
SAVING N FOR A RAINY DAY: NITROGEN MANAGEMENT AFTER A DRY FINISH

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Take home messages

- Nitrogen applied to crops that have hayed off can contribute to crop biomass and yield in the subsequent season.
- When haying off is severe, a nitrogen (N) balance based on paddock history may be inaccurate.
- Conservative N management delivered the best economic returns over the two years of the trial.

Background

Knowing how much nitrogen (N) is available to crops is critical for effective nitrogen management. However, inter-seasonal variability and its effect on nitrogen supply and demand make this a continued challenge for many growers. In particular, poor seasonal conditions can result in large amounts of applied N not being used by crops, but instead stored in the soil or lost to various processes (Küstermann et al. 2010). At the same time, applying the right amount of N – and making the most of what is already available – can be even more important in the context of tight cash flows following a dry year.

In 2015 BCG carried out a nutrition trial investigating the response of new and existing barley varieties to varied nitrogen rates at Kalkee. The trial was severely affected by dry conditions which caused plants to hay off and the results were not deemed worthy of analysis or publication. However, this failed nutrition trial provided BCG with an opportunity to examine the effect of residual or unused nitrogen inputs on a subsequent crop and to determine effective nitrogen management in paddocks where crops 'hayed off' in the previous season.

Aim

To determine the effect that nitrogen applied to a barley crop that 'hayed off' has on wheat sown in the subsequent season.

Paddock details

Location:	Kalkee
Annual rainfall:	462mm
GSR (Apr-Oct):	374mm
Soil type:	Clay
Paddock history:	2015 barley; 2014 wheat

Trial details

Crop type:	Grenade CL Plus wheat
Treatments:	Refer to Table 1
Target plant density:	140 plants/m ²
Seeding equipment:	Knife points, press wheels, 30cm row spacing
Sowing date:	19 May
Replicates:	Four
Harvest dates:	13 November 2015 22 December 2016

Trial inputs

Fertiliser:	Refer to Table 1
Herbicide:	19 May Roundup PowerMAX® @ 2L/ha + TriflurX® @ 1.5L/ha + Avadex® Xtra @ 2L/ha + Sakura® 850WG @ 118g/ha
	7 July Intervix® @ 750mL/ha + Hasten™ @ 0.5%
	5 August Lontrel™ Advanced @ 50mL/ha + Velocity® @ 670mL/ha + LVE MCPA 570 @ 300mL/ha + Uptake™ @ 0.5%
Insecticide:	12 September Fastac® Duo @ 250mL/ha + Lorsban™ 500EC @ 200mL/ha + BS1000 @ 0.25%
Fungicide:	16 August Prosaro® 420 SC @ 300mL/ha + SpreadWet 1000 @ 0.25%
	27 September Prosaro 420 SC @ 300mL/ha + BS1000 @ 0.25%
Seed treatment/inoculant:	Raxil® T 1mL/kg seed

Pests, weeds and disease were controlled to best management practice.

Method

In 2016 a replicated field trial was sown over the site of a 2015 barley nitrogen response trial, creating a split-split plot design (Table 1). A single wheat variety (Grenade CL Plus) was sown across all plots in 2016. Assessments included soil testing, NDVI, and grain yield and quality parameters.

Table 1. Treatments applied to the trial in 2015 and 2016. In 2016, four replicates were sown for every combination of 2015 variety x 2015 N treatment x 2016 N treatment.

2015 variety	2015 N treatment	2016 N treatments	
		-N	+N
Commander	0kg/ha	No additional N applied	41.4kg N/ha at GS15/22
Compass	30kg/ha		
Flinders	60kg/ha		
GrangeR	90kg/ha		
La Trobe	120kg/ha		
Scope CL			

Results and interpretation

2015 nitrogen response trial results

The seasonal conditions in 2015, combined with the nitrogen treatments applied in this trial, were highly conducive to haying off occurring.

Haying off refers to a premature end to grain filling typically associated with cereal crops that experience moisture stress in the later part of the season. Vigorous early growth stimulated by high N rates effectively exhausts the resources available to plants for grain fill, resulting in low yields and small, pinched grains (van Herwaarden and Richards 1998).

By October 2015 the symptoms of extreme moisture stress were evident across the Kalkee site. These effects were apparent in the harvest results, with a significant negative relationship between N treatment and yield (Table 2) and very high screenings in the high N treatments.

Table 2. Average yields (t/ha) achieved by barley nitrogen response trial at Kalkee in 2015.

Variety	Nitrogen treatment (kg/ha)					Average
	0	30	60	90	120	
Commander	0.87	0.75	0.49	0.33	0.20	0.53 ^b
Compass	1.55	1.64	1.30	1.13	0.85	1.29 ^a
Flinders	2.00	0.72	0.54	0.47	0.47	0.66 ^b
GrangeR	0.43	0.46	0.17	0.09	0.02	0.24 ^c
La Trobe	1.18	1.33	1.07	0.89	0.75	1.04 ^a
Scope CL	1.05	0.78	0.68	0.45	0.42	0.68 ^b
Average of all varieties	1.03 ^a	0.95 ^a	0.71 ^b	0.56 ^c	0.45 ^d	
Sig. diff.						
Variety				P<0.001		
Nitrogen				P<0.001		
Variety x nitrogen				NS (P=0.408)		
LSD (P=0.05)						
Variety				0.25		
Nitrogen				0.11		
Variety x nitrogen				0.33		
CV%				25.2		

N balance and soil test results

A simple nitrogen balance is often used as a guide to the available nitrogen in a paddock at the start of the season, and to help determine required nitrogen inputs. This is calculated by subtracting the nitrogen removed in grain at harvest from available nitrogen over the growing season (comprised of a pre-sowing soil test, applied nitrogen and an estimate of mineralisation).

Soil tests at the Kalkee site before sowing in 2015 indicated 54kg N/ha from 0-70cm depth. An additional 22kg N/ha from mineralisation was estimated using the formula: mineralised N = 0.15 x growing season rainfall x organic carbon (Peter Ridge, unpublished). However, this may be an overestimation due to a lack of topsoil moisture in spring (mineralisation predominantly occurs when the soils are warm).

The results of the nitrogen balance calculation were compared with the results from soil tests conducted prior to the 2016 season. Compass and GrangeR were the highest and lowest yielding varieties in the 2015 trial, respectively, and these varieties were used for the comparison (Table 3).

Table 3. Nitrogen balance based on 2015 paddock history, and 2016 soil test results.

Variety	2015 nitrogen balance calculation					2016 soil test results (N kg/ha)	Difference between N balance and soil test results (N kg/ha)
	Soil test (N kg/ha)	Mineralised (N kg/ha)	Applied N (N kg/ha)	N removed in grain (N kg/ha)	N balance (N kg/ha)		
Compass	54	22	0	30	46	54	8
	54	22	30	40	66	42	-24
	54	22	60	37	99	62	-37
	54	22	90	34	132	65	-67
	54	22	120	27	169	67	-102
GrangeR	54	22	0	11	65	67	2
	54	22	30	14	92	63	-29
	54	22	60	5.6	130	90	-40
	54	22	90	1.9	164	107	-57
	54	22	120	1.7	194	109	-85

Pre-sowing soil tests in 2016 displayed a similar pattern of available N to the N balance calculated (ie. higher for low-yielding plots) but differed in actual quantity (Table 3). The N balance calculation appeared to have overestimated available N in plots that had hayed off, assuming that the soil tests were accurate.

The 'missing' nitrogen (not indicated by soil tests) could still be contained in organic matter remaining from 2015, requiring further mineralisation before becoming available to crops. Other possibilities are that it has leached to below the soil sampling depth or has been otherwise lost to the environment.

Nevertheless, these results strongly suggested that 2015 yield and nitrogen treatments would have an effect on crop outcomes in 2016.

Normalised Difference Vegetative Index (NDVI) taken in September (GS37) as an indicator of mid-season biomass production, showed that N applications in both 2015 and 2016 had a significant effect. Most importantly, the interaction between them was also significant ($P < 0.001$).

This means that the size of the response to added N in 2016 depended primarily on the 2015 N treatment, and consequently upon the 2015 yield. High N treatment plots that had hayed off in 2015 had significantly higher NDVI measurements, but less of a response to added N in 2016 (Figure 1).

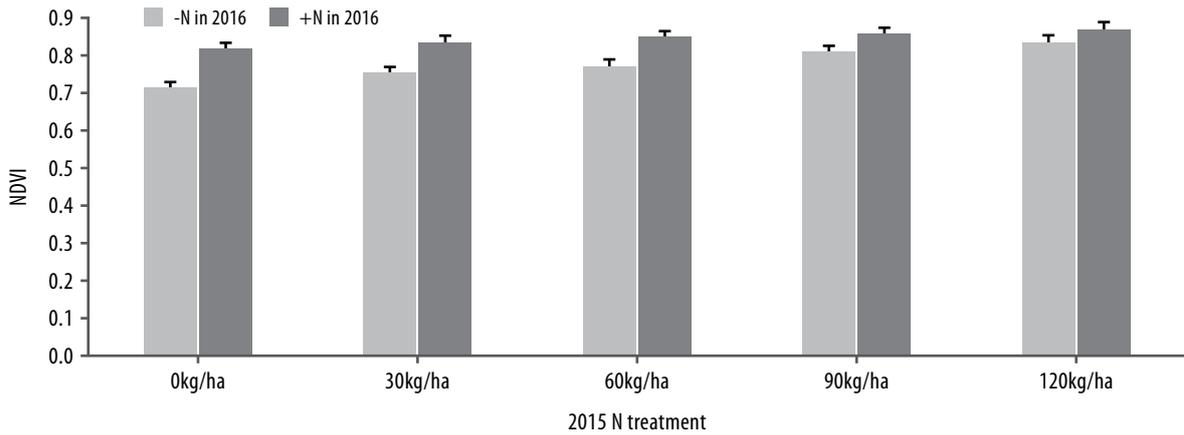


Figure 1. Average NDVI values by 2015 N treatment at GS37. Error bars indicate least significant difference (LSD) between -N and +N treatments in 2016, but differences in average NDVI between 2015 N treatment were also all significant. Stats: P=0.001, LSD=0.01755, CV=4.1%.

A wet 2016 spring delivered impressive yield results that reflected the same patterns of response shown earlier in the season. The wheat sown over plots where higher N treatments had been applied in 2015 produced higher yields, demonstrating a significant interaction between 2016 and 2015 N treatments (Figure 2).

Although neither soil test results, nor the N balance, were consistent with estimates of N requirements for 2016, a stronger correlation between yield and soil test results ($R^2=0.82$) compared to N balance calculations ($R^2=0.67$) suggests greater general accuracy in the former.

Compass was the only barley variety grown in 2015 to have a significant effect on 2016 wheat yield, with a lower yield than all varieties except for Flinders. This is likely due to Compass having the highest yield in 2015 and, consequently, the greatest N removal and least remaining N in 2016.

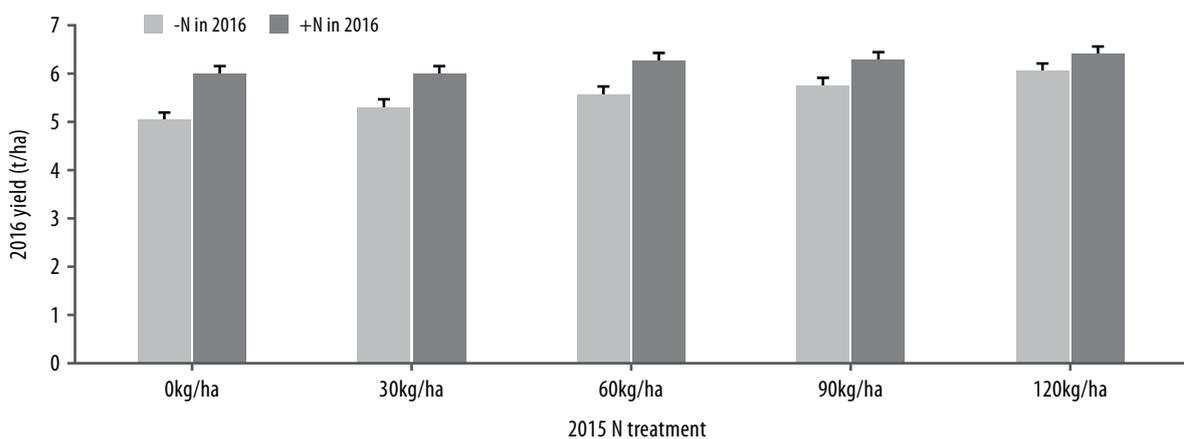


Figure 2. Average yields in 2016 by 2015 N treatment. Error bars indicate least significant difference (LSD) between 0N and +N treatments in 2016, but differences in average yield between 2015 N treatment were also all significant. Stats: P=0.001, LSD=0.16t/ha, CV=5.5%.

Grain protein levels were generally low but higher in plots where higher rates of N had been applied in 2015 ($P<0.001$). This may indicate that insufficient N was applied to reach yield potential in 2016, which may have resulted in lower N responses than might otherwise have been observed. No treatment had a significant effect on screenings.

Commercial practice

In paddocks where crops have hayed off, these results suggest that deep N soil tests may give a better general indication of available N for a subsequent crop than paddock history. While the N balance calculation is a tried and true method, the level of accuracy appeared to reduce substantially as the severity of haying off increased.

Nevertheless, the potential silver lining after a crop hays off is the yield benefit that can be achieved from leftover nitrogen the next year. But this is not necessarily in proportion to the amount of N applied in the previous season. The strong biomass response observed mid-season also has implications for risk management, since this could increase the risk of haying off yet again in a consecutive dry finish where substantial amounts of N remain from the previous season.

On-farm profitability

The relatively small investment in deep soil N testing in order to gain an accurate view of starting N in a paddock that has hayed off may be quickly recouped by avoiding over or under-applying fertiliser, especially when combined with decision support tools such as Yield Prophet®.

Thanks to excellent seasonal conditions, all treatments demonstrated average economic returns to added fertiliser in 2016 of between \$21.28/ha and \$117.84/ha, based on a grain price of \$157.25 (ASW) and net of fertiliser and application costs.

The 2015 120kg N/ha treatment combined with additional N in 2016 delivered the highest average single-year income of \$980.34/ha despite being the least N responsive. However, the most profitable treatment when approximate 2015 N costs are taken into account was the 0kg N/ha treatment with additional N in 2016 at \$914.36/ha. This was followed closely by the 60kg N/ha treatment with additional N in 2016 at \$911.11/ha.

These figures are highly sensitive to grain prices and actual quality achieved. Nevertheless, they reinforce the potential benefits of a conservative approach to N management in the long run under a highly variable climate.

References

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