DURUM NITROGEN MANAGEMENT – YIELD, PROTEIN OR BOTH?

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TAKE HOME MESSAGES

- It is important to understand soil nitrogen levels to make rotation and targeted nitrogen management decisions.
- If nitrogen is managed appropriately, durum wheat can be a profitable grain crop in the Wimmera.
- Grow durum on the back of a legume stubble to maximise protein efficiencies.

BACKGROUND

Farming systems in the Wimmera over the past 20 years have shifted away from legume pastures and towards grain legume crops which leave less residual nitrogen (N). This creates challenges for N management in subsequent cereal crops. Determining the optimal timing and quantity of N can be very difficult. Moreover, the complex nature of durum wheat receival grades (protein, test weight and screenings) results in increased challenges in producing this commodity to market specifications. The desire to produce high protein grain through late season N applications often comes at the expense of yield and nitrogen use efficiency which increases the associated risk. If the barriers to producing DR1 durum can be overcome, growers in the Wimmera have the potential to benefit significantly from having a broader range of marketing options.

AIM

Trial 1 and 2 (N risk management)

To assess a range of nitrogen timings and rates to determine the optimum yield and protein in durum, on two paddocks with contrasting residual soil nitrogen levels.

Trial 3 (N rate)

To determine the optimum rate of N based on seasonal conditions to produce durum wheat in a low starting soil N paddock.

PADDOCK DETAILS

Location:	Kalkee
Crop year rainfall (Nov-Oct):	363mm
GSR (Apr-Oct):	254mm
Soil type:	Clay
Starting Soil nitrogen:	Low N (north site): 30kgN/ha (0-100cm)
	High N (south site): 68kg N/ha (0-100cm)
Paddock history:	Low N (north site): 2018 – Barley, 2017 – Durum wheat
	High N (south site): 2018 – Lentil, 2017 – Oaten hay

TRIAL DETAILS

Crop type:	DBA-Aurora durum wheat
Treatments:	Refer to Tables 1 and 2
Sowing rate:	75 plants/m^2
Seeding equipment:	Knife points, press wheels, 30cm row spacing
Sowing date:	22 May 2019
Replicates:	Four
Harvest date:	10 and 12 December 2019
Trial average yield:	2.9t/ha

TRIAL INPUTS

Fertiliser:	Refer to Table 1 and Table 2 for individual treatments
	Granulock® Supreme Z + Flutriafol (200mL/100kg) @ 60kg/ha at sowing

Weeds, pests and disease were controlled according to best management practice.

METHOD

The three trials were established using a complete randomised block design and received the same agronomic management, apart from the nitrogen fertiliser management listed below (Table 1 and 2). These trials were bulk sown with the BCG plot seeder. Yield and grain quality indicators (protein, test weight and screenings) were assessed to ascertain treatment differences.

Table 1. Fertiliser applications (kg N/ha) top-dressed at GS13 (27 June) and GS37 (19 September) for trials 1 and 2 sown on high N (south) and low N (north) sites respectively).

Treatment	N rate (kg N/ha) applied at GS13 (27 June)	N rate (kg N/ha) applied at GS37 (19 September)	Total N applied (kg N/ha)
30kg N/ha early	30	-	30
30kg N/ha split	15	15	30
40kg N/ha late	-	40	40
60kg N/ha early	60	-	60
60kg N/ha split	30	30	60
90kg N/ha early	90	-	90
90kg N/ha split	45	45	90
120kg N/ha early	120	-	120
120kg N/ha split	60	60	120
150kg N/ha early	150	-	150
150kg N/ha split	75	75	150
Nil	-	-	-

Table 2. Fertiliser applications (kg N/ha) for trial 3 sown on low N (north) site, top-dressed at GS13 (27 June) and GS55 (12 October).

Treatment	N rate (kg N/ha) applied at GS13 (27 June)	N rate (kg N/ha) applied at GS55 (12 October)	Total N applied (kg N/ha)
40kg N/ha @ GS13 and 10kg N/ha @ GS55	40	10	50
40kg N/ha @ GS13 and 20kg N/ha @ GS55	40	20	60
40kg N/ha @ GS13 and 40kg N/ha @ GS55	40	40	80
40kg N/ha @ GS13 and 60kg N/ha @ GS55	40	60	100
40kg N/ha @ GS13 and 80kg N/ha @ GS55	40	80	120
80kg N/ha @ GS13 and 10kg N/ha @ GS55	80	10	90
80kg N/ha @ GS13 and 20kg N/ha @ GS55	80	20	100
80kg N/ha @ GS13 and 40kg N/ha @ GS55	80	40	120
80kg N/ha @ GS13 and 60kg N/ha @ GS55	80	60	140
80kg N/ha @ GS13 and 80kg N/ha @ GS55	80	80	160
Nil @ GS13 and 40kg N/ha @ GS55	-	40	40
Nil @ GS13 and 80kg N/ha @ GS55	-	80	80

RESULTS AND INTERPRETATION

Overall seasonal summary

The sowing rate was sub optimal, due to being sown with the BCG plot seeder. Which was bulk sown and when combined with large seed size (57g/1000seeds), led to the low sowing rate of 50kg/ha. Above average rainfall early in the growing season resulted in good early growth and a high yield potential despite limited stored soil water (19-23mm at 0-100cm). However, below average rainfall in the spring, resulted in reduced yields and grain quality especially in treatments with higher early biomass. Moreover, the dry spring presented limited opportunities for nitrogen fertiliser applications. Just 6mm of rain fell in the 10 days following the GS37 applications (19 September) and 13mm in the 10 days following the GS55 applications (12 October), as a result it is unclear if this was enough rain to make the nitrogen treatments available to the crop.

Trial 1 – How did N amount and timing affect optimum yield and protein at a high soil N site?

The good early growing conditions combined with below average spring rainfall resulted in a negative yield response to increased N applications early (GS13). The nil treatment achieved the highest yield and the 150kg N/ha early resulted in the lowest yield (Table 3). This is consistent with previous seasons, where significant biomass production early, resulted in a 'haying off' effect as moisture becomes limiting.

A similar trend was observed in test weight and screenings. The treatment with highest test weight was the nil treatment and the lowest was 150kg N/ha early. All treatments except the 150kg N/ha early, were above the minimum 76kg/hL required to achieve DR1 and DR2 grade. For screenings, the higher, earlier N applications resulted in increased screenings which are attributed to the 'haying off' effect. No treatment in this trial had the less than 5 per cent screenings required to make DR1 and DR2 grade. All treatments, except for 150kg N/ha early, had less than 10 per cent screenings required for DR3.

Grain protein content increased with higher N applications. The GS37 N applications had little impact on grain protein which was due to the below average spring rainfall and limited N uptake. All but three treatments achieved DR3 grain quality specifications. The nil N, 40kg N/ha late and 150kg N/ha early met feed grain standards.

Quality varied significantly with N strategy. The higher early N rates resulted in screenings above the maximum specifications and not enough nitrogen early resulted in protein below the minimum specifications. For those treatments that achieved protein high enough to achieve higher grades, screenings were the limiting factor to achieving an upgrade in quality.

The treatments closest to achieving DR1 quality were 60kg N/ha early, 120kg N/ha split and the 150kg N/ha split – these treatments had protein above the 13 per cent required to achieve DR1 but screenings were slightly above the required 5 per cent.

Table 3. Grain yield and quality parameters for N risk management trial (Trial 1, high N site) (south site). Letters indicate significant difference.

Treatment	Yield (t/ha)	Protein (%)	Test weight (kg/hL)	Screenings (%)	Grade
30kg N/ha early	3.16^{ab}	10.9^{de}	79.9^{a}	5.7^{d}	DR3
30kg N/ha split	3.32^{a}	10.55^{ef}	79.6^{a}	5.9^{d}	DR3
40kg N/ha late	3.33^{a}	9.10^{g}	79.8^{a}	5.9^{d}	FED1
60kg N/ha early	3.08^{bc}	13.20^{c}	78.0^{b}	6.4^{d}	DR3
60kg N/ha split	3.33^{a}	10.85^{e}	79.8^{a}	6.0^{d}	DR3
90kg N/ha early	2.71^{de}	14.13^{bc}	77.2^{bc}	8.4^{bc}	DR3
90kg N/ha split	3.12^{abc}	12.00^{d}	79.4^{a}	5.6^{d}	DR3
120kg N/ha early	2.51^{ef}	14.88^{ab}	76.8^{cd}	9.8^{ab}	DR3
120kg N/ha split	2.93^{cd}	13.24^{c}	77.9^{bc}	7.0^{cd}	DR3
150kg N/ha early	2.45^{f}	15.57^{a}	75.9^{d}	11.7^{a}	FED1
150kg N/ha split	2.91^{cd}	13.68^{c}	78.2^{b}	6.9^{cd}	DR3
Nil	3.34^{a}	9.43^{fg}	80.3^{a}	6.6^{cd}	FED1
Sig. diff.	**<0.001**	**<0.001**	**<0.001**	**<0.001**	
LSD (P=0.05)	**0.222**	**1.134**	**1.120**	**1.913**	
CV%	**5.1**	**6.3**	**1.0**	**18.4**	

Trial 2 – How did N amount and timing affect optimum yield and protein at a low N site?

Treatments with higher N applications early (GS13) produced some of the highest yields on the low N site (Table 4). In contrast to the trial on the high N site, the nil treatment and the late 40kg N/ha were the lowest yielding strategies. With such low soil residual N (30kg N/ha), the later applications in this trial made a small contribution to yield, indicating that N was limiting later in the season, however these were not as efficient as the earlier applications.

The test weights of all treatments in this trial were above the minimum 76kg/hL specification to achieve DR1 and DR2 and did not differ greatly between treatments (Table 4). Given the limited available soil N, early biomass production was not excessive and the haying off effect observed in the trial in the high N site was not as evident in this trial. The 60kg N/ha early and the 120kg N/ha split were the only two treatments to achieve screenings below the minimum 5 per cent required to achieve DR1 and DR2 quality. The highest screenings were observed in treatments toward the extremes of the rates applied early in this trial.

Grain protein content increased with increasing N rates – the 150kg N/ha and 120kg N/ha achieved the highest grain protein content. Most treatments did not meet the minimum 10 per cent protein required to achieve DR3 grade. The only treatments to achieve this were those receiving 75kg N/ha or greater at GS13. This highlights the importance of timing of N applications to ensure adequate rainfall and time for uptake in seasons such as 2019 where residual soil N is low.

Four treatments achieved grain quality specifications above feed: 90kg N/ha early, 120kg N/ha early, 150kg N/ha early and 150kg N/ha split. Given the low soil N available at this site, the major limitation to achieving grade was low protein levels. Of the four treatments with protein levels high enough to achieve DR3 grade, the screenings were too high to make any higher quality grades.

Table 4. Grain yield and quality parameters for N risk management trial (Trial 2, low N site) (north site). Letters indicate significant difference.

Treatment	Yield (t/ha)	Protein (%)	Test weight (kg/hL)	Screenings (%)	Grade
30kg N/ha early	2.96^{bc}	6.43^{d}	79.8^{bcde}	5.4^{cdef}	FED1
30kg N/ha split	2.86^{cd}	6.70^{d}	79.9^{abcd}	6.8^{bcd}	FED1
40kg N/ha late	2.61^{e}	6.55^{d}	78.2^{g}	7.0^{bc}	FED1
60kg N/ha early	3.05^{b}	8.80^{c}	80.3^{abc}	4.1^{f}	FED1
60kg N/ha split	3.08^{ab}	7.23d	80.6^{ab}	5.0^{ef}	FED1
90kg N/ha early	2.79^{d}	10.88^{b}	79.5^{cdef}	5.9^{bcde}	DR3
90kg N/ha split	3.23^{a}	8.40^{c}	80.5^{abc}	5.1^{def}	FED1
120kg N/ha early	2.81^{cd}	12.95^{a}	78.6^{fg}	7.6^{ab}	DR3
120kg N/ha split	3.23^{a}	8.70^{c}	80.8^{a}	5.4^{cdef}	FED1
150kg N/ha early	2.80^{d}	13.53^{a}	78.8^{efg}	6.2^{bcde}	DR3
150kg N/ha split	3.09^{ab}	11.00^{b}	80.1^{abcd}	5.0^{ef}	DR3
Nil	2.53^{e}	6.60^{d}	79.0^{defg}	8.8^{a}	FED1
Sig. diff.	**<0.001**	**<0.001**	**<0.001**	**<0.001**	
LSD (P=0.05)	**0.157**	**0.943**	**1.039**	**1.742**	
CV%	**3.7**	**7.3**	**0.9**	**20.1**	

Trial 3 – Which late N timing rate gave the best yield and protein response at a low N site?

Yields did not differ significantly between strategies, except for the two treatments that had no early N applied (Table 5). Likewise, there was very little variability in test weight, with all treatments well above the minimum required 76kg/hL to achieve grade. Similarly, the screenings were generally below or close to the 5 per cent required to achieve the maximum grade, except for the two treatments with no early N applied.

Due to the limited soil available N, the 80kg N/ha at GS13 application resulted in significantly higher protein than the 40kg N/ha and no early N. All treatments with 80kg N/ha at GS13 had protein above the 10 per cent standard required to achieve DR3 grade, however no treatment had the greater than 11.5 per cent needed to make DR2. The late N fertiliser applications at GS55 had no significant differences grain protein content, potentially due to limited rainfall received following application.

Table 5. Grain yield and quality parameters for N application rate trial (Trial 3, low N site) (north site). Letters indicate significant difference.

Treatment	Yield (t/ha)	Protein (%)	Test weight (kg/hL)	Screenings (%)	Grade
40kg N/ha @ GS13 and 10kg N/ha @ GS55	2.90[ab]	7.95[c]	80.2[abcd]	4.9[b]	FED1
40kg N/ha @ GS13 and 20kg N/ha @ GS55	2.98[a]	8.60[bc]	80.0[bcd]	4.8[b]	FED1
40kg N/ha @ GS13 and 40kg N/ha @ GS55	2.98[a]	9.28[b]	80.3[abc]	4.7[b]	FED1
40kg N/ha @ GS13 and 60kg N/ha @ GS55	3.08[a]	8.35[bc]	81.0[a]	5.0[b]	FED1
40kg N/ha @ GS13 and 80kg N/ha @ GS55	2.99[a]	9.05[b]	80.5[ab]	4.7[b]	FED1
80kg N/ha @ GS13 and 10kg N/ha @ GS55	2.94[a]	11.00[a]	79.4[de]	4.7[b]	DR3
80kg N/ha @ GS13 and 20kg N/ha @ GS55	3.07[a]	10.38[a]	80.3[abcd]	4.7[b]	DR3
80kg N/ha @ GS13 and 40kg N/ha @ GS55	3.07[a]	10.38[a]	80.3[abcd]	4.3[b]	DR3
80kg N/ha @ GS13 and 60kg N/ha @ GS55	2.93[a]	11.10[a]	79.5[cde]	5.0[b]	DR3
80kg N/ha @ GS13 and 80kg N/ha @ GS55	3.06[a]	10.60[a]	79.7[bcde]	4.3[b]	DR3
Nil @ GS13 and 40kg N/ha @ GS55	2.52[c]	6.45[d]	79.0[e]	7.4[a]	FED1
Nil @ GS13 and 80kg N/ha @ GS55	2.66[bc]	6.80[d]	80.1[abcd]	7.3[a]	FED1
Sig. diff.	**<0.001**	**<0.001**	**0.006**	**<0.001**	
LSD (P=0.05)	**0.242**	**1.062**	**0.924**	**1.210**	
CV%	**5.7**	**8.1**	**0.8**	**16.3**	

COMMERCIAL PRACTICE

Durum wheat rotations provide growers with an opportunity to diversify their marketing options which can result in a premium price compared to barley and bread wheat prices. However, receiving a good price for durum relies on producing grain that meets specifications. This trial highlights the difficulties in achieving this and the fine line between having high grain protein, keeping screenings low, and not haying off the crop to maximise yields.

This trial demonstrates that growing durum in paddocks with higher initial soil N levels increases a grower's ability to grow higher protein grain and achieve durum specification. This was demonstrated by nine out of 12 treatments on the high N paddock – compared to four out of 12 treatments on the low N paddock – having protein greater than 10 per cent. Less nitrogen was needed to achieve 13 per cent protein on the high N site, with applications of 90-150kg N/ha required on the low N paddock compared to applications of 30-120kg N/ha on the high N paddock. By growing durum on a high N paddock, the amount of urea required was reduced which lowering input costs and reducing the risk of growing durum.

Low N paddocks can be higher risk for growing durum because they require greater nitrogen inputs to meet durum specification. However, higher N paddocks have a greater risk of haying off in a tight season (low growing season rainfall and/or dry spring) and will still require careful decisions about nitrogen.

Paddock selection for durum is important. This includes understanding previous rotations and their effect on soil N. Soil testing is the only way to assess how much N is in the soil. Soil test results are essential for paddock selection and can guide nitrogen input decisions later in the season, once there is a better understanding of the season as seasonal forecasts become more accurate.

In the low N paddock, 75-150kg N/ha was needed early (GS13) to ensure the grain achieved 10 per cent protein, compared to 15-120kg N/ha in the high N paddock. Durum specification can be achieved in low fertility paddocks however the risk is substantially higher. This is most apparent when top-dressing opportunities are limited, resulting in less efficient urea applications and lower grain protein.

Growing durum in a paddock that has had its soil nitrogen depleted by a cereal rotation in the year prior may not be the best option. Due to its high nitrogen requirements, adding durum into an already cereal intensive rotation could lead to further nitrogen depletion. To maximise paddock selection options for durum, it is important to utilise legume rotations and fertiliser to ensure soil N is not depleted. This also supports work by Murray and Hunt (2019) which highlighted the importance of not depleting soil N reserves.

ON FARM PROFITABILITY

Where market specifications were achieved, durum provided good returns in 2019, even when large amounts of urea were applied to increase protein (Table 6 and Table 7). However, the highest gross margins were low urea treatments (60kg split, 30kg split, 30kg early) grown on the high nitrogen site that achieved D3 grade, with gross margins of $1210-$1266/ha (Table 6). The nitrogen applications in these treatments were small enough to not reduce yield and keep input costs to a minimum, while having high enough protein to make DR3. The highest returns on the low N site were from the treatments that received 90-150kg N/ha to increase protein above 10 per cent, which had gross margins of $918-$1024/ha (Table 7). The returns on the low N site were less because of lower yields and greater input costs (Table7).

Returns fell sharply if not enough or too much urea was applied and the grain did not make DR3 and received a significant price penalty for FED1. The lowest return was from 150kg early on the high N site that hayed off and had a gross margin of $478/ha (Table 6). This highlights the financial importance to of making nitrogen decisions that ensure growers receive a premium for growing durum, while minimising input costs.

It may be possible in a commercial header to reduce screenings to less than the 5 per cent required for DR1 by increasing fan speed to blow some screenings out of the sample. Farmers could also reduce screenings after harvest using a seed cleaner. At an estimated $25/t for grain cleaning to reduce screenings to 4.5%, there is the potential to increase gross margins by $45/ha. This calculation assumes that protein levels did not change following cleaning, however it is possible that protein could decrease when the higher protein screenings are removed.

Table 6. Gross margin analysis for N risk management trial (Trial 1, high N site) (south site). Calculated using $10/ha spreading costs, urea=$540/t + $27/t for freight to Horsham, DR3=$398/t, FED1=$275.

Treatment	Yield (t/ha)	Grade	Income ($/ha)	No. of times spread	Kg urea/ha applied	Treatment costs ($/ha)	Gross Margin ($/ha)
30kg N/ha early	3.2	DR3	1257	1	65	47	1210
30kg N/ha split	3.3	DR3	1323	2	65	57	1266
40kg N/ha late	3.3	FED1	915	1	87	59	855
60kg N/ha early	3.1	DR3	1227	1	130	84	1144
60kg N/ha split	3.3	DR3	1326	2	130	94	1232
90kg N/ha early	2.7	DR3	1079	1	196	121	958
90kg N/ha split	3.1	DR3	1242	2	196	131	1111
120kg N/ha early	2.5	DR3	999	1	261	156	841
120kg N/ha split	2.9	DR3	1164	2	261	170	996
150kg N/ha early	2.5	FED1	674	1	326	195	479
150kg N/ha split	2.9	DR3	1156	2	326	205	951
Nil	3.3	FED1	917	0	0	0	917

Table 7. Gross margin analysis for N risk management trial (low N site) (Trial 2north site). Calculated using $10/ha spreading costs, urea=$540/t + $27/t for freight to Horsham, DR3=$398/t, FED1=$275.

Treatment	Yield (t/ha)	Grade	Income ($/ha)	No. of times spread	Kg urea/ha applied	Treatment costs ($/ha)	Gross Margin ($/ha)
30kg N/ha early	2.9	FED1	813	1	65	47	766
30kg N/ha split	2.9	FED1	786	2	65	57	729
40kg N/ha late	2.6	FED1	718	1	87	59	659
60kg N/ha early	3.1	FED1	839	1	130	84	755
60kg N/ha split	3.1	FED1	847	2	130	94	753
90kg N/ha early	2.8	DR3	1109	1	196	121	988
90kg N/ha split	3.2	FED1	888	2	196	131	757
120kg N/ha early	2.8	DR3	1118	1	261	158	961
120kg N/ha split	3.2	FED1	889	2	261	168	721
150kg N/ha early	2.8	DR3	1114	1	326	195	919
150kg N/ha split	3.1	DR3	1230	2	326	205	1025
Nil	2.5	FED1	696	0	0	0	696

Currently prices for bread wheat (ASW = $331/t, APW = $324/t, AGP =$322/t delivered to Murtoa) are above the price for feed durum. As such, the results from this trial indicate growing bread wheat was a lower risk option in the 2019 season. It is not penalised as heavily for not meeting market specifications and does not require as much urea (Table 8). However, this may not always be the case, such as in 2016 when bread wheat prices were less than $200/t, while durum wheat still received a premium price ($400/t). Growing both bread wheat and durum enables growers to diversify their options and potentially receive higher returns across the whole farm.

Table 8. Gross margin comparison of bread wheat vs durum for N risk management trials (Trials 1 and 2). Calculated using $10/ha spreading costs, urea=$540/t + $27/t for freight to Horsham, DR3=$398/t, FED1=$275, ASW=$331/t, APW=$324/t, AGP=$322/t. Assumes same yield and protein in bread wheat as observed in durum.

Treatment	Treatment Cost ($/ha)	Site	Yield (t/ha)	Durum		Bread Wheat		Difference ($/ha)
				Grade	Gross Margin ($/ha)	Grade	Gross Margin ($/ha)	
30kg N/ha early	47	High N	3.2	DR3	1210	AGP1	1017	193
		Low N	3	FED1	766	AGP1	952	-186
30kg N/ha split	57	High N	3.3	DR3	1266	AGP1	1070	196
		Low N	2.9	FED1	729	AGP1	920.3	-191
40kg N/ha late	59	High N	3.3	FED1	855	AGP1	1071	-216
		Low N	2.6	FED1	659	AGP1	840.4	-182
60kg N/ha early	84	High N	3.1	DR3	1144	AGP1	993	151
		Low N	3.1	FED1	755	ASW1	1009.6	-255
60kg N/ha split	94	High N	3.3	DR3	1232	AGP1	1072.6	159
		Low N	3.1	FED1	753	ASW1	1019.5	-266
Nil	0	High N	3.3	FED1	917	AGP1	1074	-157
		Low N	2.5	FED1	696	AGP1	815	-119

Consider the full management package before deciding to incorporate durum as a part of the rotation to maximise financial returns through diversifying markets. There is a limited number of grain receival centres for durum in the Wimmera, with most being delivered directly to Adelaide. This has implications for logistics and storage at harvest and should be taken into consideration before planting durum. There are also limited registered herbicide options, so durum should be grown on clean paddocks to minimise weed pressure. Durum also has a different disease package to bread wheats, with higher susceptibility to crown rot and better resistance to Septoria tritici blotch than Scepter (Agriculture Victoria 2019).

To have the best chance of producing durum that makes DR1 standard, carefully select weed-free paddocks with high starting soil nitrogen. Feed with urea early, before providing a finishing hit of urea later in the season, if needed. Applying nitrogen to any dryland cereal crop is risky given its reliance on rainfall but making carefully considered decisions supported by soil tests is one way to maximise the chances of producing durum that meets specifications and achieves the best returns.

REFERENCES

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