Improving sorghum yield and quality in northern NSW

Background

Grain sorghum is the dominant summer crop grown in New South Wales (NSW), with the bulk of the crop grown in northern NSW. Sorghum is primarily used in the domestic intensive livestock industries as a source of starch and protein. There is also an increasing human consumption market.

Growing sorghum enables growers to include a summer crop in predominantly winter cereal-based rotations. This allows the use of herbicides of different modes of action, the ability to spread labour and machinery resource use over both summer and winter and increase cash flow. Sorghum can provide an important disease break for winter cereal crops, and is more drought tolerant than maize.

Sorghum stubble provides ground cover for following crops, which can increase water infiltration and retention and increase nitrogen (N) mineralisation.

Sorghum production in northern NSW occurs in 2 main regions:

1. The Liverpool Plains
2. North West (NW) NSW.

The Liverpool Plains has a long history of reliable, profitable sorghum production with the current research focus on increasing yield and improving resource efficiency, primarily water and N.

North West NSW has a shorter history of sorghum production, especially west of the Newell Highway. This environment is characterised by high summer temperatures, variable rainfall and winter dominant crop rotations. This region's research focus is improving yield, production reliability and increasing water use efficiency (WUE).

Between 2018–2023, the Grains Research Development Corporation (GRDC), The University of Queensland (UQ), NSW Department of Primary Industries and Regional Development (DPIRD) and Queensland Department of Primary Industries (QDPI) partnered to conduct research on sorghum agronomy, including earlier planting times, under the GRDC Optimising Sorghum Agronomy project (UOQ 1808-001RTX).

Optimising sorghum production in variable climates

In 2024–25, GRDC and NSW DPIRD continued their joint investment in sorghum research in northern NSW through a project titled DPI2407-001RTX Improved Yield and Quality Outcomes for Sorghum Growers in Northwestern NSW. The results of this season's experiments, and previous research form the basis of this guide.

Selecting the right paddock – where to use sorghum in the rotation

Most sorghum crops are planted using no-till or minimum-till farming methods following a long-fallow after a winter cereal. Consider the following when selecting your paddock:

1. Soil type

Both dryland and irrigated sorghum is usually grown on heavy clay soils with high water holding capacity (WHC). These soils are capable of supplying water to the plant until flowering in most seasons, with no in-crop rain.

2. Soil water

The sorghum plant has a WUE of ~15 kg/ha/mm of available soil water and in-crop rainfall.

Sorghum should not be planted in a dryland situation unless there is a full soil moisture profile to a depth of 120 cm. The sorghum plant has a water use efficiency (WUE) of ~15 kg/ha/mm of available soil water and in-crop rainfall, this can vary greatly between paddocks and seasons.

3. Weeds

Paddocks with high numbers of grass weeds are not suited to sorghum, as sorghum is also in the grass (Poaceae) family. Select paddocks with low weed burdens, especially if planting early, as many winter weeds will still be able to germinate at the same time as the emerging sorghum. Identify problem paddocks, such as those with high black oat populations, and choose the cleanest paddocks.

4. Disease

Sorghum is a good disease break from many winter crop diseases such as fusarium crown rot and is resistant to the root lesion nematode (RLN), *Pratylenchus thorneii*. However, sorghum is a host of charcoal rot and several other fusarium species which can cause stalk rots and lodging under ideal environmental conditions.

5. Rotation

Sorghum is best placed between 2 winter crops, usually following a wheat or barley crop and before a chickpea crop. A winter cereal provides an even level of stubble cover which aids in building the soil moisture profile.

Sorghum crops can be harvested as early as January in the NW, this allows several months of fallow refill prior to planting, for example, a chickpea crop in May.

Figure 1 Sorghum plants emerging through a heavy wheat stubble.

Measuring soil water for sorghum in your region

Stored soil moisture is one of the main factors setting yield potential in sorghum. Manipulating soil water use to produce the highest WUE and grain yields is key to increasing growers' profit.

The most accurate method for measuring starting soil water is by taking soil cores from the field and using the methods outlined by Dalgliesh and Foale (1998) in the book '*Soil Matters*'. APsoil is also a useful database of crop and soil water characteristics. In the northern region, a range of soils have been characterised for bulk density and crop lower limits for individual sub-regions. These sites and the Soil Matters book can be accessed through APSIM https://www.apsim.info.

Figure 2 Soil coring at Breeza, Liverpool Plains.

Alternatively, estimates of starting soil water can be made through using a push probe or calculating stored soil moisture from fallow rainfall.

Aim to start with a soil profile as close to full to a depth of at least 120 cm before planting sorghum. For most soils in northern NSW this means starting plant available water (PAW) for sorghum of between 150–220 mm.

Before planting sorghum, aim for a close to full soil water profile to a depth of at least 120 cm.

Sorghum soil water use can be manipulated through planting time, row spacing, plant population and hybrid selection.

Early planted sorghum uses less water in the vegetative phase, allowing more soil water to be available for grain fill compared to summer sown sorghum. This is because growing conditions are cooler in the spring, meaning less evaporative demand on the crop.

Narrow row spacings (~50 cm) encourage faster root penetration and use of deeper soil water compared to wide row spacings as demonstrated by research conducted by UQ. Higher plant populations also create increased crop competition and use of soil resources to support growth.

The best time to plant

The ideal time to plant sorghum is always a compromise. Planting should commence when you can meet the highest number of ideal parameters for successful establishment and yield, such as starting soil water and soil temperature. Traditionally sorghum planting starts in mid-September in NW NSW and late October on the Liverpool Plains, when soil temperatures reached 16–18 °C.

Research conducted under the Optimising Sorghum Agronomy project (2018- 2023) showed that early planting sorghum, when soil temperatures are at 13 °C and rising, is a feasible option. This roughly correlates to mid-late August at Mungindi/ Moree and mid-September on the Liverpool Plains, depending on the season.

Soil temperature should be measured at planting depth at 8 am Eastern Standard Time, which is close to the minimum daily soil temperature. A traffic light system can be used to guide when soil temperatures have reached levels suitable for sowing (Figure 3).

Early sorghum planting requires emergence under cooler soil temperatures. This results in slower seedling emergence (up to 14 days) compared to traditional planting dates. Adequate seedbed moisture is needed for longer to ensure seed does not dry out and stop germinating.

Table 1 The pro's and con's of early or late planting times.

Early planting (August/September)		Late planting (December/January)	
Pro's	**Con's**	**Pro's**	**Con's**
Crop should flower before the extreme heat period. **Crop establishment in a period of low Fall Army Worm pressure.**	Soil temperature needs to reach a minimum of 13 °C and rising. False starts can reduce establishment.	Fallow weed control can be completed to ensure weeds are controlled.	Soil temperature can be very high, reducing seed emergence and drying out the seedbed quickly.
Crop yields will be as good or better than planting in summer.	Crop growth and development will be slower, so it takes more days to reach 50% flower.	Seed will rapidly emerge due to very warm soil temperature.	Later to flower, slower maturity and grain dry down. Harvest will be late so grain may need to be dried. Shorter days mean fewer harvest hours.
Earlier harvest, usually from mid-January for a late August planting. This starts the fallow re-fill earlier, allowing the possibility of double cropping.	Paddocks need to be clean of winter weeds, e.g., black oats, as the crop will be emerging when these species can still be germinating.	Opportunity to wait longer for a full soil moisture profile prior to planting.	Harvest can clash with winter planting.
Avoid clashes with winter crop planting & harvest.	High quality seed is needed. Hybrid cold tolerance varies so hybrid choice is important.	Crop growth and development will be quicker. Most hybrids will flower in 65–70 days.	There is no opportunity to double crop, so a long fallow is required to move back into a winter crop.

In the traditional planting window, plants emerge in 5–7 days or as short as 3 days in summer, when soil temperatures are well above 20 °C. The main draw-back of traditional planting times is the increased risk of extreme temperatures during flowering and grain fill that may cause pollen sterility and poor seed set.

It is not recommended to plant during November in most situations as the crop will reach flowering and grain fill in December/January when the risk of heat stress is high. This can reduce head exertion, seed set, crop yield and increase the likelihood of crop failure.

Soil temperature	Action
<10 °C	Stop! It's too early
11–13 °C	Get ready for planting
>13 °C and rising	Start planting

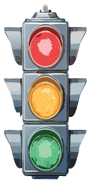


Figure 3 A traffic light system using soil temperature to identify optimum sowing time.

Early planted crops can be ready for harvest from mid-January in the Moree/Mungindi region, and late January on the Liverpool Plains. Summer harvesting allows a shorter harvest period and lower grain moisture contents than harvesting in autumn. Earlier harvest dates also allow more time for fallow soil moisture refill prior to planting a winter crop, such as chickpeas.

Row spacing and plant population

The ideal row spacing is a compromise between machinery available, region, yield potential (based on seasonal forecast, starting soil water and historical performance) and the individual grower's attitude to risk. Match your row spacing to your location, expected yield and the available soil water.

A list of advantages and disadvantages for consideration is included in Table 2.

Precision planters enable less seed to be used, increased seed spacing uniformity and crop maturity. Sorghum can still be established using air seeders accepting these limitations.

Sorghum row spacing and plant population

- Row spacing is a compromise between planting machinery, yield potential (climate and available soil water) and attitude to risk.
- Sorghum can be grown in row spacings from 25–150 cm or using skip configurations.
- Where yield potential is: >4 t/ha, row spacings of 50–100 cm produced the highest yields; <3 t/ha, 100–150 cm and skip configurations are lower risk.
- Plant populations of 4–6 plants/m^2 are the most reliable across environments and yields.

Table 2 Advantages and disadvantages of narrow and wide row spacings.

Narrow rows (50–75 cm)		Wide rows (150 cm or skip configurations)	
Advantages	**Disadvantages**	**Advantages**	**Disadvantages**
Machinery efficiency-using one planter for summer and winter planting.	More crop biomass produced = increased stubble load, which may make sowing the following winter crop more difficult due to planter blockages.	Moisture is conserved in the skip areas for flowering and grain fill. The plant roots are generally unable to reach this area fully before flower.	Weed control is more critical as there is more open space between rows for weeds to grow.
Improved ground cover and crop competition provides better weed control.	Increased risk of the crop using all available soil water prior to flowering.	Wide or skip rows are very reliable. The risk of a total crop failure is low.	Yield is capped in high yielding seasons.

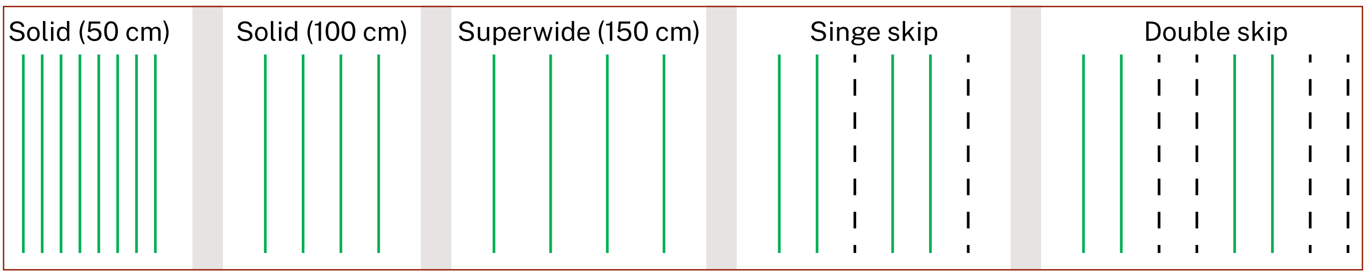


Figure 4 Row spacing options for grain sorghum in northern NSW.

Row spacing and plant population research

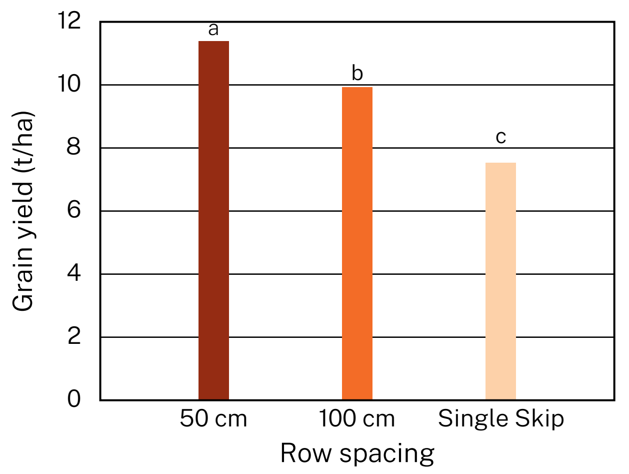
NSW DPIRD and GRDC have been investigating narrow row sorghum (37–50 cm) responses through a series of experiments since 2022. Over 3 seasons (2022–23 to 2024–25), rainfall has been average or above average at most sites, producing yields greater than 4 t/ha. Interactions between row spacing and plant population were studied, comparing 4 and 6 plants/m^2.

Liverpool Plains

In 2024–25, Liverpool Plains experiments were conducted at Breeza, Spring Ridge and Kelvin (north of Gunnedah). The experiments compared 50 cm, 100 cm and single skip (SS) based on 100 cm.

There was a maximum of 35% yield difference between the 50 cm and SS row spacings at Spring Ridge (Figure 5). At most sites, the differences were less, but 50 cm yielded better or equal to the 100 cm row spacing. Both 50 cm and 100 cm always outyielded the SS.

Changing between 4 and 6 plants/m^2 made small or insignificant differences.



Data with the same letter are not significantly different (P<0.05).

Figure 5 Grain yield at 3 row spacings at Spring Ridge, 2024–25.

Moree/Mungindi region

Long-term average grain yields are lower in the Moree/Mungindi region than the Liverpool Plains, however in the last 3 seasons yields have been historically high. All experimental sites had mean yields greater than 4 t/ha.

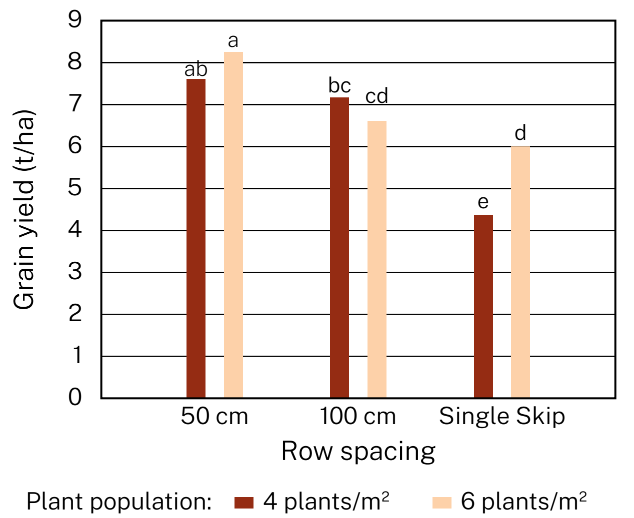
Responses to row spacings were similar to those on the Liverpool Plains. The grain yields from 50 cm have been equal to or better than 100 cm. Single skip commonly yielded less than the 50 cm and 100 cm. Data from the Garah and Moree sites in 2024–25 have shown 50 cm being 0.8–1.0 t/ha higher yielding than the 100 cm, and 2.0–2.7 t/ha better than a SS.

Key findings – row spacing

- The higher the expected yield, the greater the response to using narrow row spacings.
- At harvest there was no difference in finishing soil water under the sorghum plant row between the 50 cm, 100 cm and single skip row configurations.
- Fallow soil cores taken 2–4 months after harvest showed all sites to have refilled to close to the starting PAW with no difference between the row spacings to a depth of 180 cm.

At Mungindi in 2021–22 a 33 cm row spacing was included. The site averaged 8.2 t/ha and there was no yield difference between 33, 50 and 100 cm row spacings.

Interactions between row spacing and plant population often occur, but typically the differences in population are more common in the SS. There was no yield difference between 4 and 6 plants/m^2 in the 50 cm or 100 cm row spacing, but there were yield differences between populations under the SS (Figure 6).



Data with the same letter are not significantly different (P<0.05).

Figure 6 Grain yield at 3 row spacings and 2 plant populations at Garah, 2024–25.

Selecting a hybrid

Selecting the right hybrid depends on both the location and the seasonal forecast. Hybrid characteristics of current commercially available varieties in NSW are listed in Table 3. There are 19 sorghum hybrids available this season offering a mix of traits. It is recommended to select at least 2 hybrids for planting each season.

Figure 7 Sorghum row spacings: (left) 50 cm; (middle) 100 cm; and (right) single skip at Moree, 2024.

Table 3 Sorghum hybrid characteristics, 2025–26.

Hybrid	Maturity	Days to 50% flower	Height	Standability	Sorghum midge rating#	Staygreen	Head type	Tillering	Irrigation suitability
Barenbrug									
Cracka	M	68–78	S–M	5	3	L	SO	M–H	Yes
Liberty White	MS	70–80	MT	4	4	L	SO	H	Yes
Bar Cyclone	MS	70–80	S–M	5	6	M	SO	M–H	Yes
Pacific Seeds									
MR Bazley	MQ	65–75	S–M	5	4	ML	SO	H	Yes, limited
MR Taurus	MQ	66–74	M	5	6	ML	SO	M	Yes
MR Buster	M	69–77	S–M	5	4	ML	SO	M–H	Yes
Sentinel IG*	M	69–77	MT	4	5	L	SC	H	Yes
Resolute	M	70–80	M	5	8+	M	O	M	Yes
Halifax	MS	72–82	M	5	7	M	O	M	Yes
Viper IG*	Q	62–72	S	5	4	ML	SO	M	No
Sterling	MQ	66–74	S–M	8	6	M	SO	M	Yes
Acclaim	M	69–77	M	5	7	M	SO	H	Yes
Maestro	M	69–74	M	8	6	M	SO	M	Yes
Pioneer									
84A66	MQ	66–77	M	5	7	L–M	SO	M	Yes
84A88	MS	70–80	M	5	4	M	O	M	Yes
85G33	MQ	65–76	S–M	5	6	L–M	SO	M–H	Yes
85A14	MS	67–79	M	4	6	M	SO	ML	Yes
84A50	M	67–77	MT	5	8+	M	SC	MH	Yes
84A90	MS	72–82	MT	5	5	M	O	MH	Yes

*Imidazolinone tolerant hybrids.
Maturity: Q – quick; MQ – medium quick; M – medium; MS – medium slow
Days to 50% flower: estimated, will vary based on planting time, location and seasonal conditions.
Height: S –short; M –medium; MT –medium tall
Standability: 1 – poor; 2 – fair; 3 – good; 4 – very good; 5 – excellent.
Staygreen: L – low; M – medium; H – high
Head type: O – open; SO – semi-open; SC – semi compact; C – compact
Tillering: VL – very low; L – low; M – medium; H – high
Irrigation suitability: seed company recommendation
Sorghum midge rating: 1 – susceptible; 2 – low; 4 – moderate; 6 – high; 7 – very high; 8+ – excellent; P – preliminary

Midge rating is the factor by which a hybrid's midge resistance exceeds that of a fully susceptible hybrid (rating 1). For example, if it is cost effective to control 2 midges/head in a rating 1 hybrid, then cost effective control in a rating 7 hybrid occurs when there are 14 midges/head.

This information was kindly supplied by seed companies and is not based on DPIRD data. Only varieties that are commercially available in NSW are listed. Please consult seed companies before final selection of sorghum hybrids for specific markets and for localities.

Nutrition

Sorghum can be an integral rotation crop in northern NSW, but nutrition needs to be optimised to maximise yields. Soil testing is a useful tool to establish nutrient baseline levels and to better understand a site's chemical properties.

Sorghum can use large amounts of N, potassium (K) and zinc (Zn) in high yielding seasons (Table 4). Many soils in northern NSW have large stores of sulfur (S), and sometimes phosphorus (P) and K at depth (>60 cm) which can be accessed by crops. However, these deep soil sources cannot be used until the crop has fully developed root systems, which is often at flowering.

Table 4 Typical nutrient uptake for commonly applied nutrients in sorghum in NSW and Qld.

Nutrient	N	P	K	S	Zn
Uptake (kg/tonne)	30	4.5	16.3	5.2	24

Source: https://www.pacificseeds.com.au/wp-content/uploads/2021/02/GrainSorghumNutritionGuide_Aug2024.pdf

Fertiliser application builds long term soil nutrient levels as well as providing for the sorghum crop when applied pre-plant or at planting.

Data from the Australian Bureau of Statistics on sorghum production in NSW shows that in the 10 year period between 2015–16 and 2023–24 average yields have increased by close to 1.0 t/ha, from 3.9 t/ha to 4.70 t/ha. As such, there is a need to invest in crop nutrition to match the nutrient requirements of these increasing yields.

Managing N to achieve higher yields and maintain positive returns

Strategies to improve targeting of N rates and timing are important to ensure we maximise our yield potential while maintaining crop profitability. Measurement of the amount of post-harvest N in the soil profile also gives us an indication of the N required for the next crop.

Nitrogen fertiliser can be supplied to a sorghum crop either as fertiliser (pre-plant, at planting or in-crop) and through the plant accessing available N in the soil profile. A N budget can be used to estimate the amount of N fertiliser required to grow a sorghum crop. This does not account for mineralisation which occurs during the growing season.

Sorghum removes ~15 kg N/t grain and can take up 60% of the total N required by flag leaf.

Key findings – nitrogen

- Grain yield responses are dependent on starting soil N levels and timely in-crop rainfall.
- Yield responses were not always measured at sites which should have been responsive if rainfall was limiting.
- Yield responses to N applied at sowing, 6- and 10-leaf stage were similar.
- Nil plots used the largest proportion of the total soil N pool.
- Large amounts of N remained at harvest in all plots where N was applied. Up to 50% of the N remained in the mid row area at harvest.
- Maintaining a total N bank of 160–180 kg N/ha is a reliable strategy to optimise yield and profitability.

N budget calculation:

$$\text{N required for crop} = \text{target yield (t/ha)} \times \text{grain protein (\%)} \times 1.6^{*} \times 2^{**}$$

* = protein to N conversion factor
** = N use efficiency factor

Grain sorghum removes ~15 kg N/t of grain, so for example, a 4 t/ha sorghum crop exports on average ~60 kg N/ha. For sorghum a 50% N use efficiency (NUE) is assumed, so the crop requires twice the amount of N to be removed in the grain.

Sorghum N budgets are a guide to the crop's requirements. Grain yields can be higher than an N budget suggests was possible. This could be explained by better NUE than reported in literature for sorghum and/or possibly in-crop N mineralisation rates higher than estimated.

Nitrogen is recommended to be applied pre-plant or at planting in northern NSW as post-emergent applications are considered riskier due to variable in-crop rainfall. Sorghum can take up 60% of its total N requirement by 60 days post-emergence (flag leaf). As such in-crop applications need to be applied early enough for N to be available to the crop prior to peak demand. NSW DPIRD research suggests that in-crop applications up to 10 leaf stage can produce yield responses equivalent to N applied at planting, when application has been followed by effective rainfall to allow movement into the soil for root uptake.

Nitrogen research in 2024–25

NSW DPIRD experiments conducted in 2024–25 measured yield responses from 9 different N strategies, applied as urea at planting and in-crop (6- and 10-leaf stage).

Four sites located at Garah, Millie, Kelvin (Gunnedah) and Spring Ridge tested the response to N treatments of 2 hybrids; Sterling and A88. Nitrogen rates were matched to potential yield based on background N and starting PAW levels (Table 5).

Table 5 Nitrogen application rates and timing applied as urea in 2024/25.

	N rates (kg urea/ha)	
Treatment	Liverpool Plains	Moree & Mungindi
Nil	0	0
Upfront 25%	100	75
Upfront 50%	200	150
Upfront 100%	400	300
6-leaf 100%	400	300
10-leaf 100%	400	300
Upfront 50% + 6-leaf 50%	200 + 200	150 + 150
Upfront 50% + 10-leaf 50%	200 + 200	150 + 150
Upfront 50% + 6-leaf 25% + 10-leaf 25%	200 + 100 + 100	150 + 75 + 75

Plant biomass

Plant biomass supports grain yield potential. In the 2024–25 season, plant biomass was measured in the Sterling plots only, at 6 leaf, 10 leaf and physiological maturity. There was no difference in the amount of biomass produced regardless of the application of N, at any of the 4 sites.

Fertiliser use on sorghum – Moree/Mungindi

Attitudes towards crop nutrition in the northwest region is changing as agronomic practices improve crop reliability and yields. It is still common in this region for dryland sorghum to be planted without N, and sometimes without any starter fertiliser. Historically fertiliser has been applied to the winter cereal crop and residual N was then relied on to supply the following sorghum crop, along with N mineralised during the fallow.

Any N application timing or rate increased sorghum yield compared with the nil treatment at Spring Ridge.

Measured nitrogen responses in northwest NSW over the last 2 seasons have been observed as increased grain protein level and sometimes yield. Identifying the situations where grain yield responses are most likely to occur is critical, since sorghum profitability is based on yield.

Grain yield – Moree/Mungindi

Yield responses vary between sites and seasons. Nitrogen responses can be expected when starting soil N levels are low–medium, as seen at Garah in 2024–25, where starting soil N levels averaged 144 kg N/ha to a depth of 180 cm. These levels were sufficient to support a yield of 4.5 t/ha based on a N budget. Starting soil water levels were 175 mm PAW, or 2/3 full, which is adequate to support yield potentials of >4 t/ha.

Actual harvested yields at Garah were >6 t/ha without any additional N. The application of 75 kg urea/ha (37 kg N/ha) increased yield by 0.6 t/ha. There was no yield difference when more than 75 kg/ha of urea was applied (Figure 8). Nitrogen applied at the 6-leaf or the 10-leaf stage resulted in the same yield as applying N at sowing, either as full or split applications.

Hybrids also differ in their N response, with some hybrids more responsive than others. For example, at Millie, A88 was not responsive to N while in Sterling yields increased, but only in 2 treatments:

1. 150 kg urea/ha upfront (0.86 t/ha increase over nil)
2. 300 kg urea/ha 6-leaf (0.76 t/ha increase over nil) (Figure 9).

Grain protein – Moree/Mungindi

Grain protein levels below 9% in sorghum are an indicator that higher yields would have been possible with additional N. This statement has held true in these experiments. Unfortunately, since there is no price premium for grain protein, the industry focus remains on yield as its profit driver.

When protein levels have been less than 9%, grain yield increases have been measured, such as at Garah where the nil treatment grain protein was 7.83% (Figure 10). Millie had higher protein levels with all treatments, >9%, and few yield responses.

Sorghum protein levels also vary between hybrids. In 2024–25 Sterling had consistently higher grain protein than A88.

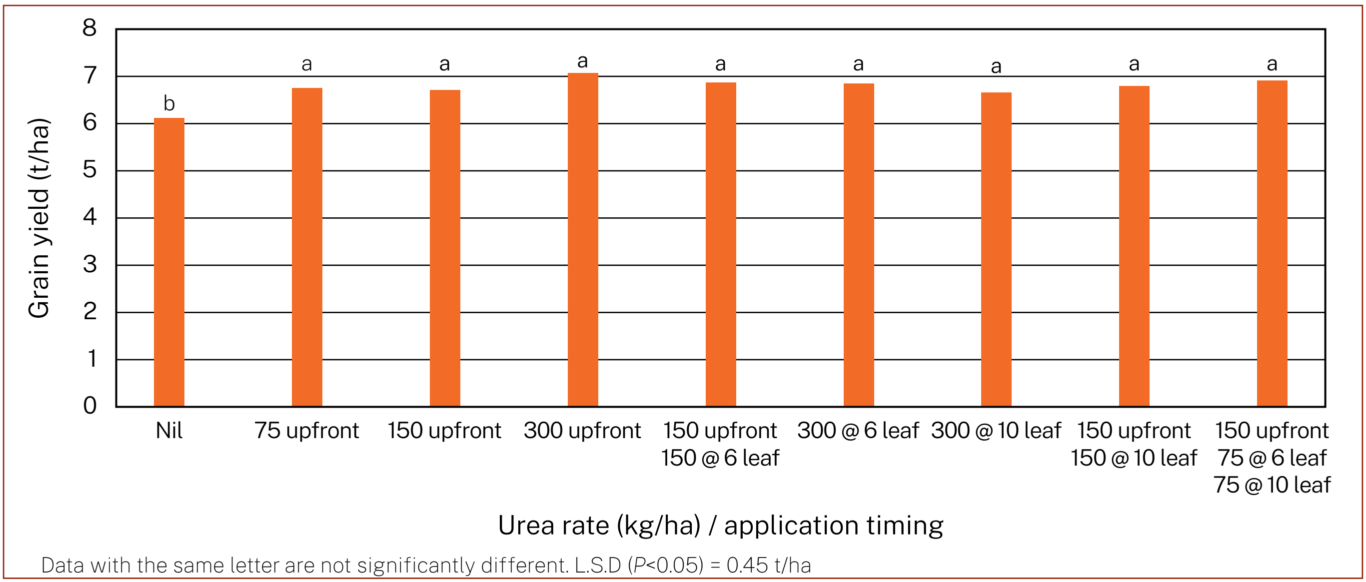


Figure 8 Grain yield response to various rates and timings of urea application at Garah, 2024–25.

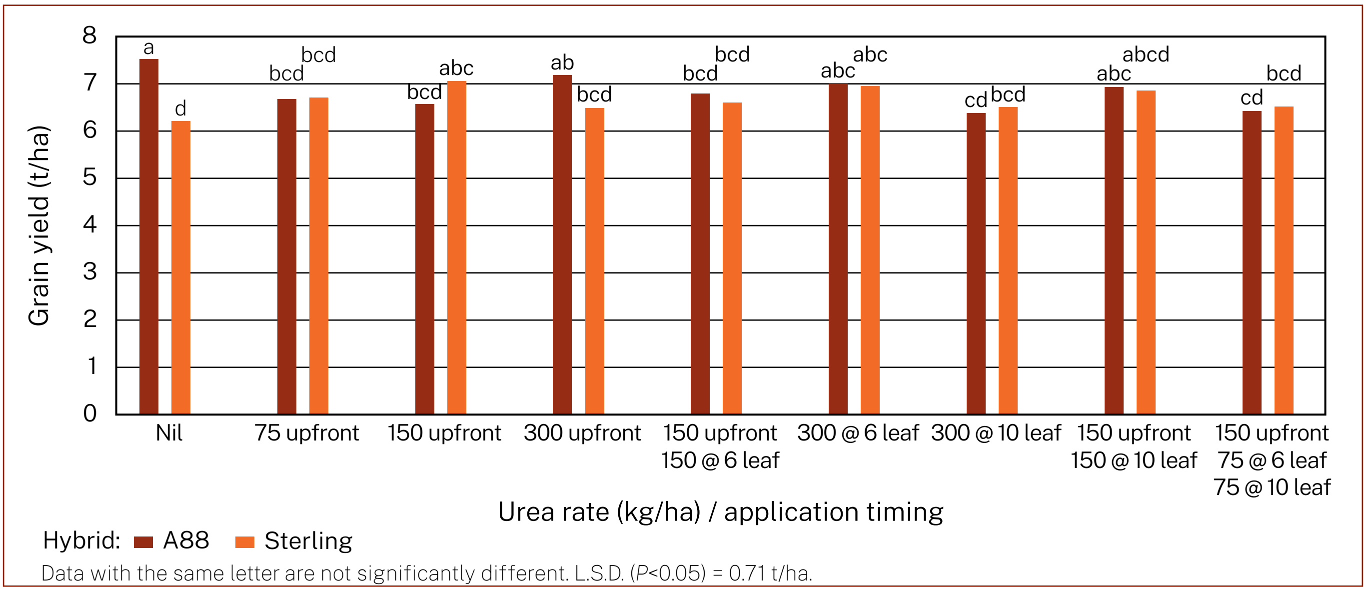


Figure 9 Grain yield response to various rates and timings of urea application at Millie, 2024–25.

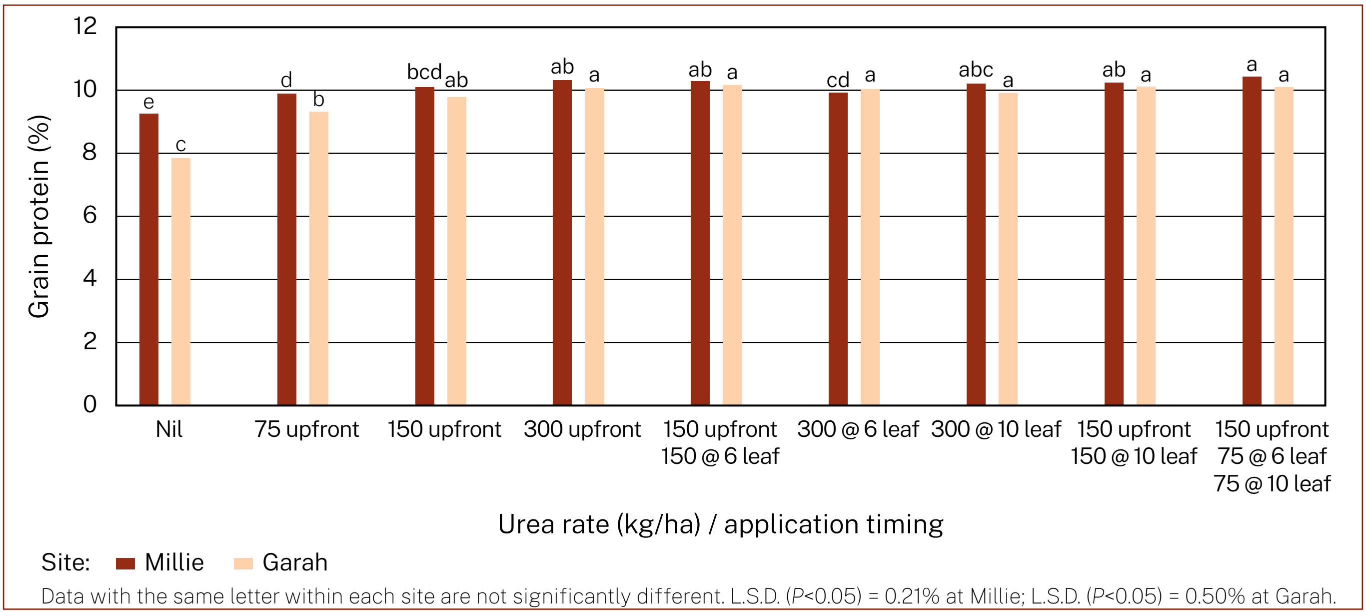


Figure 10 Grain protein response to various rates and timings of urea application at Millie and Garah, 2024–25.

Fertiliser use on sorghum – Liverpool Plains

Sorghum crops on the Liverpool Plains are commonly supplied with 100–150 kg N/ha. Application is generally via spreading urea either pre-sow or at sowing to aid in managing farm logistics, as spreading fertiliser is much quicker than drilling at planting time.

Average grain yields have continued to rise, with a run of favourable seasons on the plains. This has led to a trend in lower grain protein levels. A survey of 29 sorghum crops grown on the Liverpool Plains between 2022–25 found 62% of crops had grain protein <9%.

> Sorghum grain protein levels below 9% are an indicator that higher yields would have been possible with additional N.

Grain yield – Liverpool Plains

In 2024–25 the Liverpool Plains experiments had average yields of 7.14 t/ha at Kelvin (Gunnedah) and 9.00 t/ha at Spring Ridge. However, N responses were very different between the 2 sites.

Starting soil N levels were similar with Kelvin (143 kg/ha) and Spring Ridge (160 kg/ha) to 180 cm, but in-crop rainfall differed. The Kelvin site missed critical, in-crop rainfall in November and as a result there was no increase in yields from N application. Spring Ridge, in comparison, had more than double the in-crop rainfall (384 mm versus 175 mm) and a yield response to N of up to 1.65 t/ha.

Any N application timing or rate increased yields compared with the nil treatment at Spring Ridge (Figure 11).

The key to N responses is identifying responsive sites and receiving effective in-crop rainfall.

Grain protein – Liverpool Plains

Grain protein levels are responsive to N application, even without yield increases. The protein increase has often been around 1.0–1.5% (Figure 12).

Nitrogen return on investment

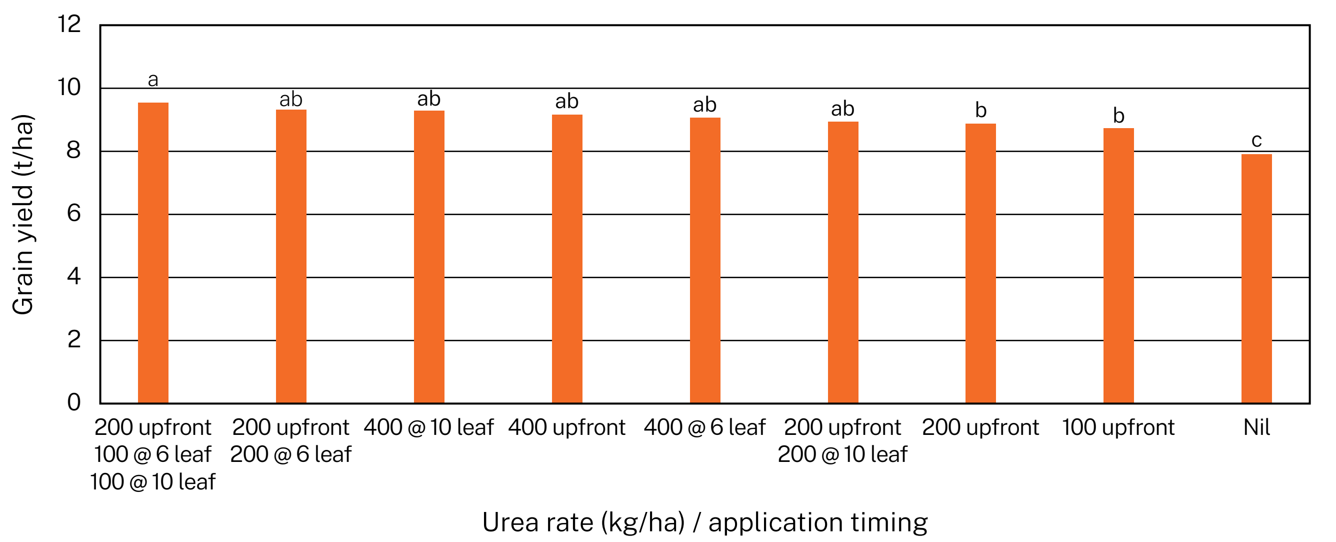
The value of applying N varies between sites and seasons. Using a combination of fertiliser price, application costs and grain prices a return on investment (ROI) for applying N can be calculated.

In this guide we used a sorghum grain price of $320/t, spreading costs of $15/ha and urea price of $1000/t, to calculate the ROI for the treatments used in the experiments.

At Garah, a positive ROI was gained from the upfront 75 kg/ha ($108/ha) and upfront 150 kg/ha ($23/ha) applications of urea only (Figure 13). All other treatments returned a negative ROI as the cost of urea outweighed the value of increased yields.

Returns on investment should be balanced over the cropping sequence. Residual soil N needs to be accounted for to ensure input costs are calculated correctly for a sorghum gross margin and to account for residual N levels that can be used by the next crop.

At Spring Ridge the highest ROI ($153/ha) was from the single application of 100 kg urea/ha (Figure 14). The next best ROI ($92/ha) was from 200 kg urea/ha. These were not the highest yielding treatments, however they only required one spreading pass at a cost of $15/ha as opposed to the 3-way split treatment which had the highest yield, but also 3 times the spreading costs. This illustrates that the ROI on split applications is likely to be lower due to higher application costs.



Data with the same letter are not significantly different. L.S.D. (P<0.05) = 0.65 t/ha.

Figure 11 Grain yield response to various rates and timings of urea application at Spring Ridge, 2024–25.

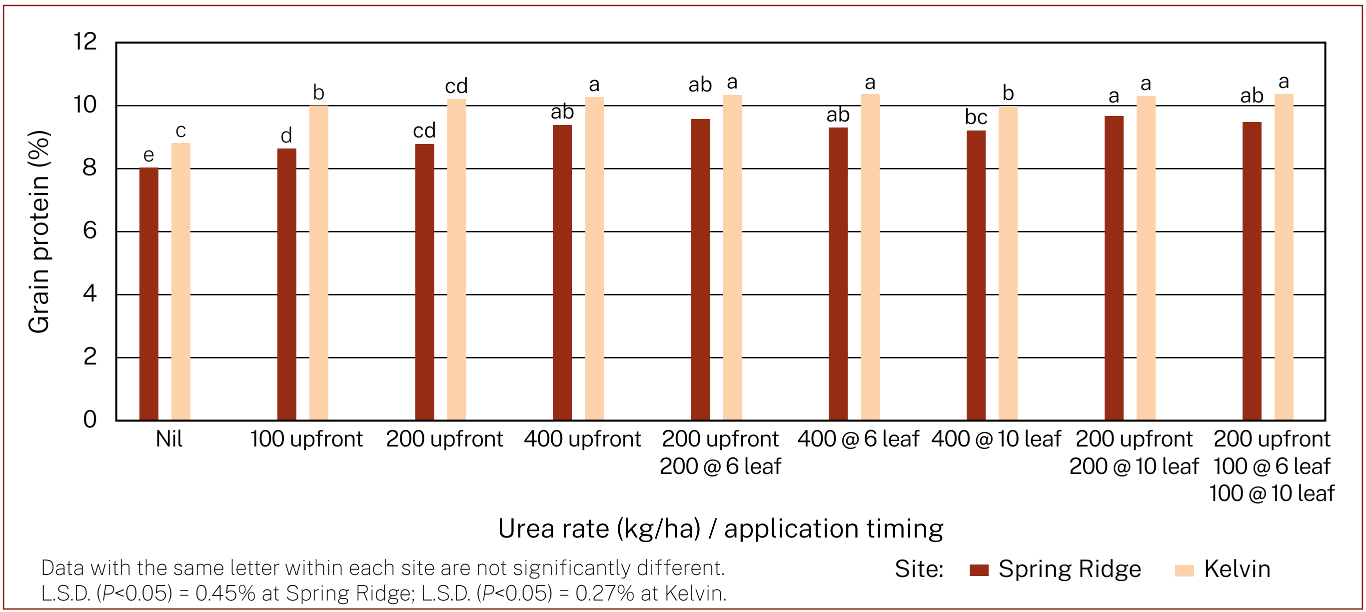


Figure 12 Grain protein response to various rates and timings of urea application at Spring Ridge and Kelvin, 2024–25.

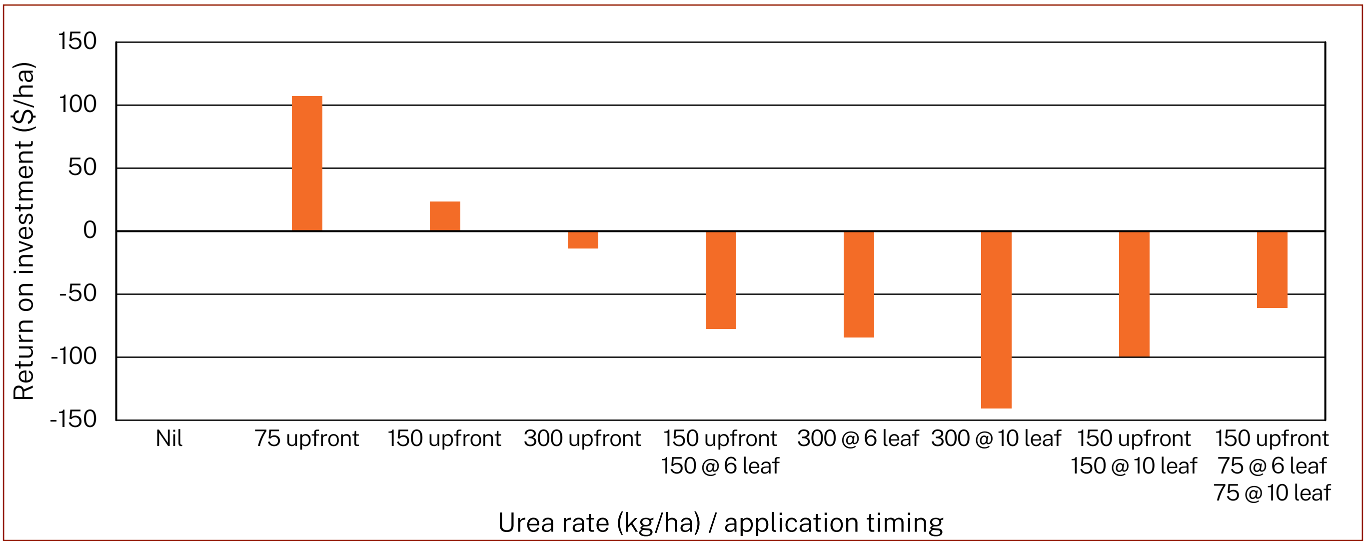


Figure 13 Return on investment from various rates and timings of urea application compared to the nil treatment at Garah, 2024–25.

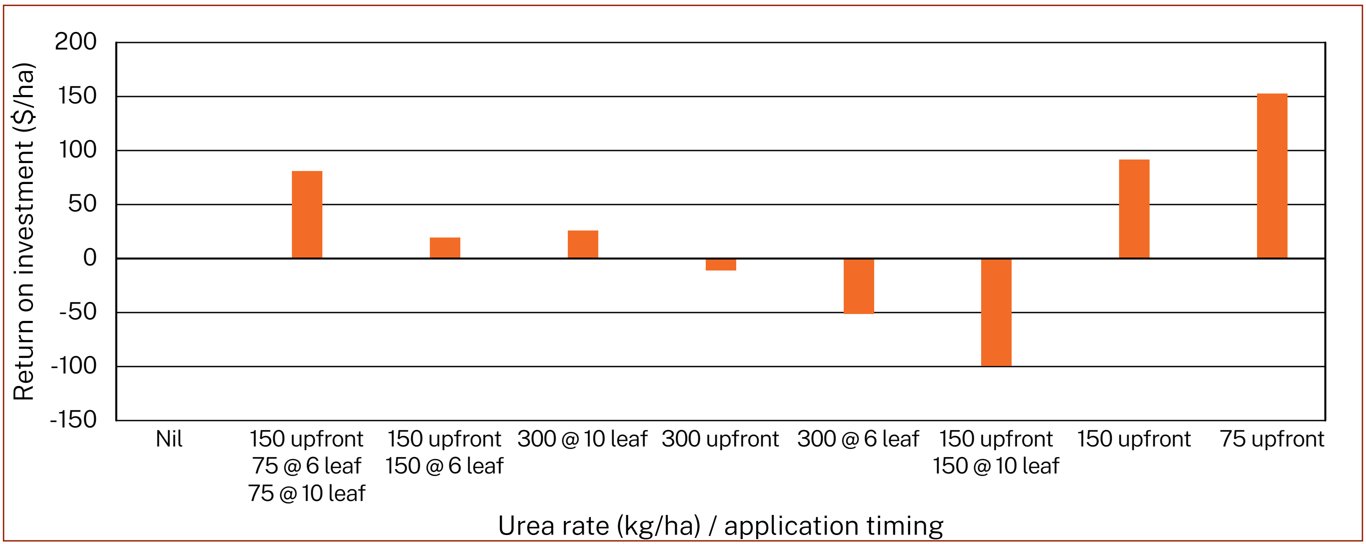


Figure 14 Return on investment from various rates and timings of urea application compared to the nil treatment at Spring Ridge, 2024–25.

Residual nitrogen at harvest

Soil N (0–180 cm) was assessed at harvest on the row (under the sorghum plant), 25 cm off the plant row, and 50 cm off the plant row (mid row) in the nil and upfront 100% treatments in each experiment. The sorghum crop used N in the 0–60 cm layer of soil and the trend showed more N to be used under the crop row (Figure 15).

At Millie, the nil plots used ~85% of the N available from under the plant row (0–60 cm) and this declined to 77% in the mid row. By contrast in the upfront 300 kg/ha treatment, spread at planting, N usage declined from 75% under the row to 47% in the mid row (Figure 15a).

At Garah, 55% of the N was used in the nil plots and closer to 65% of the upfront 300 kg/ha in the top 60 cm of soil (Figure 15b).

At Spring Ridge N use was uniform across the 3 Nil soil sampling points: on row, 25 cm off and 50 cm off the plant row (Figure 16a), most likely due to excellent in-crop rainfall helping to distribute the N.

Kelvin, which received much less in-crop rainfall, had a more usual N distribution with more remaining the further away from the plant row the core was taken (Figure 16b).

In all 2024–25 experiments >50% of applied N was measured in the soil at harvest.

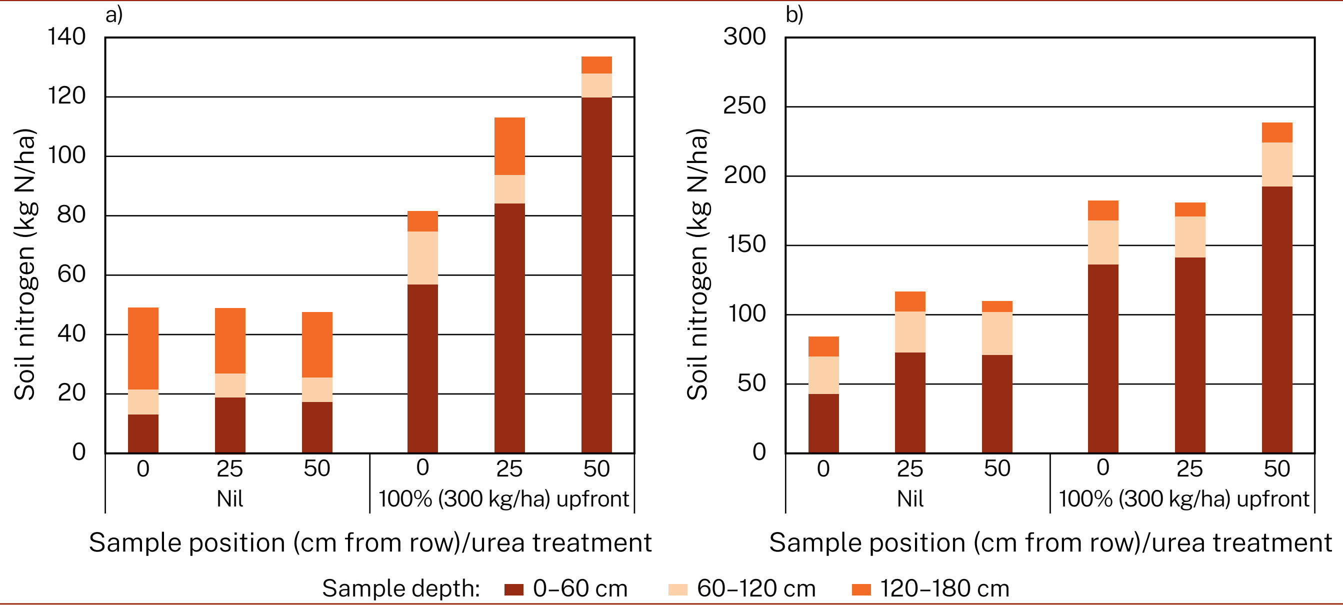


Figure 15 Soil nitrogen levels at harvest for each 60 cm depth segment to 180 cm in the nil and upfront 300 kg/ha treatments of Sterling sorghum at a) Millie and b) Garah, 2024–25.

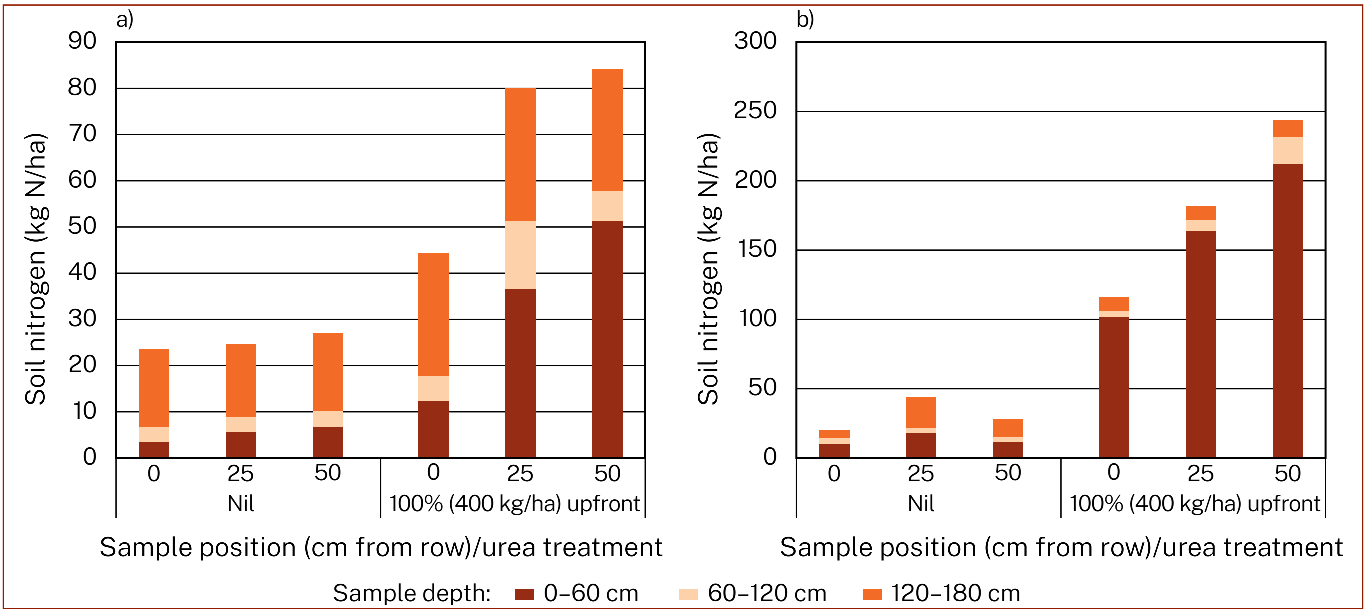


Figure 16 Soil nitrogen levels at harvest for each 60 cm depth segment to 180 cm in the nil and upfront 400 kg/ha treatments of Sterling sorghum at a) Spring Ridge and b) Kelvin, 2024–25.

At all sites, a large amount of N (>50%) was measured in the soil at harvest. As such, sorghum crops do not have the ability to take up and utilise all the N when it is applied at sowing or in-crop.

The N remaining in the soil is, however, an asset for following crops. For example, 100 kg N/ha remaining in the top 60 cm soil = $217/ha of N at urea prices of $1000/tonne.

Phosphorus, sulfur and potassium nutrition

After several high yielding seasons, the timing seemed appropriate to begin testing for responses to phosphorus (P), sulfur (S) and potassium (K).

Phosphorus

Phosphorus uptake peaks at early flowering, with 45% of the total P demand taken up during booting and flowering.

Sorghum is more tolerant of low soil P levels than wheat or barley as it is more efficient at extracting P from the soil profile due to its deep, fibrous root system.

Phosphorus is vital for the early development of sorghum, especially when sown into cold soils. It helps promote early root formation and increases WUE. Early planting can result in slow root development and lead to earlier planted crops displaying visual symptoms of P deficiency (Figure 17). Low soil P can cause reduced plant biomass as well as delays in flowering time.

Sorghum P uptake occurs rapidly in early growth stages with approximately 30% of uptake occurring by 40 days post sowing.

Figure 17 Phosphorus deficiency in seedling sorghum.

Sulfur

Sulfur responses have been more commonplace in Queensland than NSW. In many soils in northern NSW, levels of S are borderline. However, gypsum at depth can supply large amounts of S to the crop once the root system is established. Where soil tests show S levels are <4 mg/kg there may be a response to S application (Figure 18).

Figure 18 Pale yellow sorghum leaf on the top with low sulfur versus a healthy leaf on the bottom. Photo: N Grundon.

Potassium

Potassium deficiency is rarely seen in sorghum (Figure 19), however, it should be monitored as successive high yielding crops remove significant amounts of K. Potassium fertilisers need to be side banded or applied pre-plant as applying K based fertilisers can cause emergence issues due to fertiliser burn if applied with the seed.

Half the K requirement is taken up during the vegetative period prior to floral initiation. K is important for winter hardiness and is said to increase disease resistance.

Figure 19 Upper and lower leaves with leaf margins affected by potassium deficiency. Photo: N Grundon.

Phosphorus, sulfur and potassium research 2024–25

Four experiments focusing on P, S and K nutrition were conducted in 2024–25. These experiments were located near Moree, Millie, Kelvin and Spring Ridge.

These experiments were designed to evaluate responses from upfront granular fertiliser applied at sowing and in-crop foliar applications at 6 leaf and booting, of individual and combined P, S and K treatments. The sowing application rates were 20 kg/ha P, 20 kg/ha S and 50 kg/ha K, to ensure adequate rates of the key nutrients for early plant growth and development (Table 6).

Phosphorus

The P applied was triple super, side banded, approximately 5 cm from the seed row. Triple super is highly water soluble. Soil moisture dissolves the fertiliser granules, making the soil solution highly acidic. The product should be placed away from the seed row when applied at high rates to avoid seedling burn and potential reduction in plant establishment.

Sulfur

The S treatments were applied with the seed. The S fertiliser was GreenCal, which was applied at a rate of 110 kg/ha (20 kg S/ha).

Half the K requirement is taken up during the vegetative period prior to floral initiation. K is important for winter hardiness and is said to increase disease resistance.

Potassium

The soil applied K was muriate of potash, side banded at 100 kg/ha and placed ~5 cm from the seed row due to the high salt content of the product that could cause fertiliser burn and a subsequent reduction in establishment.

Foliar treatments

The foliar treatments were:

- potassium nitrate (N 4; K 11)
- PK 10-25 (P 10; K 25): a foliar product, predominantly applied to cotton to maintain adequate levels of P and K during crop growth. Can be applied to the crop or direct to the soil
- CaP (P 13.8; Ca 4.2): a liquid, trace element product primarily used in horticultural crops.

Table 6 Phosphorus, sulfur and potassium treatments.

Treatment	Treatment	Product rate	Application method and timing
Nil	Nil	-	-
P:20	Triple super	100 kg/ha	Side banded as granular at sowing
S:20	GreenCal	110 kg/ha	Applied with the seed at sowing
K:50	Muriate of potash	101 kg/ha	Side banded at sowing
P20:S20	Triple super + GreenCal	P: 100 kg/ha S: 110 kg/ha	P side banded, S applied with the seed, both in granular form at sowing
P20:K50	Triple super + muriate of potash	P: 100 kg/ha K: 101 kg/ha	Side banded as granular at sowing
S20:K50	GreenCal + Muriate of potash	S: 110 kg/ha K: 101 kg/ha	K side banded, S applied with the seed, both in granular form at sowing
P20:S20:K50	Triple super + GreenCal + muriate of potash	P: 100 kg/ha S: 110 kg/ha K: 101 kg/ha	K and P side banded, S applied with the seed, both in granular form at sowing
9	Potassium nitrate	30 L/ha	Foliar application at booting
10	PK 10-25	5 L/ha	Foliar application at 6-leaf stage
11	PK 10-25 @ 6 leaf & boot	5 L/ha & 5 L/ha	Foliar application at 6-leaf and booting stage.
12	CaP Foliar	10 L/ha	Foliar application at booting

Plant biomass responses to phosphorus, sulfur and potassium

Plant biomass supports grain yield potential. In the 2024–25 seasons trials, plant biomass was measured in all plots at the start of flowering and physiological maturity. There was no difference in the amount of biomass produced regardless of the treatment.

Plant biomass at the start of flowering was close to 40% of the final biomass produced at each site (Figure 20).

Grain yield responses to phosphorus, sulfur and potassium

Grain yields were high at all sites, with yields ranging from 4.88 t/ha at Moree to 6.25 t/ha at Millie, 6.77 t/ha at Kelvin and 8.75 t/ha at Spring Ridge (Figure 20). There was no yield difference measured between any of the treatments at any site in 2024–25.

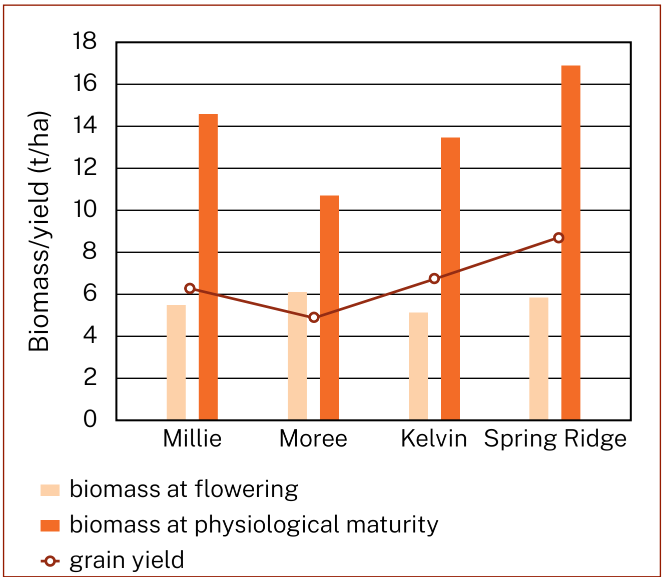


Figure 20 Plant biomass at flowering and physiological maturity and grain yield in northern NSW.

Further information

For more information on hybrid comparative performance, refer to NVT online | GRDC (grdc.com.au) (https://nvt.grdc.com.au/trial-results/?year=2024&crop=Sorghum&date_range=0101,3112)

For the latest midge ratings, refer to the NVT disease ratings NVT Disease Ratings | GRDC (grdc.com.au) (https://nvt.grdc.com.au/nvt-disease-ratings?crop=25&state=NSW)

Optimising sorghum production in variable climates | NSW DPIRD (www.dpi.nsw.gov.au/agriculture/broadacre-crops/summer-crops/sorghum,-maize-and-other-summer-cereals/optimising-sorghum-production-in-variable-climates)

Early planting grain sorghum in northern NSW Early planting grain sorghum in northern NSW 2021 | NSW DPIRD (https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/1343982/Early-planting-grain-sorghum-in-northern-NSW.pdf)

Early sowing sorghum, with Loretta Serafin | NSW DPIRD Podcast (https://soundcloud.com/user-889937785/earlysowing-sorghum-with-loretta-serafin)

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