Early planting sorghum—Emerald

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Research Question: *Can sowing sorghum early avoid heat and water stress in cropping systems in Central Queensland?*

Key findings

1. Preliminary results show better yields and slightly improved grain quality from the earliest sowing date (25 July).
2. There was a difference in plant phenology and physiology between the two early sowing dates (25 July and 16 August).

Background

Water stress and extreme heat at flowering are common abiotic stresses limiting yield in cereal crop production across the northern grains region. Early sown sorghum crops in Central Queensland (CQ) have shown high yield potentials, but with an increase in perceived risk due to water/heat stress at flowering or frost damage at emergence. The Grains Research and Development Corporation (GRDC) research project, Optimising Sorghum Agronomy (UOQ 1808-001RTX), led by the Queensland Alliance for Agriculture and Food Innovation (QAAFI) in partnership with the Queensland Department of Agriculture and Fisheries (DAF) and New South Wales Department of Primary Industries (DPI NSW), looks to challenge these perceptions. This project will test the ability of sorghum to germinate and withstand cold temperatures during early growth stages in order to reduce heat stress during flowering and grain fill.

The early sowing dates were selected using *CliMate* to target a suitable flowering temperature window; maximum temperatures <35 °C to minimise heat stress and minimum temperatures >10 °C to reduce the chance of ergot infection. Planting dates were determined so head emergence began mid-September (Figure 1).

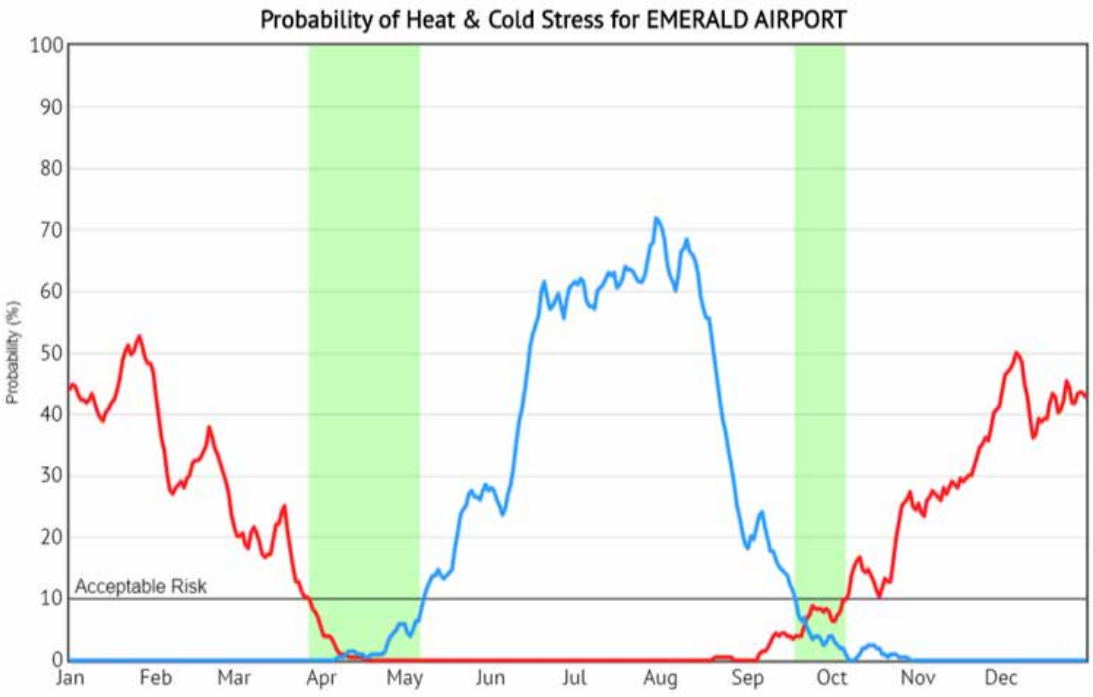

Figure 1. *CliMate* data showing the likelihood of a temperature 'sweet spot' for flowering and grain fill. The green bars on the graph indicate, based on historical climate data back to 1990, there was a less than 1 in 10 year chance of receiving temperatures below 10 °C and above 35 °C in those periods.

What was done

The trial was planted on 1 m solid row spacing, using a tyned parallelogram with vSet® precision seeding system on the Emerald Research Facility. Eight hybrids with a range of maturities were planted across three times of sowing (TOS) at four populations ranging from 3-12 plants/m^2. Early sowing dates were 25 July 2018 and16 August 2018 with a third 'traditional' sowing date of 17 January 2019 (Table 1).

Table 1. Treatments and sowing dates for the three times of sowing in the 2018/19 trial.

Hybrids used
A66 (Pioneer)
Agitator (Radical Seeds)
Cracka (NuSeed)
G33 (Pioneer)
HGS-114 (Heritage Seeds)
MR Apollo (Pacific Seeds)
MR Buster (Pacific Seeds)
MR Taurus (Pacific Seeds)
Target populations (plants/ha)
30,000
60,000
90,000
120,000
Time of sowing (TOS) dates
TOS 1: 25 July 2018
TOS 2: 16 August 2018
TOS 3: 17 January 2019*

*** limited data available at time of publication.**

Results

Establishment

Soil temperatures at TOS 1 (17.8 °C) and TOS 2 (17.3 °C) were already above the industry-recommend minimum planting temperature of 16 °C. As a result, good establishment was achieved (Figure 2) with minimal post emergent mortalities, despite minimum air temperatures regularly dropping to below 5 °C between 25 July (TOS 1) and 24 August.

Conversely, establishment was challenging for TOS 3 (Figure 2). The field received 25 mm of rain on 22 December 2018 and an additional 60 mm of overhead irrigation prior to planting, however soil temperature often exceeded 40 °C in the first 10 days post-plant (Table 2) resulting in lower establishment.

Table 2. Soil temperature readings (°C) for the first 10 days after TOS 3, 17 January 2019 (measured using a probe placed in the trench at seed depth).

	@ 8am	min	max	Daily avg.
17/01/2019	29.5	29.3	41.3	31.3
18/01/2019	28.8	27.1	36.9	31.2
19/01/2019	28.3	26.5	38.1	31.6
20/01/2019	28.1	26.6	39.2	32.1
21/01/2019	28.9	27.1	38.5	31.8
22/01/2019	28.6	27.2	39.4	32.2
23/01/2019	29.2	26.7	42	33.1
24/01/2019	29.9	28.1	42.2	33.7
25/01/2019	30.2	27.8	41.4	33.5
26/01/2019	30.7	28.6	40.1	33.1
27/01/2019	30.1	27.9	41.3	33.2

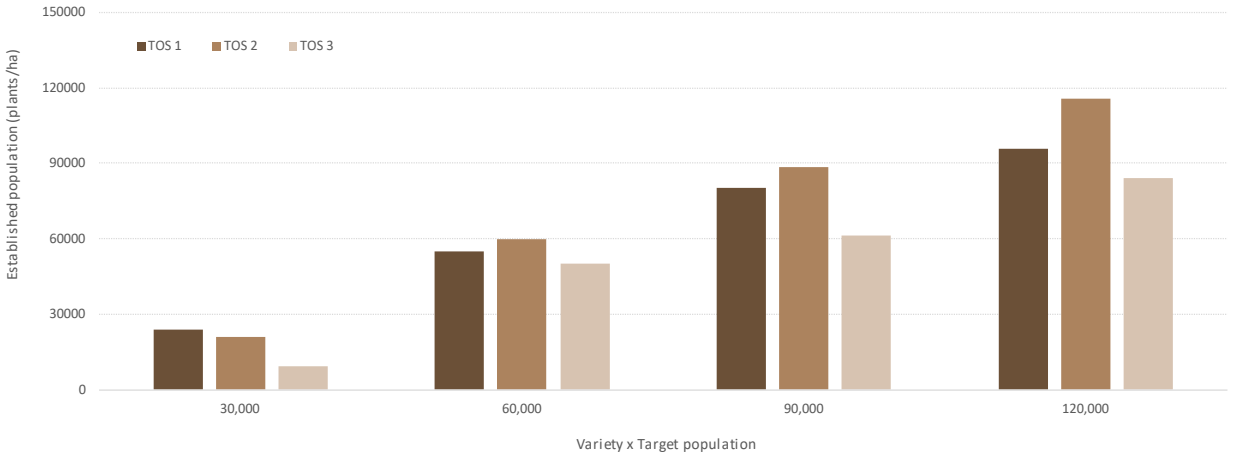

Figure 2. Average emergence across the three TOS dates for the four target populations.
Statistical analysis yet to be completed.

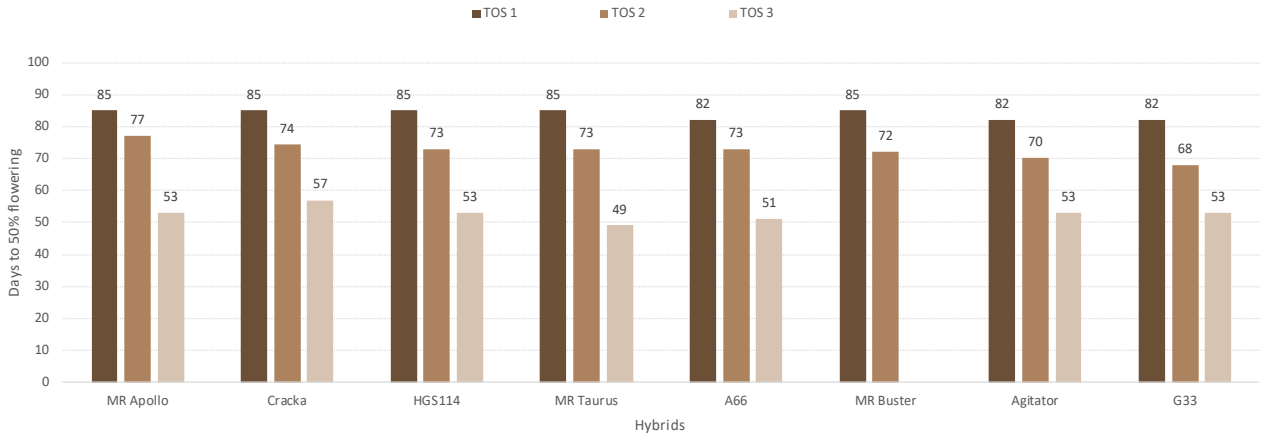

Figure 3. Average days to flowering for each of the eight varieties across the three different times of sowing.
Statistics not available at time of publishing (statistical analysis yet to be completed).

Flowering

Days to 50% flowering varied across TOS dates; average days to 50% flowering were 84 days (TOS1) and 73 days (TOS2), with TOS 3 only taking 53 days (Figure 3). The target window for flowering for TOS 1 and TOS 2 was to commence flowering by mid-September to early October; this was missed by TOS 1 by 10–15 days (50% flowering achieved on 15/10/18) and TOS 2 by more than 20 days (first variety achieving 50% flowering on 23/10/2018).

The quickest of the hybrids to 50% flowering was G33; MR Apollo and Cracka were the longest to flowering, depending on TOS (MR Apollo was faster in TOS 3, but the longest in TOS 2).

Plant height

There was a significant effect on plant height by TOS date. On average, TOS 1 main stems were 12 cm shorter than TOS 2 across all treatments (Figure 4). G33 showed the greatest variation between the two sowing dates of 15 cm difference while HGS-114 and MR Apollo showed the least difference with only 7.5 cm on average.

Population also had a significant effect on plant height; as population increased, average plant height decreased in TOS 1 (98 to 95 cm) whereas it increased in TOS 2 (10.6 to 11.1 cm) (Figure 5).

Grain yield

Grain yield was significantly different (P(0.01)) between TOS 1 and 2, with average yields of 3.8 t/ha for TOS 1 and 2.4 t/ha for TOS 2 across all varieties. However, crop yield was affected by bird damage and lodging, particularly in TOS 2.

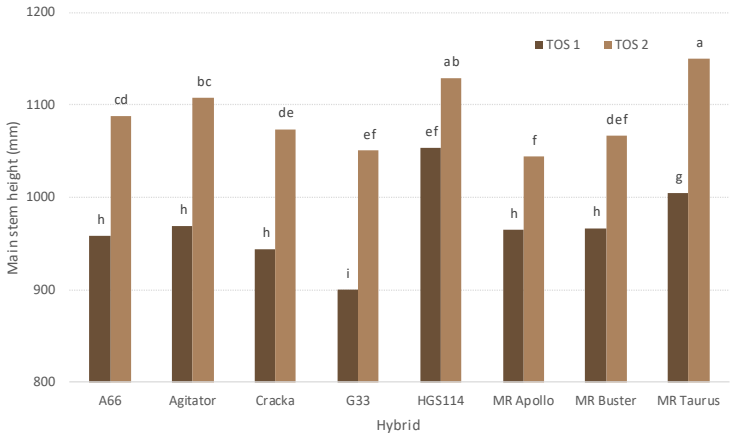

Figure 4. Main stem plant height for TOS 1 and 2.
P(0.001); lsd = 27.1 mm.

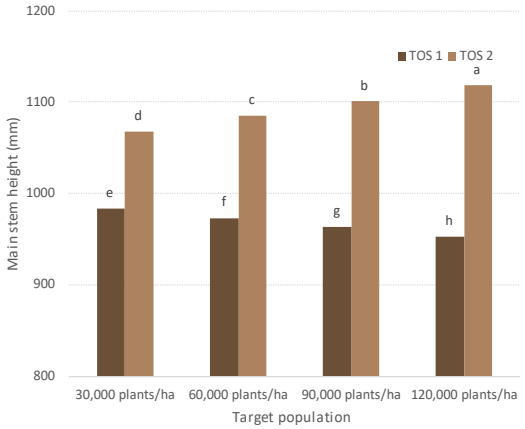

Figure 5. Effect of population on main stem height. P(0.001); lsd = 11.8 mm.

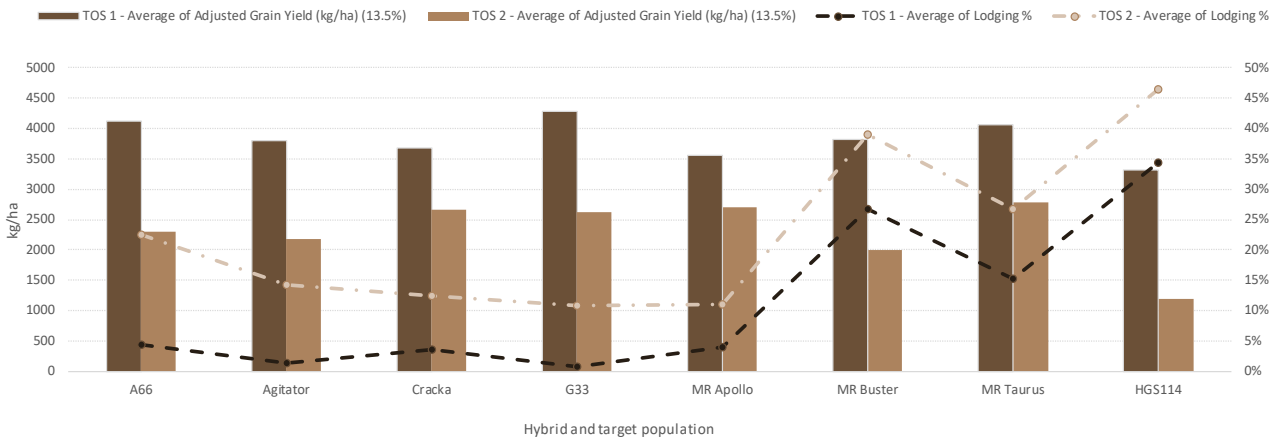

Figure 6. Grain yield for TOS 1 and 2 overlayed with percentage (%) of heads lodged (unharvestable).
There was a significant difference between TOS P(0.001) yield. There was also a significant difference in average lodging (%) between varieties.

MR Buster, MR Taurus and HGS-114 were significantly affected by lodging in TOS 1, while all varieties had levels of lodging above 10% for TOS 2. A66, MR Buster, MR Taurus and HGS-114 had more than 20% of heads on the ground (Figure 6) in TOS 2. Much of the lodging occurred post-spray-out, however HGS-114 and MR Buster were showing signs well before physiological maturity. Charcoal rot was observed in a number of treatments during biomass cuts. Other stems showed no sign of any infection, yet appeared quite fibrous and weak, despite the size of the plant.

Screenings for both early TOS dates were above grain receival specifications, however TOS 1 had significantly lower screenings (P(0.003)) compared to TOS 2, except at the lowest target population (Figure 7). Screenings generally decreased in TOS 1 as populations increased, with the highest population treatments (and the most heads per m^2) on average having lower screenings than both TOS 1 and TOS 2 low population treatments. TOS 2 displayed a more typical response to population, with screenings increasing as population and viable heads per m^2 increased (Figure 7).

Implications for growers

The progression into summer 2018/19 was exceptionally dry and hot; despite this, it was interesting to observe how little stress appeared to be showing as both early times of sowing progressed towards head emergence.

Just under 80 mm of rain on 13 and 14 October 2018 (Figure 8) had a transformational effect on the crop, by seemingly accelerating development. Additional secondary tillers developed because of this rain and maturity was dragged out considerably for both sowing dates. There was no additional useful rainfall before harvest.

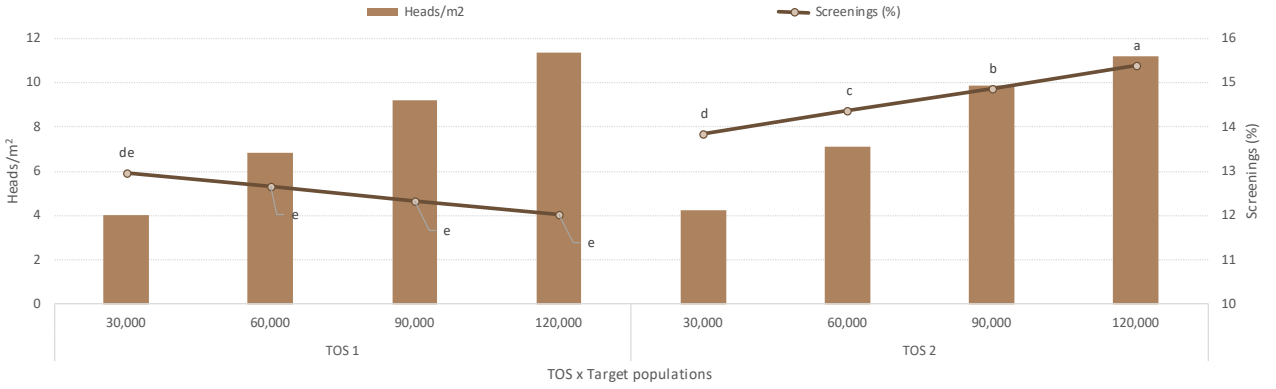

Figure 7: Relationship between heads per m² and REML assessed screenings across the four populations for the first two sowing dates. There was no significant difference in screenings between the four populations in TOS 1; however, there was a significant difference in TOS 2; P(0.002), lsd = 0.81%. There was no significant difference in head number/m² between TOS for each population, however there was a population difference; P(0.001).

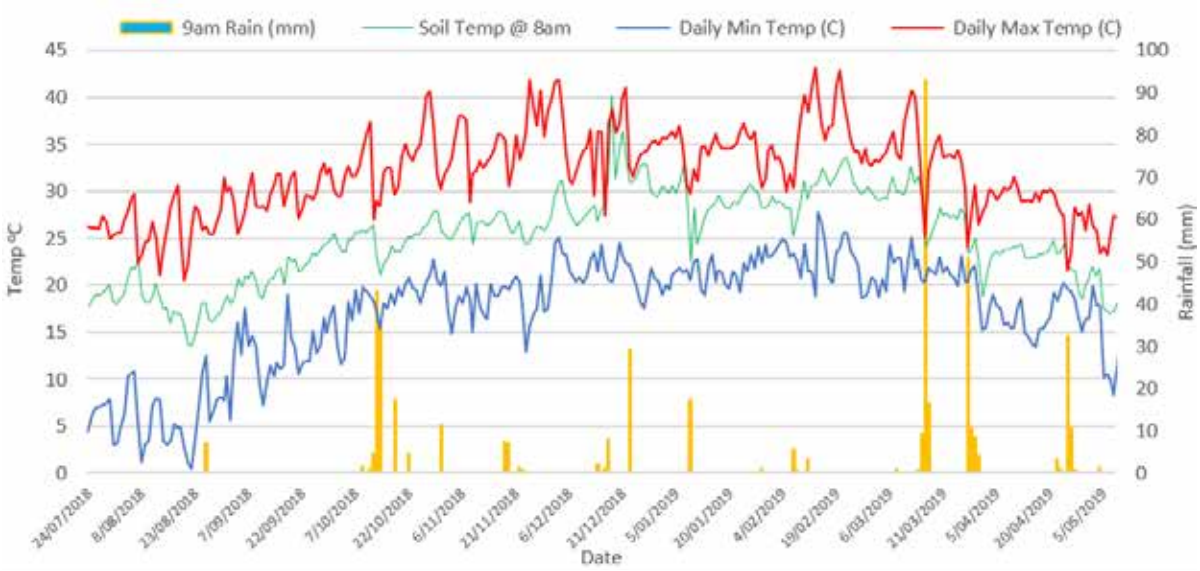

Figure 8: Daily climate observations throughout the duration of the 2018/2019 trial.
Note that due to soil cracking, the soil temp probe became exposed from 16 December to 11 January 2019; hence the spike in soil temperature readings over that period.

The 2018 trial was the first of four years of research focused on understanding the agronomy and phenology effects of winter-sown sorghum in a range of sub-climates across Queensland and northern New South Wales. While initial yield results indicate a potential yield increase from planting earlier, further research is required to confirm these results.

This research will improve our understanding in regards to the effect of sowing date on time to flowering, allowing us to better target the flowering window between mid-September and mid-October in CQ. Research partners in Southern Queensland and northern NSW have shown that seedlings can emerge in soil temperatures as low as 12 °C, and can withstand -2 °C frosts. The 2019/20 trial brings sowing dates forward to mid-June and mid-July, along with irrigation versus dryland treatments.

Possibly the greatest challenge for this type of out-of-season cropping is pest management. Birds were very attracted to this sorghum as it was the only crop on the Emerald Research Facility (due to very dry conditions). Despite significant efforts to move the birds on, they were as keen to share in the new learning experience as we were.

Acknowledgements

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The DAF biometry team and SAGI (co-funded by GRDC) have provided statistical analysis of the data presented.

Thank you to Cotton Seed Distributors for allowing us to utilise their FastStart™ Soil Temperature Network data set while on-site logging equipment was established.

Trial details

Location:	Emerald Research Facility
Crop:	Sorghum
Soil type:	Cracking, self-mulching, Grey Vertosol in excess of 1.5 m deep. Estimated PAWC to 1.5 m of approximately 240 mm. Starting PAW at planting was 195 mm. Post-harvest PAW indicated average PAW was approx. 140 mm to 1.5 m, with more than 70 mm sitting below 1 m depth.
In-crop rainfall:	See Figure 8