The influence of fertiliser type, placement and rate on crop establishment and vigour in 2025

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Location – Barunga Gap

Key Messages

- This site was responsive to P fertiliser (DAP) applications when placed with either the seed or deep banded producing an average yield increase of 240 kg/ha (8%) compared to nil fertiliser.
- Application of 100–200 kg/ha DAP, either single or double shoot, was safe when dry sown in both the 2024 and 2025 trials and produced the highest grain yields.
- Crop establishment declined linearly as urea rate increased when applied with the seed, decreasing 2.7 plants/m² for every 10 kg/ha of urea applied.
- Applying ≥50 kg/ha of urea with the seed (single shoot) reduced crop establishment and resulted in an average yield loss of 300 kg/ha (9%). This is consistent with the 2024 trials, where applying 50 kg/ha urea with the seed resulted in a 200 kg/ha (9%) yield reduction.
- Separating urea from the seed by 11–25 mm (double shoot) prevented the yield loss observed when urea was applied with the seed.
- Despite MoP having the highest salt index of all fertilisers used it did not have any negative fertiliser toxicity effects when sown with the seed in 2025. This is in contrast to results from 2024 trials, where the inclusion of MoP reduced grain yields compared to DAP treatments.

Why do the trial?

With the increasing adoption of variable rate (VR) fertiliser applications at seeding it is important to understand the effects that high rates of fertilisers may be having on crop growth. VR fertiliser maps can result in fertiliser being applied to some soil types at much greater than traditional rates. This has the potential to increase the risk of fertiliser toxicity especially if sown single shoot with the seed. On the other hand, in soils with a high phosphorus buffering index (PBI), which have a strong capacity to fix P, the placement of fertiliser becomes critical for root access. In these soils, P can rapidly precipitate with calcium, becoming unavailable to the crop. Therefore, placing P fertiliser near the seed and early root growth is important for establishing the crop.

The potential of fertilisers to cause toxicity is linked to the salt index of individual formulation. Fertilisers with a higher salt index are more likely to cause crops to exhibit toxicity/burning symptoms (Rader et al. 1943). Common fertilisers with lower salt indexes are MAP (30) and DAP (34), compared to urea (75) and MoP (116) with higher salt indexes. Ammonia toxicity is also a cause of crop injury from nitrogen fertilisers and is higher in alkaline soils due to the chemical reactions that convert urea into ammonia being favoured in alkaline soils.

This trial aims to assess the risks associated with fertiliser placement, type and quantities.

How was it done

Barunga Gap rainfall:	Annual 292 mm Growing season 247 mm	**Fertiliser:**	As per treatment. Post emergent urea was applied to treatments to match 64 kg N/ha applied 4th July
		Fertiliser separation:	With Seed – 0 mm Banded shallow – 11 mm Banded – 25 mm
Sowing date:	29th April 2025		
Variety:	Titan barley @ 75 kg/ha		
Row spacing:	250 mm	**Seed spread:**	50 mm
Soil moisture at sowing	Dry	**Seed bed utilisation (SBU):**	20%

The trial was located on a clay loam (Table 1) soil at Barunga Gap, SA. It was a randomised complete block design (RBCD) consisting of 16 treatments with 3 replicates. The plots were 10 m x 1.5 m sown on 2 m centres. Plots were sown using knife points and press wheels. Fertilisers used within the trial were di-ammonium phosphate (DAP), urea and muriate of potash (MoP).

Table 1. Trial site soil characteristics (0-10 cm) for the fertiliser toxicity trial at Barunga Gap in 2025.

Soil property	Units		Comments
Soil Texture		Clay loam	
pH	$CaCl_2$	7.56	Moderately alkaline
	H_2O	7.99	
Organic Carbon	%	1.52	Moderate
Phosphorus Colwell	mg/kg	58	High
PBI		91	Moderate
DGT-P	ug/L	43	Marginal
Colwell K	mg/kg	570	High
Sulfur	mg/kg	8.7	
	kg/ha	11	
Conductivity	EC1:5 dS/m	0.16	Low salinity
	EC_e	1.52	

Measurements throughout the season included establishment counts, GreenSeeker NDVI (23rd July, 4th August and 26th August). The trial was harvested on the 21st of November with grain quality conducted post-harvest.

The cumulative salt index was calculated for each of the treatments (Table 2). Where treatments with more fertiliser have a higher value indicating greater osmotic potential and therefore risk of fertiliser burn. Each fertiliser has a different salt index depending on its properties, calculation in this table are based on values of 34 for DAP, 75 for Urea and 116 for MoP. The salt index does not account for other toxicities such as ammonia, in the case of urea or DAP/MAP.

This trial is a repeat of a similar design that was established on the same soil type in the same paddock using the same methodology in 2024. A selection of results from that trial are also included in this report.

Table 2. Treatments evaluated in the fertiliser toxicity trial at Barunga Gap in 2025.

Trt #	Fertiliser position	DAP rate (kg/ha)	Urea (kg/ha)	MoP (kg/ha)	Cumulative salt index
1	-	-	-	-	-
2	Double shoot – deep band	100	-	-	3400
3		200	-	-	6800
4	Single shoot – with seed	100	-	-	3400
5		200	-	-	6800
6		100	25	-	5275
7		100	50	-	7150
8		100	75	-	9025
9		100	100	-	10900
10		100	50	100	18750
11	Double shoot – deep band	100	25	-	5275
12		100	50	-	7150
13		100	75	-	9025
14		100	100	-	10900
15	Double shoot – low separation	100	50	-	7150
16		100	100	-	10900

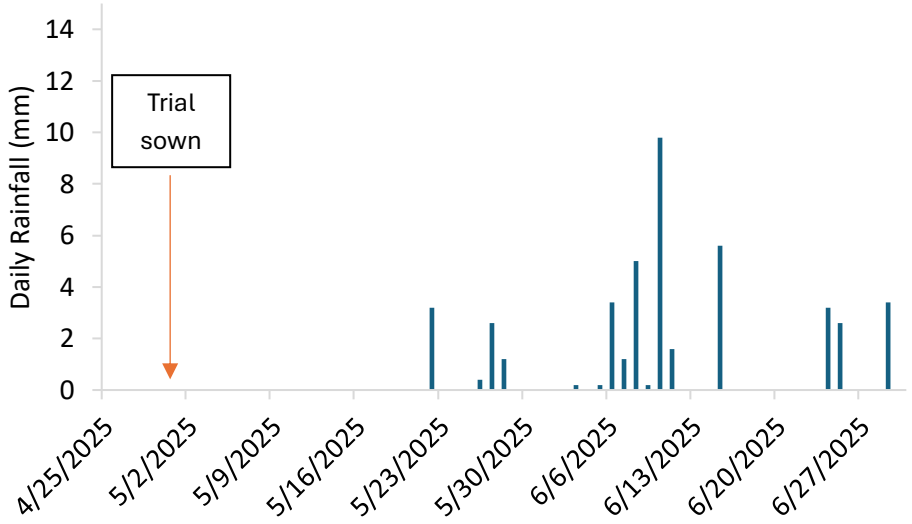


Figure 1. Daily rainfall during crop establishment, at Barunga Gap Mesonet station.

Results and Discussion

It is important to only interpret these results in the context of a calcareous soil with low P availability. Results will likely differ on other soil types.

Crop establishment

The trial was dry sown and remained in dry soil for approximately two weeks before any rainfall. The first rain events, in the 6 weeks post-sowing were small with the largest event of 9.8 mm on the 10th June. These conditions resulted in very slow crop establishment under marginal moisture, which also produces the greatest risk of fertiliser toxicity occurring.

The untreated, which received no fertiliser at seeding had a final crop establishment of 111 plants/m^2 (Table 3). This level of establishment is much less than expected with a target density of 180 plants/m^2, which is likely due to the marginal moisture conditions. Application of DAP did not affect crop establishment at any rate (100 – 200 kg/ha) or placement position in 2025 with all treatments having similar populations to the untreated. Urea was also safe at all rates (25 – 100 kg/ha) when separated from the seed by 11 or 25 mm. However, establishment was reduced when urea was applied with the seed at higher rates. There was a strong negative relationship between urea rate placed with the seed and plant establishment (Figure 1). As the urea rate increases, plant population decreases at a rate of 2.7 plants/m^2 for every 10 kg/ha of urea applied with the seed. Under marginal moisture conditions, these results highlight that urea applied at high rates should be separated from the seed.

The addition of MoP (100 kg/ha) was also included in combination with DAP 100 kg and urea 50 kg/ha (Table 3). This season MoP did not reduce crop establishment further beyond the reduction that was associated with the 50 kg urea/ha. This indicates that the toxicity causing the reduction in plant numbers is likely to be a result of ammonia toxicity rather than the salt index of the product or product combination. This is in contrast with the results from 2024, where MoP was damaging to the crop when applied with the seed, either with or without urea.

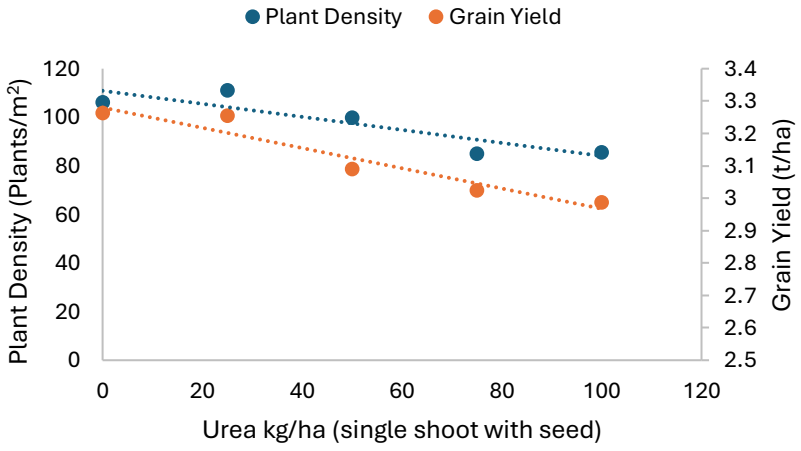


Figure 1. Plant density (plants/m²) and grain yield (t/ha) response to urea rate applied with seed at sowing (single shoot). All rates also had 100kg/ha DAP with the seed and N rate balanced with post emergent urea on 4/7/25. Plant density; y = -0.27x + 111, R^2 = 0.80, grain yield; y = -0.0031x + 3.28, R^2 = 0.92.

Table 3. Effect of fertiliser placement, rate, and product on early crop vigour (NDVI 4th August and 26th August 2025) and grain yield. Fertiliser applied either with seed (single shoot) or banded below seed (double shoot) at varying depths and nutrient rates. Different letters within each column indicate significant differences between treatments (LSD, P < 0.05 or P < 0.10).

Trt #	Fertiliser position	Description	Plants/m²		NDVI 4th August		NDVI 26th August		Grain yield (t/ha)	
1	-	Nil	111	abc	0.183	defg	0.458	f	3.09	def
2	Banded 25mm below seed (double shoot)	100 kg/ha DAP	124	ab	0.197	bcde	0.596	abcd	3.31	abc
3		200 kg/ha DAP	118	abc	0.217	ab	0.623	ab	3.32	abc
4	With seed (single shoot)	100 kg/ha DAP	106	abcd	0.227	a	0.637	a	3.26	abcd
5		200 kg/ha DAP	107	abc	0.200	bcd	0.652	a	3.42	a
6		100 kg/ha DAP + 25 kg/ha Urea	111	abc	0.203	bcd	0.611	abc	3.26	abcd
7		100 kg/ha DAP + 50 kg/ha Urea	100	cde	0.167	g	0.491	ef	3.09	def
8		100 kg/ha DAP + 75 kg/ha Urea	85	e	0.170	fg	0.491	ef	3.03	ef
9		100 kg/ha DAP + 100 kg/ha Urea	86	de	0.167	g	0.454	f	2.99	f
10		100 kg/ha DAP + 100 kg/ha MoP + 50 kg/ha Urea	103	bcde	0.193	cde	0.562	bcd	3.16	cdef
11	Banded 25mm below seed (double shoot)	100 kg/ha DAP + 25 kg/ha Urea	110	abc	0.193	cde	0.544	de	3.18	bcde
12		100 kg/ha DAP + 50 kg/ha Urea	124	a	0.190	cdef	0.549	cde	3.26	abcd
13		100 kg/ha DAP + 75 kg/ha Urea	109	abc	0.177	efg	0.546	cde	3.19	bcde
14		100 kg/ha DAP + 100 kg/ha Urea	104	abcde	0.203	bcd	0.538	de	3.17	bcde
15	Banded 11mm below seed (double shoot)	100 kg/ha DAP + 50 kg/ha Urea	124	ab	0.203	bcd	0.603	abcd	3.32	abc
16		100 kg/ha DAP + 100 kg/ha Urea	114	abc	0.207	abc	0.569	bcd	3.35	ab
		Pr(>F)	0.071		<0.001		<0.001		<0.001	
		LSD (0.05)	-		0.021		0.066		0.18	
		LSD (0.1)	21		-		-		-	

GreenSeeker NDVI and grain yield

DAP

On this P responsive soil, NDVI recorded in early August show greatest responses were achieved from DAP at 100kg/ha placed with the seed or 200kg/ha banded below the seed. Soil available P levels were marginal for this site, with a DGT-P of 43 µg/L (Table 1) and therefore a P fertiliser response was expected. The 100 kg/ha DAP banded further away from the seed (25 mm) did not have the same level of early vigour as banding with the seed, suggesting delayed access to the P fertiliser. By late August, the NDVI data shows that the crop had accessed enough P at all rates and placement positions to maximise crop production without any negative effects.

Grain yields across the trial were generally highest when DAP was applied alone, irrespective of being banded (25 mm) or with the seed. The average grain yields for these treatments were 3.33 t/ha. Similarly high yields were maintained where low rates of urea were combined with DAP with the seed or banded at 11 mm below seed. Strategies to minimise fertiliser toxicity from urea are discussed further below.

Urea

Applying urea with the seed, at rates above 25 kg/ha had a similar effect on NDVI as observed for crop establishment (Table 3). At both NDVI assessment timings these treatments recorded the lowest values. The reduction in plant number and NDVI translated into lower grain yield, averaging 3.04 t/ha which was not significantly different from the control (3.09 t/ha), that received no DAP at seeding and all its N (64kg N/ha) post emergent. The yield decline equates to 3.1kg grain yield lost for every kg urea applied with the seed (Figure 1).

Banding urea below the seed at separations of 11 mm or 25 mm did not affect crop vigour at the early August assessment (Table 3). However, by late August NDVI was reduced where urea had been banded at 25 mm below the seed compared to the no urea at seeding treatments. This was surprising, as the narrower separation (11 mm) would generally be expected to result in greater fertiliser toxicity.

In terms of grain yields, banding urea with narrow separation (11 mm) was as high yield as DAP alone treatments, averaging 3.34 t/ha (Table 3). Where separation was greater (25 mm) grain yields were similarly high yielding at 3.20 t/ha to those with narrower separation.

MoP

Adding 100 kg/ha MoP to DAP + urea increased NDVI at both timings compared with the equivalent treatment without MoP sown with the seed. This result was not expected, given the soil test results indicate high soil potassium levels. While the grain yields were not significantly different for the plus/minus MoP treatments, across the broader results the minus MoP treatment was lowest yielding treatment. The reasons for this observation are not clear.

Grain quality

There were no effects of fertiliser rates or position on grain protein, test weight or screenings which averaged 14.5%, 62.4 kg/hL and 4.4% respectively. Grain retention ranged between 72.5% and 84.3% and was inversely related to grain yield.

Conclusion

Fertiliser toxicity remains a problem for single shoot seeding systems, particularly where higher rates of N are applied with the seed. Recent SAGIT funded studies by Trengove Consulting have found that calcareous soils on the YP and Mid North are highly responsive to P fertiliser, including MAP and DAP and often require rates of up to 200 kg/ha to maximise gross margins. Recent work on potassium fertiliser has also highlighted the responsiveness of some of these soils to MoP. Consequently, increasing rates of fertiliser at seeding also raises the risk of crop injury.

These trials over the last two seasons have demonstrated the benefits of high rates of P fertiliser and that DAP alone, even at high rates applied with the seed has not negatively impacted crop production. This provides growers confidence to continue with higher rates of DAP even where only single shoot systems are available.

However, these trials have shown that applying urea with the seed was damaging in both seasons and MoP applied with the seed was damaging in 2024. The results from urea application are consistent with previous studies. In the 2025 trial, a separation of 25 mm was not enough to fully prevent crop injury, presumably from ammonia toxicity. Caution should be taken when using more than 25 kg urea/ha at seeding in marginal moisture conditions on calcareous soils.

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