

# Early sown sorghum and water productivity on the Liverpool Plains, NSW

*Loretta Serafin<sup>1</sup>, Malem McLeod<sup>1</sup>, Mark Hellyer<sup>1</sup>, Paul Murphy<sup>1</sup>, Delphi Ramsden<sup>1</sup>,  
Daniel Rodriguez<sup>2</sup>, Joe Eyre<sup>2</sup>, Michael Mumford<sup>2</sup> and Darren Aisthorpe<sup>3</sup>*

<sup>1</sup> NSW Department of Primary Industries, Tamworth

<sup>2</sup> Queensland Department of Agriculture and Fisheries, Toowoomba

<sup>3</sup> QAAFI, University of Queensland, Gatton

<sup>4</sup> Queensland Department of Agriculture and Fisheries, Emerald

## Key words

Sorghum, early sowing, water use, water productivity

## GRDC code

UOQ 1808-001RTX Optimising sorghum agronomy

## Take home message

- The potential benefits of early sown sorghum include but are not limited to:
  - Improved grain yields due to reduced risk of crop exposure to heat and moisture stresses at flowering and grainfill periods
  - Increased water productivity (kg grain sorghum/ha/mm water used)
  - Improved grain quality as demonstrated by reduced screenings when compared to the normal sowing time and
  - Increased chance of double cropping with a winter crop as the harvesting time is moved forward
- Planting into cold soils e.g. ~ 12° C, can reduce establishment of early sown sorghum
- The grain yield of early sown sorghum is comparable or above grain yields of normal sowing times
- Early sowing alters the crop growth pattern, water use and time to flowering, leading to reduced risk of crop exposure to heat and moisture stress at critical stages (i.e. flowering and grain fill periods)
- Early sowing improved water productivity of dryland sorghum in the 2018-19 season. But in the 2019-20 season, water productivity declined as plant population increased for both very early (winter) and early (spring) sowing times. This suggests the need for a longer-term evaluation into the effect of sowing times and plant density on water productivity
- Additional trial data generated in 2020-21 and to be collected in 2021-22 will improve understanding of crop water productivity in early sowing for a range of hybrids.

## Across sites analysis 2018-2020

The optimising sorghum yield project has just completed its third year of trials across seven production zones from Emerald, central QLD, to the Darling and Western downs in southern QLD, and Mungindi, Moree and the Liverpool Plains in NSW.

The focus of the trial series is on adaptation of sorghum to early sowing and managing the associated risks and benefits of this practice. These trials used three sowing times (very early/TOS1, early/TOS2 and a normal planting time/TOS3); four plant populations (3,6,9 and 12 plants/m<sup>2</sup>), and a range of commercial sorghum hybrids (a minimum of 6) at each site in each season. The sowing dates for TOS1,2 and 3 are determined by the soil temperature (~12°C for TOS1; 14°C for TOS2, and 16-18°C for TOS3).

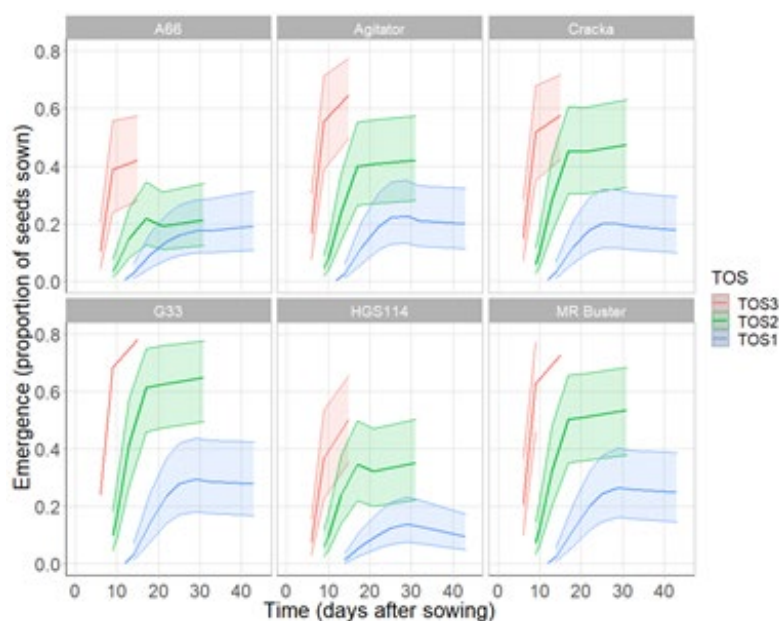
The results of 2018-19 and 2019-20 trials from 14 sites show consistent and interesting responses across regions as summarised below:

The main driver for uniform crop emergence is the quality of seed batch (germination and vigour) (irrespective of the hybrid). This presents a management challenge, as there is no commercial seed testing method available for seed companies or farmers to reliably predict the likely seed establishment rate.

Early sowing (at ~ 12°C soil temperature) has been possible with little to no frost damage for 2018-2020 seasons. The reduced seed emergence and establishment with earlier sowing (Figure 1) means more seed must be sown to achieve the same plant population as for a normal sowing time.

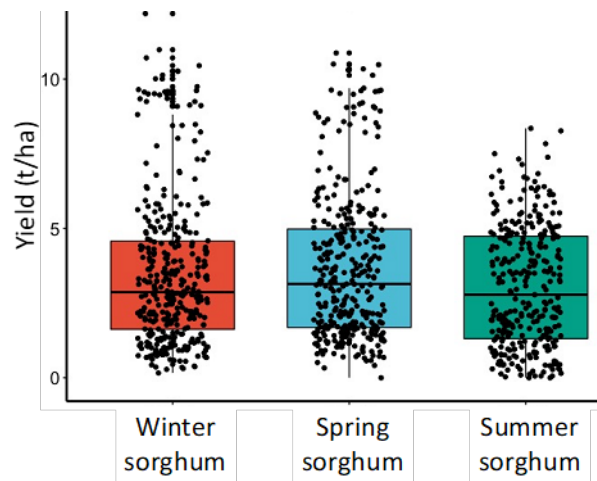
The early sown crops grow under cooler temperatures and a lower photothermal quotient. This has resulted in more tillers and longer vegetative and panicle growth stages. As a result, it takes more days to reach 50% flowering when compared to a normal sowing time.

However, potential yield loss from a longer vegetative duration is offset by a reduced risk of heat and water stress at flowering, which occurred earlier in December instead of late December / early January at Breeza.



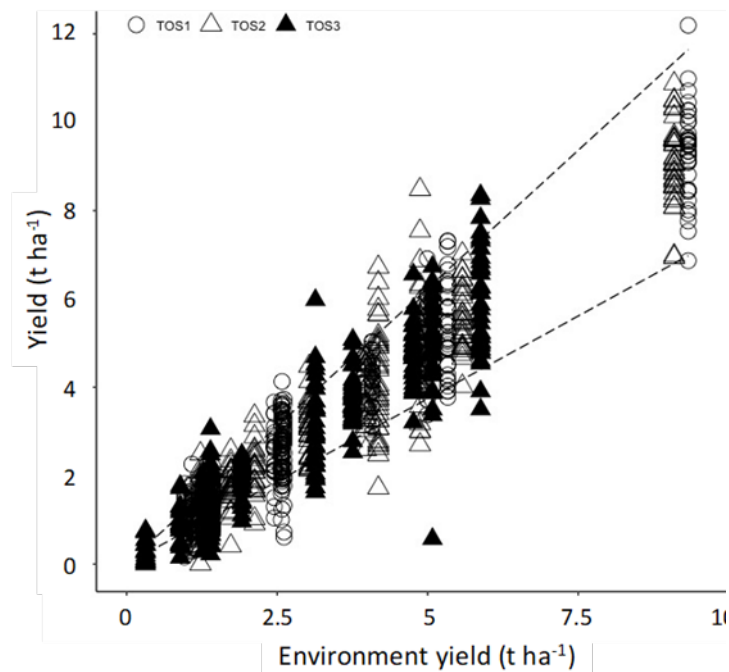
**Figure 1.** Predicted means (lines) and 95% confidence interval (shading) for the effect of time of sowing (TOS) on sorghum emergence dynamics (Nangwee, 2020-21 data set)

Grain yield of the very early and early sowing times were similar or higher than the normal sowing times (Figure 2). The added benefit of these earlier sowing times is the increased chance of double cropping with a winter crop as the harvesting time is moved forward.



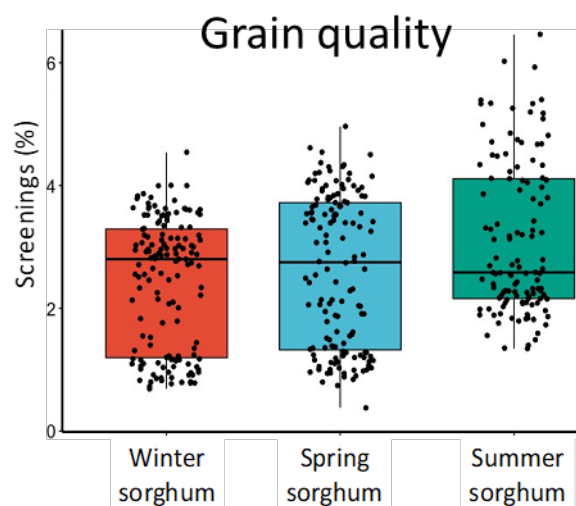
**Figure 2.** Treatment yields for the sowing times in winter (TOS 1), spring (TOS 2) and summer (TOS 3)

There was a large variation in yield measured (~66%) across all treatment combinations; hybrids (G), planting times and plant populations (M) (n=3,072), indicating that informing optimum Genetics x Management for each system is critical to maximising crop performance (Figure 3).



**Figure 3.** Grain yield as a function of the environment yield (average treatment yields for each site x season x time of sowing) for 2018-2020 with different time of sowing. Open circle indicates very early (TOS 1), open triangles early (TOS2) and closed triangle normal (TOS3).

Additional benefits from early sowing include improved grain quality as indicated by less screenings (Figure 4).



**Figure 4.** Observed screenings for sowing times in winter (TOS 1), spring (TOS 2) and summer (TOS 3).

#### Breeza 2020-21 dryland trial results

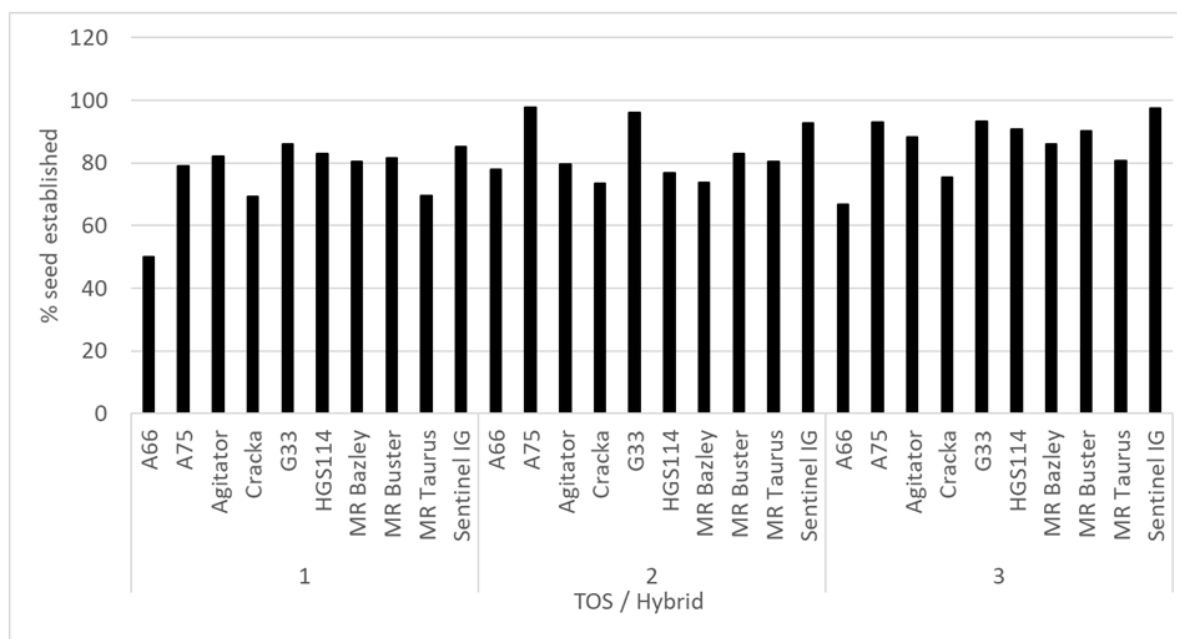
The 2020-21 dryland trials were conducted at the Liverpool Plains Field Station (Breeza), using three sowing times, four plant populations and 10 hybrids (Table 1).

**Table 1.** Sowing dates, target populations and hybrids for the trials in 2020/21 season at Breeza.

Sowing date	Soil temperature (7 days post sowing at 8 am)	Target plant population (plants/m <sup>2</sup> )	Hybrids
TOS 1 - 16 <sup>th</sup> Sep	16.2	3	A66, A75, Agitator, Cracka, G33, HGS114, MR Taurus, MR Bazley, MR Buster, Sentinel IG
TOS 2 - 6 <sup>th</sup> Oct	19.4	6	
TOS 3 - 3 <sup>rd</sup> Nov	20.1	9	
		12	

#### Plant establishment

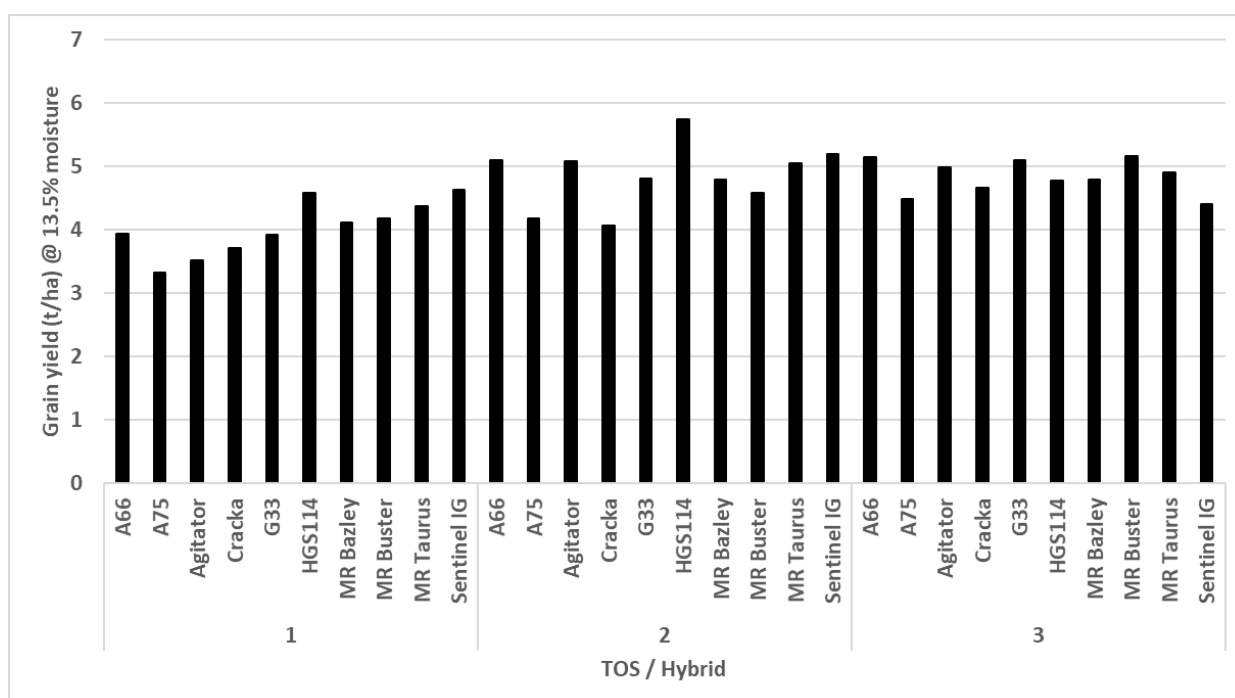
Plant establishment percentages were good across all sowing times (>60%) (Figure 5) at 22—29 DAS. This is most likely due to the unusually warm soil temperatures (i.e. averaged 16.2 °C for the 7 days post sowing for TOS1). Significant differences occurred between hybrids, which was correlated to the seed germination and vigour (data not shown).



**Figure 5.** Plant establishment (% of seeds emerged from seeds sown) at 29 DAS -TOS 1, 22 DAS -TOS 2 & 3.

### Grain yield

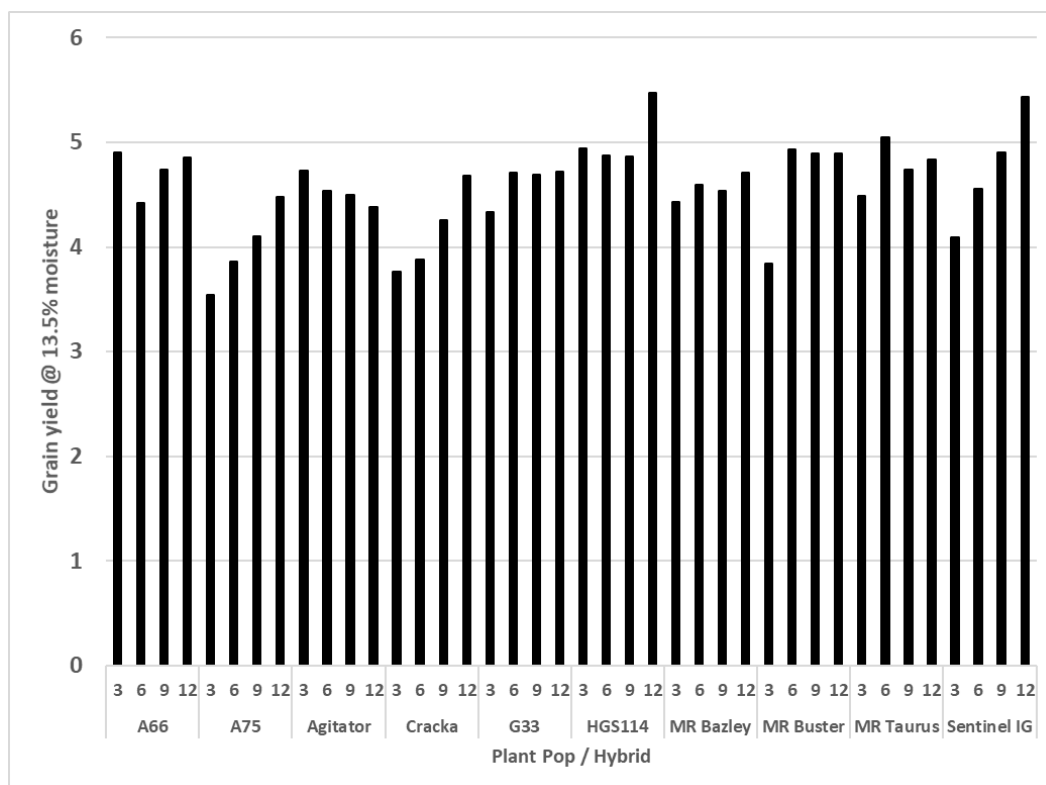
The average grain yield of the site was 4.57 t/ha (at 13.5% moisture). Time of sowing alone did not have a significant impact on yield but there was an interaction with hybrids. Yields for most hybrids were higher from the early (TOS 2) and normal sowing times (TOS 3), but this pattern was not consistent for all hybrids. For example, Sentinel IG produced higher yields from TOS 1 and 2, compared to the normal sowing time (TOS3) (Figure 6).



**Figure 6.** Grain yields at 13.5% moisture content across TOS and Hybrid at Breeza 2020-21 season.

There was also a significant interaction between hybrids and plant population.

Grain yields increased as plant population increased, with an interaction between hybrids. The highest yielding treatments were HGS114 and Sentinel IG at 12 plants/m<sup>2</sup> and MR Taurus at 6 plants/m<sup>2</sup> (Figure 7).



**Figure 7.** Grain yields at 13.5% moisture content across hybrid and plant population

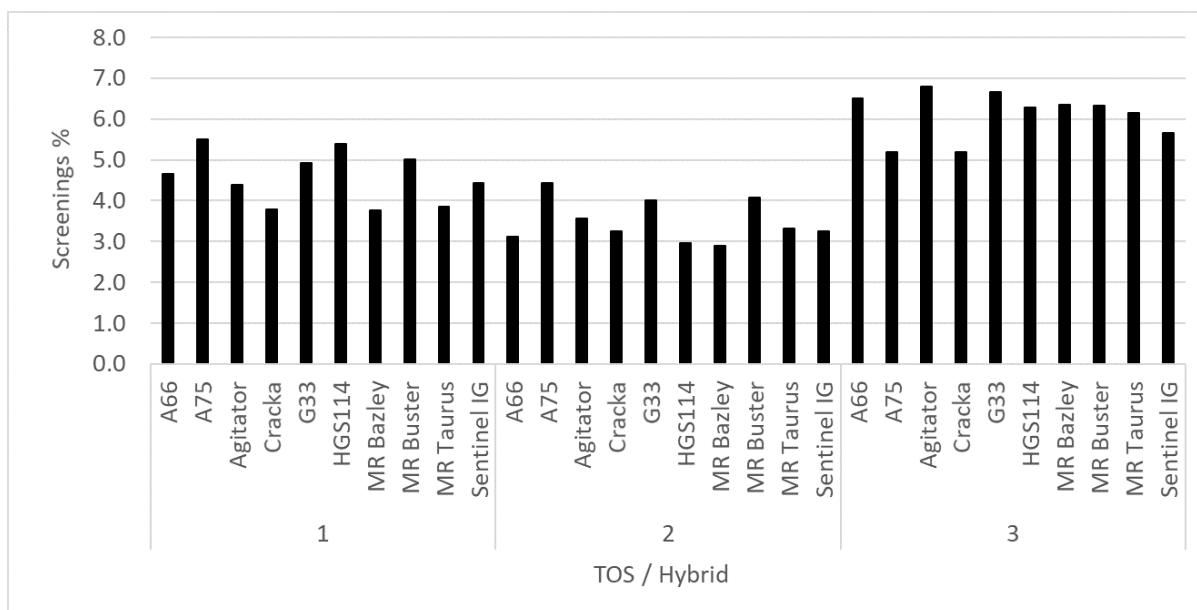
### Grain quality

The average grain protein contents for this season were 11.9% and it was affected by plant population and TOS (Table 2). Within TOS 1, grain protein contents declined as plant population increased, but differences were not always significant (Table 2). In contrast there was no difference in protein for populations in TOS 2.

**Table 2.** Time of sowing (TOS) and target plant population effect on grain protein %

TOS	Population (plants/m <sup>2</sup> )			
	3	6	9	12
1	12.21% <sub>a</sub>	12.18% <sub>abc</sub>	11.93% <sub>de</sub>	11.78% <sub>e</sub>
2	11.87% <sub>e</sub>	11.7% <sub>e</sub>	11.81% <sub>de</sub>	11.72% <sub>e</sub>
3	11.94% <sub>acde</sub>	11.88% <sub>de</sub>	12.07% <sub>abcd</sub>	12.21% <sub>ab</sub>

The average screenings were 4.7% across all treatments which is within the limits for the receival standard 'Sorghum 1'. There was an interaction between TOS and hybrid for screenings (Figure 8). Screenings in general were higher in TOS 3 and was particularly higher for hybrids Agitator, MR Bazley and Sentinel IG. MR Buster was the only hybrid with no significant impact on screenings between sowing times



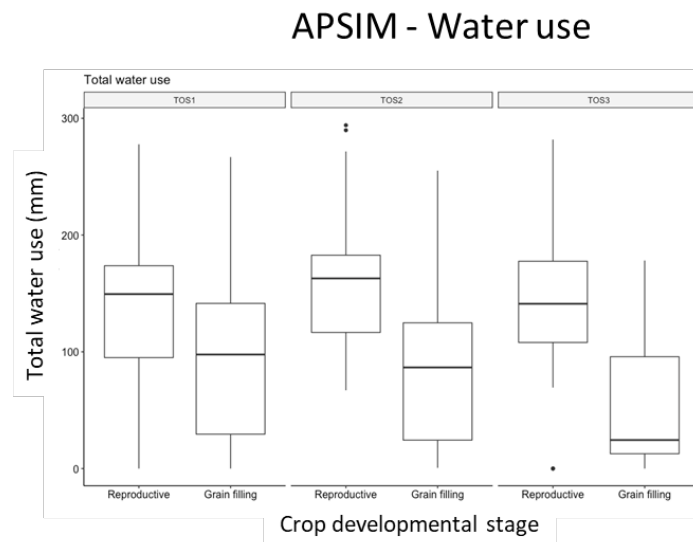
**Figure 8.** Screenings % at Breeza 20-21 across times of sowing and hybrid

Grain test weights were on average 67 kg/hL, which was below the 71 kg/hL Grain Trade Australia receival standard for Sorghum 1, but acceptable for Sorghum 2 (>62 kg/hL). Like screenings, there was a significant interaction between hybrid and TOS (data not shown). Test weights were higher from TOS 2.

### Water productivity in early sown sorghum

Water use and more specifically, efficient use of water by the crops or 'water productivity', are critical to sorghum crop success in the western zone. The higher water productivity, the more kilograms of grain is produced for each millimetre of water used by the crop.

Sowing sorghum into cooler soil affects plant development by extending the vegetative phase or number of growing days required to reach flowering. However, as temperatures are lower during this vegetative phase (August – October), the crop water demand/use is also lower, leaving more available water in the soil profile for the grain fill period. APSIM simulations of total crop water use for 8 trial sites between central QLD and the Liverpool Plains NSW in the 2018-19 season (Figure 9), showed increased water use during the grain filling stage in the early sown sorghum (TOS 1 and TOS2), compared to the normal sowing time (TOS 3).



**Figure 9.** APSIM simulated water use (mm) between floral initiation and flowering (reproductive) and after flowering (grain filling) periods for all the treatments and sites trialled during the first season of trials.

#### Water productivity of dryland and irrigated sorghum under three sowing times at Breeza in the 2018-20 seasons

In 2018-19 and 2020-21 trials seasons, crop water use was monitored from dryland and irrigated treatments that also incorporated plant population density in two sorghum hybrids, at Breeza, Liverpool Plains NSW. To assess water use patterns across the three sowing times, profile soil water was monitored to a depth of 180 cm using a neutron moisture meter (NMM), from selected plots at strategic times of crop development. NMM readings were taken from all MR Buster and Agitator plots with populations of 30 and 120 plants/m<sup>2</sup>, as well from the MR Buster 6 plants/m<sup>2</sup> plots to provide a commercial standard comparison. These measurements were conducted at emergence, 6 leaf, flag leaf, flowering and physiological maturity.

The NMM readings were used to estimate total crop water use (in mm), water use efficiency which is expressed as water productivity, and biomass water ratio expressed as transpiration efficiency. Water productivity (WP) is the measure of the amount of grain yield produced per mm of water used (kg grain/ha/mm water). The water biomass ratio (BWR) or transpiration efficiency is used to measure the amount of above ground biomass produced per unit of water used (kg dry matter/ha/mm water).

#### Dryland trials

For the 2018-19 season, the water productivity of dryland sorghum was higher in TOS 1 and TOS 2 when crops were sown into cooler soil temperatures (11.2 and 10.3 °C, respectively) compared to the normal sowing time (TOS 3, sown at soil temperature of 18.8 °C) (Table 3). There was no difference in water productivity between plant populations or hybrids in this season or significant interaction effects.

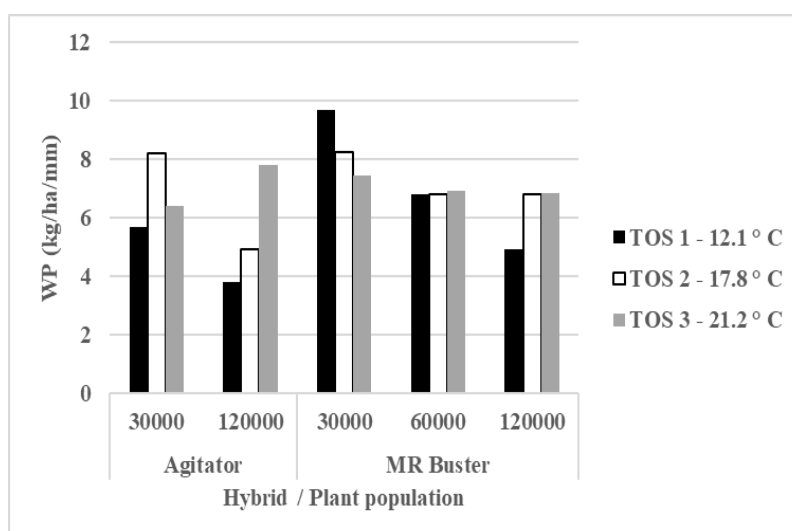


**Table 3.** Water productivity (kg/ha/mm) of dryland sorghum grown at Breeza 2018-19 (averaged across populations and hybrids).

Sowing time	Water productivity (kg biomass/ha/mm)
Very early (TOS 1)	6.51 <sub>a</sub>
Early (TOS 2)	5.68 <sub>a</sub>
Normal (TOS 3)	2.44 <sub>b</sub>

L.S.D: 2.25

In the 2019-20 season, there was an interaction between sowing time and plant population. Water productivity declined as plant population increased for both TOS 1 and 2, (soil temperature at sowing of 12.1 and 17.8 °C, respectively) (Figure 10). There was no difference in water productivity between populations for TOS 3 which was sown into higher soil temperatures (21.2 °C). MR Buster had a higher water productivity than Agitator in this season.



**Figure 10.** Water productivity response to varying sowing time at Breeza for 2019-20 season (LSD = 2.61 kg/ha/mm)

### ***Irrigated trial***

The irrigated trial was sown on 2 m raised beds and was flood irrigated pre-sowing. Three in-crop irrigations were applied at; 6 leaf stage, flag leaf emergence and flowering. The very early and early sowing times used significantly more water than the normal sowing time, by 100-110 mm, leading to a higher biomass water ratio on later sowing (Table 4). There was no interaction effect between treatments on water use and biomass water ratio. These patterns of water use or biomass water ratio did not translate into water productivity. The average water productivity of irrigated sorghum (8.8 kg/ha/mm) was higher than the dryland sorghum, but was not significantly different between time of sowing, hybrid or plant populations.

**Table 4.** Water use, biomass water ratio (BWR) across sowing times at Breeza irrigated trial in 2018-19

Sowing time	Total water use (mm)	Biomass water ratio (kg DM/mm)
Very early (TOS 1) - 3 <sup>rd</sup> Sept	576 <sub>a</sub>	14.83
Early (TOS 2) – 18 <sup>th</sup> Sept	589 <sub>a</sub>	17.99
Normal (TOS 3) – 16 <sup>th</sup> Oct	475 <sub>b</sub>	21.71

Plant population had a significant impact on total water use, with higher populations using more water (516 mm for 3 plants/m<sup>2</sup> and 578 mm for 12 plants/ m<sup>2</sup>). The biomass water ratio of MR Buster (19.23 kg DM/mm), was also higher than Agitator (17.12 kg DM/mm). However, the water productivity between these hybrids was not different.

### Conclusions

The potential benefits of early sown sorghum include but are not limited to improved grain yield due to reduced risks of crop exposure to heat and moisture stresses at flowering and grain fill periods; increased water productivity (kg grain sorghum/mm water used); improved grain quality as indicated by reduced screenings; and increased chance of double cropping with a winter crop as the harvesting time is moved forward.

Early sown sorghum could reduce establishment when planted into cold soils (e.g. ~ 12° C). But increasing planting population can help offset this impact. When considering planting population, it is important to note that there is a high correlation between establishment and seed lot quality.

The variable responses of water productivity over 2018-19 and 2019-20 seasons, suggest the need for a longer-term evaluation into the effect of sowing times and plant density on water productivity. To improve understanding of water productivity of early sown sorghum, additional data has been collected in the 2020-21 season and will continue in the 2021-2022 season.

### Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the author would like to thank them for their continued support.

The support of Andrew Earle “Bullawarrie” Mungindi, Tom & Melissa Greentree “Morialta” Mungindi, Michael Brosnan, Alexandra McDonnell and the team at B&W Rural Mungindi, Geoff Manchee & JR McDonald “Bogamildi” Moree, and Rob Holmes, Alex Trindall and Liz McDonald, HMAg is gratefully acknowledged.

We would also like to acknowledge Lucy Loveridge, Bronwyn Clarendon, Scott Goodworth, Wayne McPherson, Mathew Dunn, Simon Tydd, NSW DPI for technical support in the conduct of the trials and data collection.

### Contact details

Loretta Serafin  
NSW Department of Primary Industries  
4 Marsden Park Road, Calala  
Ph: 0427 311 819  
Email: Loretta.serafin@dpi.nsw.gov.au