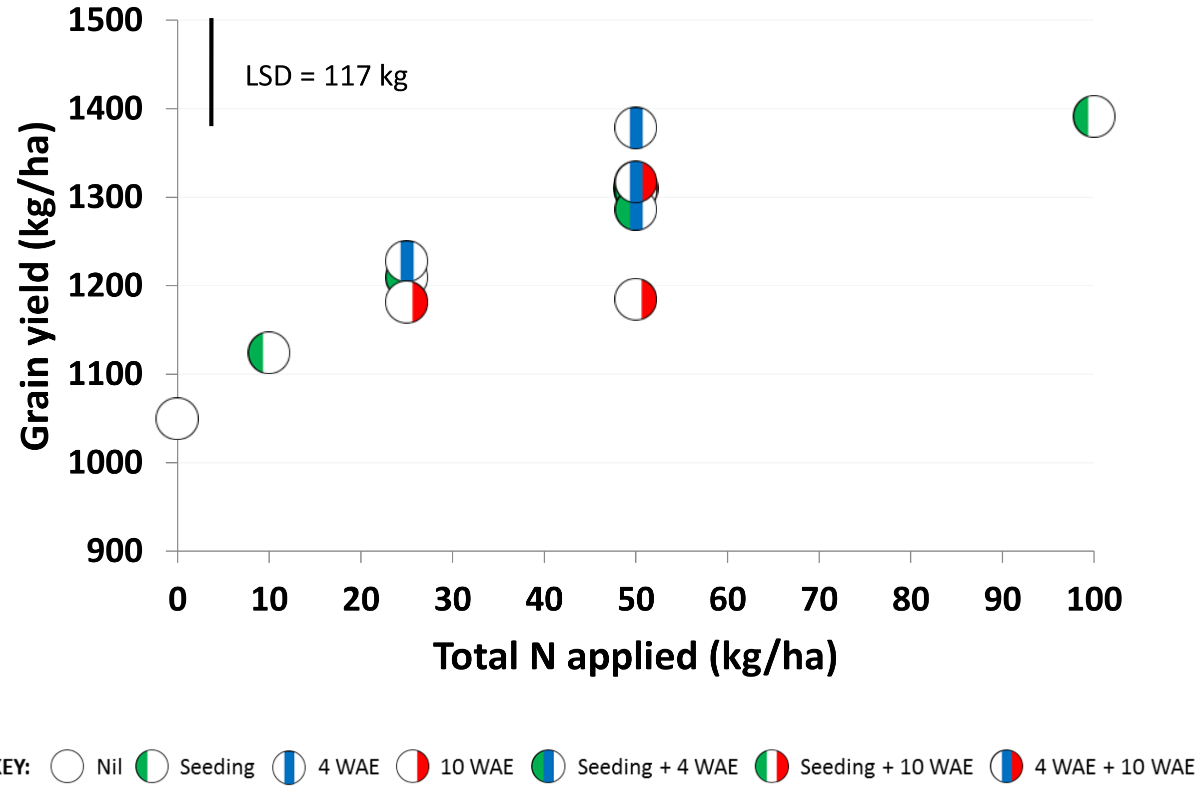

Figure 1: Wheat grain yield from various rates and times of nitrogen fertiliser applied in a trial at Bonnie Rock in 2018**.**

Treatments that resulted in the highest yield were 100 kg/ha N at seeding and treatments that received a total of 50 kg/ha N (as single application or as split), with the exception of 50 kg/ha N applied at 10 WAE, which resulted in a significantly lower yield.

Findings indicated that delaying nitrogen application for up to four weeks after emergence was not detrimental to grain yield. However, putting off all nitrogen to 10 WAE resulted in a yield penalty. This was likely caused by a dry finish to the 2018 season. In the seven weeks following the third application of nitrogen at Z30–Z32, a total of 18 mm of rain was received in 13 minor rainfall events of less than 4 mm each. Follow-up rain was required to carry the surface-applied N fertiliser to the root zone for uptake by the plant (Lemon, 2007).

When only small quantities of nitrogen were applied (10 and 25 kg/ha), yields were lower than those from applying 50 kg/ha suggesting that the former were insufficient to realise the yield potential of the crop. In contrast, yields from applying 100 kg N were similar to most treatments receiving 50 kg N. The high rate of N resulted in significantly higher plant biomass (data not shown) that would have 'hayed off' due to the terminal drought, causing a yield reduction (van Herwaarden, 1998).

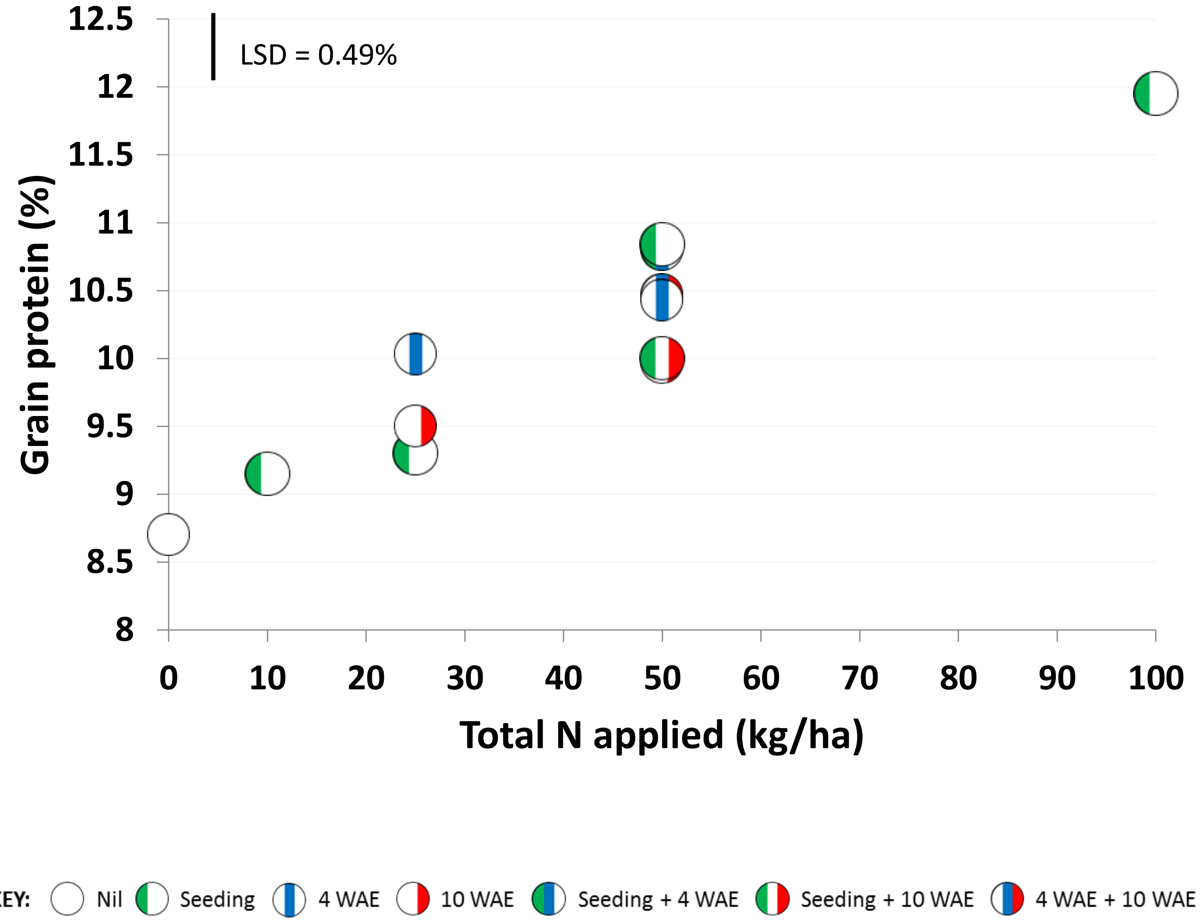

Figure 2: Wheat grain protein from various rates and times of nitrogen fertiliser applied in a trial at Bonnie Rock in 2018.

Protein concentrations ranged between 8.7% and 11.95% (Figure 2), with significant differences seen among treatments (ANOVA (F (11, 47) = 26.54, p = <.001))).

Applying 100 kg/ha N at seeding resulted in the highest protein concentrations ($\bar{\bar{x}}$ = 11.95% ± 0.366 (SEM)), which was 1.15% higher than the second best treatment. Applying a total of 50kg/ha N at seeding or at four WAE resulted in similar protein yield. However, when nitrogen was delayed to 10 WAE, protein levels were reduced. The reduction in protein content was likely caused by the dry finish to the season which limited the uptake of the nitrogen applied at 10 WAE.

We also calculated the cost-effectiveness of the various rates of nitrogen. For this calculation, the cost of applying nitrogen was set at $0.80 per unit of N and the selling price of wheat at $300 per tonne. These figures are derived from rough approximations of the 2018 prices for these commodities. The net dollar return per hectare ranged from -1 for 50 kgs applied 10 WAE to +59 per hectare for 50 kgs applied 4 WAE (Table 4). At each rate of nitrogen, early applications (planting or 4 WAE) led to better net returns when compared to a late application (10 WAE). Due to the low rainfall received (156 mm GSR), the site had a low yield potential and the net dollar return, per hectare, was low across all treatments.

Table 4. Dollar return from applying nitrogen

N Treatments	Amount N (kg)	Cost of N ($)*	Yield (t/ha)	Return ($)/ha**
0-0-0	0	0	1.05	**0**
10-0-0	10	8	1.15	**22**
25-0-0	25	20	1.21	**28**
0-25-0	25	20	1.23	**34**
0-0-25	25	20	1.18	**19**
50-0-0	50	40	1.31	**38**
0-50-0	50	40	1.38	**59**
0-0-50	50	40	1.18	**-1**
25-0-25	50	40	1.31	**38**
25-25-0	50	40	1.29	**32**
0-25-25	50	40	1.32	**41**
100-0-0	100	80	1.39	**22**

*cost of nitrogen approximated to be $0.80 per unit of N applied
** dollar return is calculated on a selling price of $300 per tonne of wheat

Conclusions

Nitrogen fertiliser is a significant cost to growers and its application needs to be managed to maximise returns. The key to doing this is accurately estimating a crop's yield potential, which then allows for the correct amounts to be applied. If too little nitrogen is applied, the yield potential is not realised while if excess is applied, optimum economic returns are not achieved.

This trial investigated the effect of delaying nitrogen application, which allows a better estimate of yield potential, on the yield on wheat in Bonnie Rock.

We found that the application of nitrogen can be delayed to four weeks after emergence without grain yield or protein penalty. However, delaying all N application to 10 WAE reduced grain yield. Very little rain was received post 10 WAE and pre-grain fill and the nitrogen would not have been taken up by the plants. Consequently, the yield from this treatment was statistically similar to that of the nil. Bonnie Rock historically receives very little rain in the months of August and September (data not shown) and nitrogen applied in these months is unlikely to influence crop yield.

Delaying nitrogen application for a few weeks was not detrimental to the grain and protein yield of wheat. However, our findings emphasize that while delaying all nitrogen application even further may lead to a greater confidence in the estimation of yield potential, the risk of no significant follow-up rainfall should be considered.

Acknowledgements

This research was carried out under the 'Building crop protection and crop production agronomy research and development capacity in regional Western Australia' project (DAW00256), a co-investment of GRDC and DPIRD. We also wish to thank Cameron Wild for technical assistance and Ashleigh Donnison for review comments in the writing of this report.

References and useful links

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Important disclaimer