Northern Grains Region Experimental Results

2016-17 growing season

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Foreword

The information contained in QAAFI's Northern Grains Region Experimental Results Book has been produced by the Farming Systems Research Group at the Queensland Alliance for Agriculture and Food Innovation (QAAFI); a collaboration between the Queensland Government's Department of Agriculture and Fisheries (DAF) and The University of Queensland

The GRDC, ACIAR and the Queensland Department of Agriculture and Fisheries (DAF) funded the work, which was carried out in collaboration with seed companies, agribusinesses, consultants and farmers.

In the highly variable and risky climate of Australia's Northern Grains Region, every year, farmers face the task of matching hybrids and managements to prevailing and expected conditions. To support farmers and consultants with such a task, we conduct high quality on-farm and on-research station trials, incorporating contrasting managements, across a large number of Queensland sites. Although the focus of these trials is the performance of commercial hybrids, we are increasingly including pre-breeding and pre-commercial lines in our trials. This book summarises the results from the 2016/17 season, while similar books from previous years can be downloaded from https://www.qld-fsr.info/copy-of-tactical-agronomy-for-sorgh

The main message that emerges from analysing the data is that to achieve high yields in grain cereals, what really matters is to understand how to match hybrids and management to sites and expected seasonal conditions. We hope this document provides some insights towards that outcome.

We thank our collaborating farmers and hope you find the information useful. Please feel free to send us feedback to improve our book.

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These trials are part of two GRDC funded projects "Tactical agronomy for maize and sorghum in the Northern Region" (UQ00075); and the ACIAR SIMLESA Program http://aciar.gov.au/page/simlesa-program

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Maize hybrid by population by configuration trial at Emerald, Qld

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Key Findings

⇒ The best hybrid by population combination lead to yield advantages of 1 t/ha.

⇒ 1.5 m wide rows yielded about 0.5 t/ha more than 1 m wide rows.

Hybrid Pac 606IT was most consistently high yielding across all tested population and row configuration combinations

What is the problem?

- Sorghum is the dominant dryland cereal crop in Queensland due to lower production costs and greater yield reliability than other summer cereals. Having well-adapted maize hybrid and agronomy packages for Central Queensland will provide options for farmers to diversify cropping systems and profit from emerging market oppertunities.

- Understanding how different maize hybrid and agronomy combinations perform across sites and seasons will help farmers optimise crop designs to local and expected conditions, maximising yields and profits, and minimising risks.

What are we doing?

- We are researching the yield response of hybrids that produce contrasting numbers of ears per plant to changes in management, including plant population and row width, across sites and seasons in Queensland.

- Four maize hybrids were sown at three plant populations and two row widths in a trial planted at the Emerald Agricultural College, Queensland. The trial details are provided in Table 1.

What did we find?

- Ex-tropical cyclone Debbie delivered 65 mm rainfall and 40 km/hr winds in late March 2017 when the crop was in the vegetative stage. As a result, lodging was observed at the highest plant populations, and was worse in wider row configurations. The results presented below are yields for non-lodged plants.

- The different hybrid and management combinations resulted in yields (dry basis) ranging from 2 to almost 5 t/ha (Figures 1 – 3).

Table 1. Context for maize hybrid by population by configuration trial at Emerald

Attribute	Value
Soil type	Black Vertosol (PAWC 287 mm)
Initial soil water (mm)	194 mm
Initial soil nitrogen (kg N /ha)	40 kg N/ha
Fertilisation (kg N/ha)	150 kg N/ha
Sowing date	16 Feb 2017
Harvest date	20 June 2017
Hybrids	P1070, P1414, P1467 and Pac 606IT
Population densities (target)	20, 40 and 60 k plants/ha
Row configurations	Solid
Row spacing	1 and 1.5 m
Replications	3
In-crop rainfall (mm)	248 mm
Irrigation	25 mm

- The choice of the highest yielding hybrid (Pac 606IT) or target population (40 k plants/ha) increased yields by about 1 t/ha relative to the other treatments (Figures 1 and 2). However, these effects were not additive – e.g. Pac 606IT sown at a target population of 40 k plants/ha did not yield 2 t/ha more.

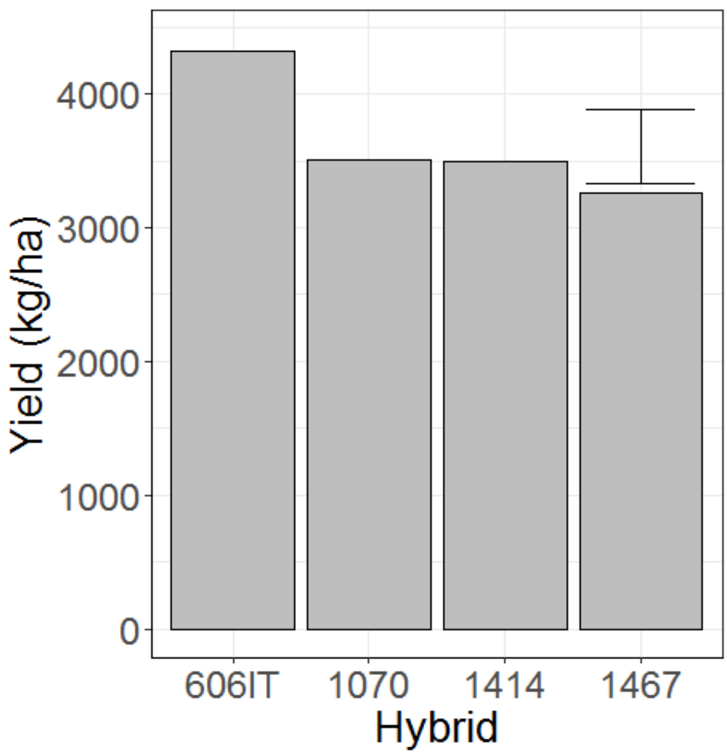

Figure 1. The average effect of hybrid across all population and configurations on yield. Treatment differences are only statistically significant when greater than the error bar.

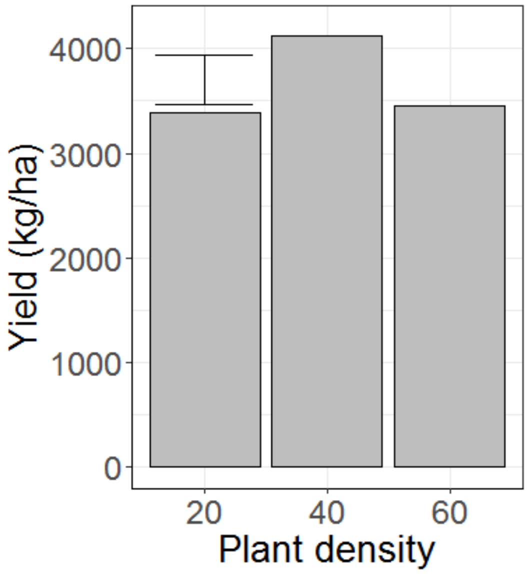

Figure 2. The average effect of plant density ('000 plants/ha) on yield across all hybrids and row configurations. Treatment differences are only statistically significant when greater than the error bar.

- Irrespective of the hybrid or plant population, 1.5 m wide rows yielded about 0.5 t/ha more than 1 m rows (Figure 3).

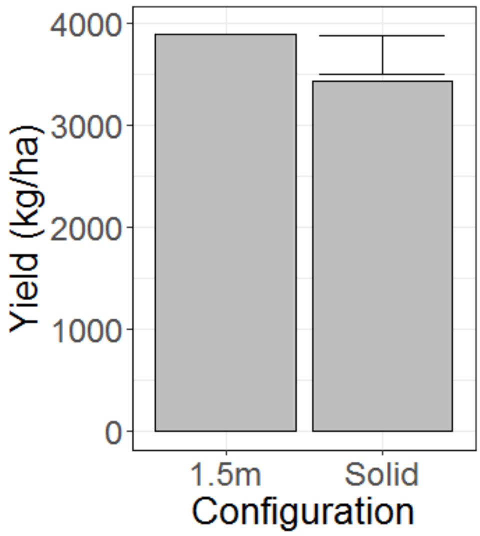

Figure 3. The average effect of row width (1.5 m and 1.0 m, both solid) on yield across all hybrids and populations. Treatment differences are only statistically significant when greater than the error bar.

- The harvest index, which is the ratio between the yield and the total crop biomass (grain + stubble), showed significant hybrid, population and row width effects (Figure 4 shows this for the effect of hybrid). The higher hybrid yields were explained by a higher harvest index (Figures 1 and 4).

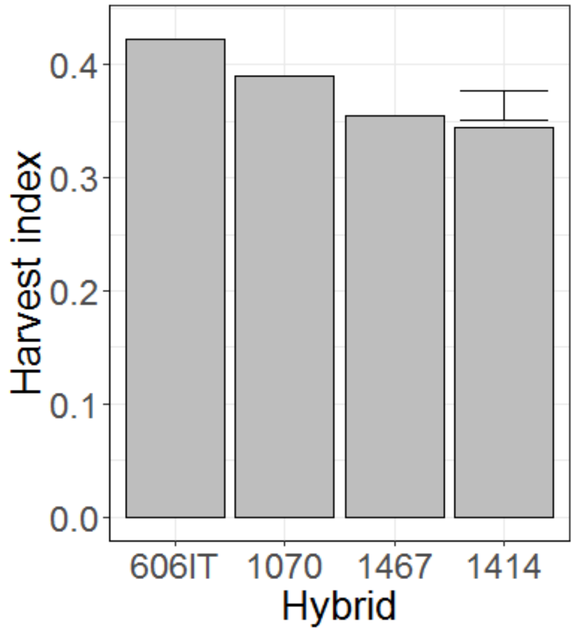

Figure 4. The average effect of hybrid on the harvest index (yield/biomass) across all populations and configurations. Treatment differences are only statistically significant when greater than the error bar.

- The economic implications of the treatments were estimated using gross margins (Figure 5). Gross margins ranged from close to $0 to over $600/ha, with Pac 606IT showing the highest and most consistent returns across all combinations of population and configuration.

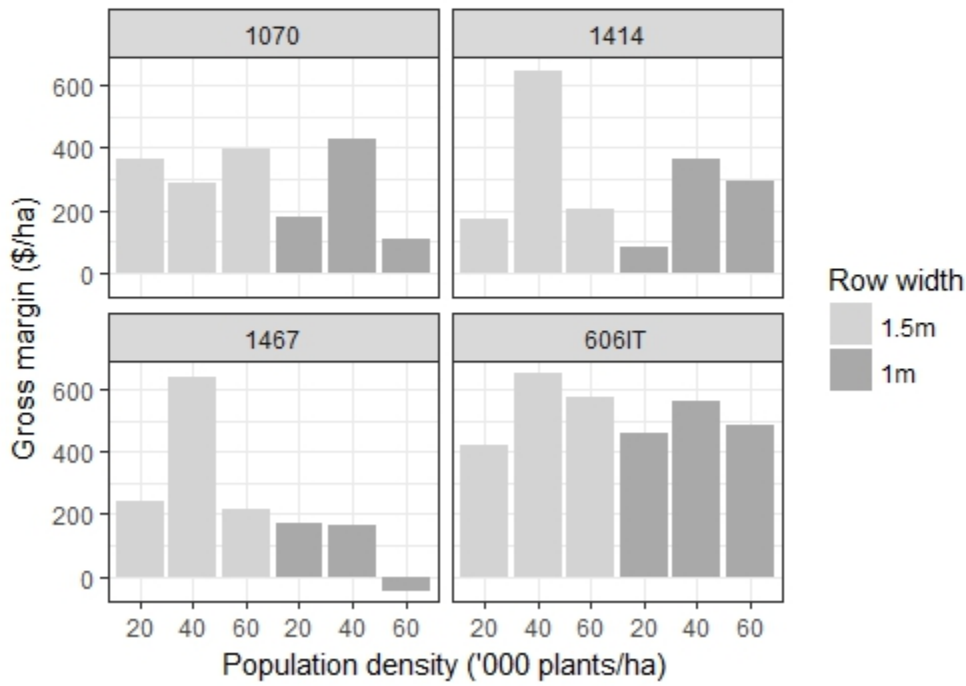

Figure 5. The effect of hybrid, population and row width on gross margins.Gross margins calculated using estimated trial yields, average prices and input costs(Darling Downs, 2017) from agmargins.net.au

What does this mean?

- The Emerald 2016-17 maize agronomy trial provides an excellent example of how hybrid, population and configuration can influence yield and economic returns in a particular site and season. However, the optimum selection of hybrid, population density and row configuration will change season-to-season depending on weather patterns.

- This trial challenges the conventional thinking that maize yields don't respond to wider rows. However, this may reflect a lack of diversity in traits such as root angle within older commercial germplasm.

- This trial is one of many the UQ-QAAFI Farming Systems Research Group has run across the growing environments of Queensland. The longer-term objective is to use these trials to understand how hybrid traits, such as prolificity (the ability to produce multiple ears per plant) and tillering, interact with management (such as row width and population) and the environment (as determined by soil characteristics, and conditions at sowing and weather during the crop cycle) to influence yield distribution and risks.

Sorghum hybrid by population by configuration trial at Emerald, Qld

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Key Findings

⇒ The highest yields were obtained with a solid 1 m row spacing.

⇒ The harvest index (yield/biomass) was significantly lower for the hybrid MR-43, and for the highest plant population (80 k pl/ha).

What is the problem?

- In rainfed cropping systems, there is potential to increase yields and profits by matching hybrid selection and management, to the available resources, e.g. initial soil water, and expected seasonal conditions.

What did we do?

- We ran a plant population and row configuration trial in Emerald, Central Queensland using commercial sorghum hybrids to determine the effect of row configuration and population density on the yield of commercial hybrids (Table 1). The trial was run at the Emerald Agricultural College.

Table 1. Context for sorghum hybrid by population by configuration trial at Emerald

Attribute	Value
Soil type	Black Vertosol (PAWC 287 mm)
Initial soil water	194 mm
Initial soil nitrogen	43 kg N/ha
Fertilisation	150 kg N/ha
Sowing date	14 Feb 2017
Harvest date	21 June 2017
Hybrids	MR-Apollo, MR-Bazley, MR-Buster, Pacific MR 43
Population densities (target)	40, 60, 80 k plants/ha
Row configurations	Solid and single skip
Row spacing	1 m
Replications	3
In-crop rainfall	254 mm
Irrigation	25 mm

What did we find?

- Yields ranged between 4 and 7 t/ha across treatments (dry basis). However, the only statistically significant effect was row configuration (Figure 1): single skip rows yielded approximately 0.8 t/ha less than solid rows.

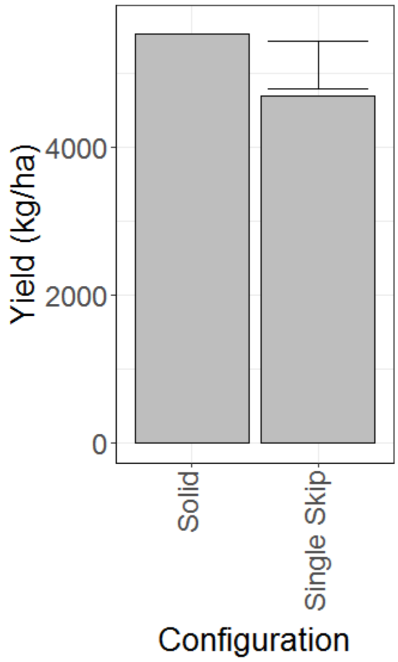

Figure 1. The average effect of row configuration on yield across all hybrid and population treatments. Treatment differences are only statistically significant when greater than the error bar.

- Like yield, total above-ground biomass was larger in solid rows than single skips (Figure 2).

- The harvest index (yield relative to total above-ground biomass) showed significant hybrid and (target) population effects (Figures 3 and 4, respectively). MR-Buster showed a significantly higher harvest index than MR-43, with intermediate values for the other hybrids. The harvest index at target populations of 80 k pl/ha was significantly lower than at 40 and 60 k pl/ha treatments. There was also a strong tendency for the harvest index of single skip row configurations to be greater than those of solid rows (results not shown).

- The higher harvest index was not related to higher yields. The implication is that, for this site and season, some crop designs with sub-optimum yields might produce yield more efficiently, perhaps using less soil moisture and nutrients relative their yield.

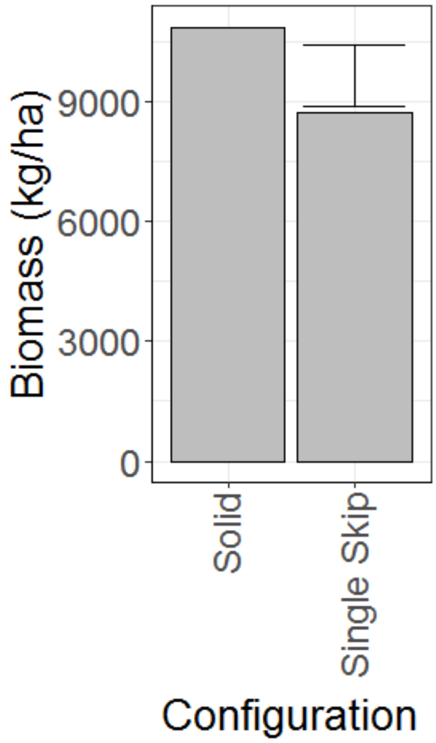

Figure 2. The average effect of row configuration on total above-ground biomass across all hybrids and population densities. Treatment differences are only statistically significant when greater than the error bar.

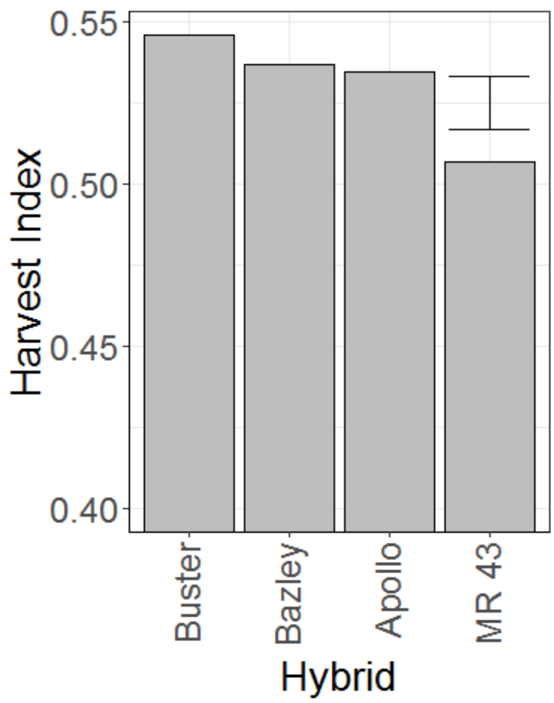

Figure 3. The average effect of hybrid on the harvest index (yield/biomass) across all population and row configurations. Treatment differences are only statistically significant when greater than the error bar.

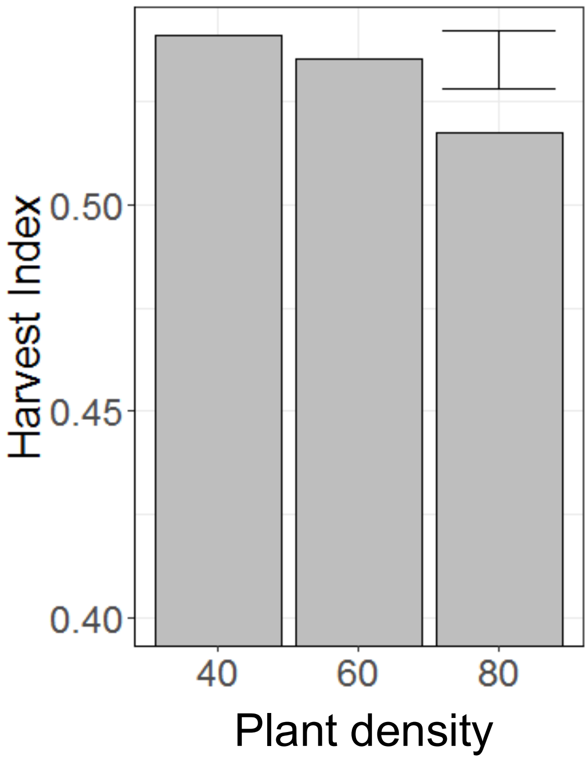

Figure 4. The average effect of target plant population ('000 plants/ha) on the harvest index (yield/biomass) across all hybrids and row configurations. Treatment differences are only statistically significant when greater than the error bar.

- The economic implications of the treatments were estimated using gross margins (Figure 5). Gross margins ranged between $500 and almost $1200/ha, with the target population that showed the highest margins varying between hybrids. However, solid rows often had larger gross margins than single skip (Figure 5).

What does this mean?

- The Emerald 2016-17 sorghum agronomy trial provides an excellent indication of yield and economic returns for this particular site and season. Optimal genotype x environment x management combinations can only be informed after yield distributions are contextualised in terms of climate variability with multi-environment trials, simulation modelling and seasonal forecasts.

- The trial is consistent with previous observations that skip rows limit the yield potential unless yield targets are less than approximately 2 t/ha.

- The commercially available sorghum hybrids are able to compensate yield in response to population by tillering. However, other research has shown that non-tillering hybrids have less downside risk. The effect of population density on yield distribution will need re-evaluation as lower tillering hybrids sown with precision planters become available to growers.

- This trial is one of many the UQ-QAAFI Farming Systems Research Group has run across the growing environments of Queensland. The longer-term objective is to use these trials to understand how hybrid traits (such as tillering, maturity type and stay-green) interact with management (such as row configuration and population) and the environment (as determined by soil characteristics, and conditions at sowing and during the crop cycle) to influence yield distribution and risk.

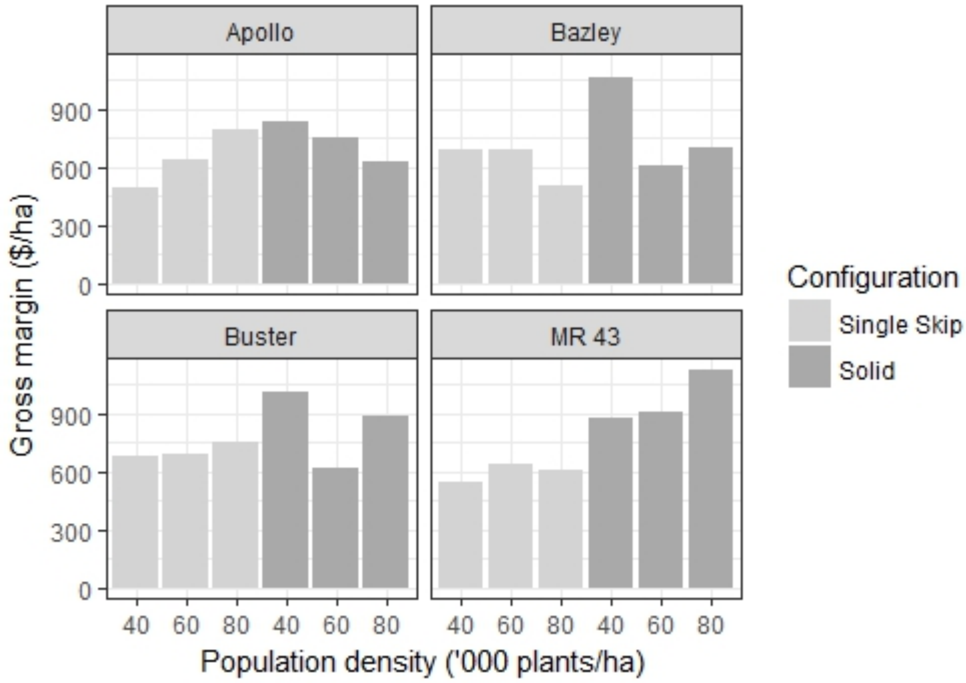

Figure 5. The effect of hybrid, population and row configuration on gross margins. Gross margins calculated using estimated trial yields, average prices and input costs (Central Highlands, 2017) from agmargins.net.au

Sorghum and maize time of sowing trial at Jimbour, Qld

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Key Findings

⇒ Maize establishment was insensitive to sowing time, whereas sorghum establishment improved with later sowing dates.

⇒ August frosts that damaged a neighbouring chickpea crop resulted in transient purpling of sorghum but otherwise no damage to leaves, heads or ears of maize or sorghum.

⇒ Crops sown on the 2 and 22-Aug flowered before the first heat stress event of the season.

⇒ Yields of maize hybrids Pac 606IT and P1756 were not affected by the sowing time, whereas Pac727IT had its highest yields at the standard sowing time.

⇒ Sorghum yields were severely affected by Rutherglen bugs.

What is the problem?

- The risk of extreme heat and dry spells around flowering are the two main sources of risk faced by rainfed growers across the Northern Grains region.

- Whether it is possible to reduce these risks by sowing earlier on colder soils than present recommendations (8 am soil temperature at sowing depth greater than 16°C and rising) is not known. Also unclear is the susceptibility of sorghum to frost damage early in the season, and the cropping system benefits of harvesting early on farm profitability (i.e. double cropping).

What did we do?

- We sowed an on-farm trial with maize and sorghum hybrids at soil temperatures of 10 °C on the 2nd of August, 14 °C on the 22nd August, and 16 °C on the 30th of September, at Jimbour, Queensland (Table 1). We monitored soil water, plant survival, canopy dynamics and yield components.

- The collaborating farmer was St John Kent.

Table 1. Context for maize and sorghum time of sowing trial at Jimbour

Attribute	Sowing 1	Sowing 2	Sowing 3
Soil type		Black Vertosol (PAWC = 275 mm)	
Initial soil water (mm)	58	49	174
Initial soil nitrogen (kg N /ha)	126	126	126
Fertilisation (kg N/ha)	75	75	75
Soil temperature at sowing (°C)	10	14	16
Sowing date	2 Aug 2016	22 Aug 2016	30 Sep 2016
Flowering date: maize	Mid Nov	Late Nov	Mid Dec
Flowering date: sorghum	Late Nov	Mid Dec	Late Dec
Harvest date: maize	10 Jan 2017	17 Jan 2017	14 Feb 2017
Harvest date: sorghum	12 Jan 2017	19 Jan 2017	17 Feb 2017
Hybrids		Sorghum: G33, MR-Apollo, MR-Buster Maize: P1756, Pac 606IT, Pac 727IT	
Population densities (k plants/ha)		Sorghum: 69, maize: 21	
Row configuration		Solid	
Row spacing (m)		1	
Replications		3	
In-crop rainfall (mm)	288.6	285.6	158.4

What did we find?

- Maize
    - Irrespective of soil temperature at sowing, the maize stand at harvest was ~ 90 % of the target population (Figure 1).
    - Maize sown on 2 and 22-Aug flowered before the first heat stress event (maximum temperature greater than 38 °C during flowering) (Figure 2).
    - As a percentage of above-ground biomass, the production of tillers in maize was not affected by sowing time (Figure 3). Hybrid Pac 606 produced the least tiller biomass, Pac 727 the greatest, with P1756 intermediate.
    - Earlier sowing of maize did not provide a yield advantage over regular time of sowing (Figure 4). However, temperatures were relatively mild during flowering for the regular time of sowing, i.e. only one day at 38 °C during the sensitive period.
    - The earliest-sown maize and sorghum were both harvested approximately 35 days ahead of the late-sown crops. This relatively early harvest increased the length of the fallow and increases the likelihood of a double crop chickpea. Simulation results for Warra, Qld demonstrate that early sowing could increase chickpea double cropping frequency from 20 to 70 % of years (Figure 5).

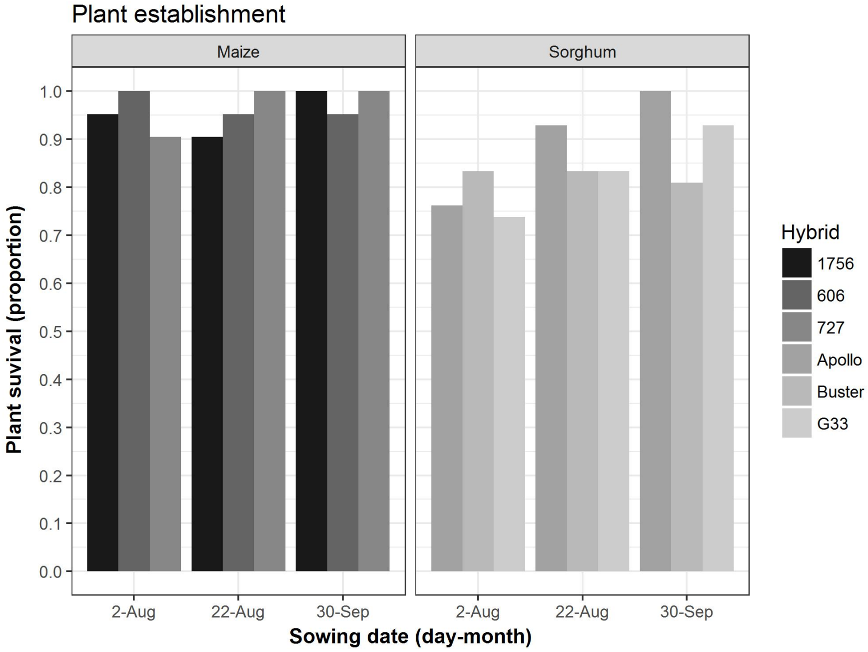

Figure 1. The effect of sowing time on the emergence-to-maturity survival of maize and sorghum.

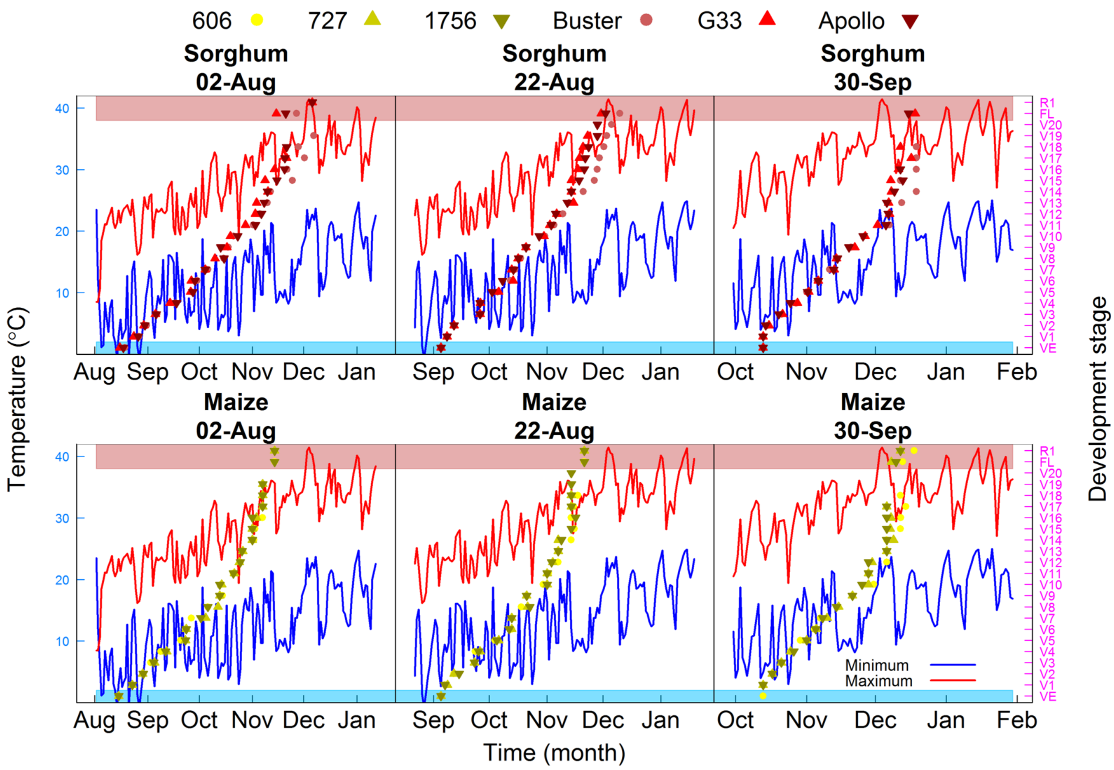

Figure 2. Daily minimum (blue line) and maximum (red line) temperatures (left hand axis) for three sowing times (left to right) for sorghum (top) and maize (bottom) crops. Heat or frost stress events occur when the maximum or minimum temperatures reach the red or blue shaded areas, respectively. Growth stages are indicated on the right hand axis. For example, V6 = 6 expanded leaves, FL = flowering, R1 = silking.

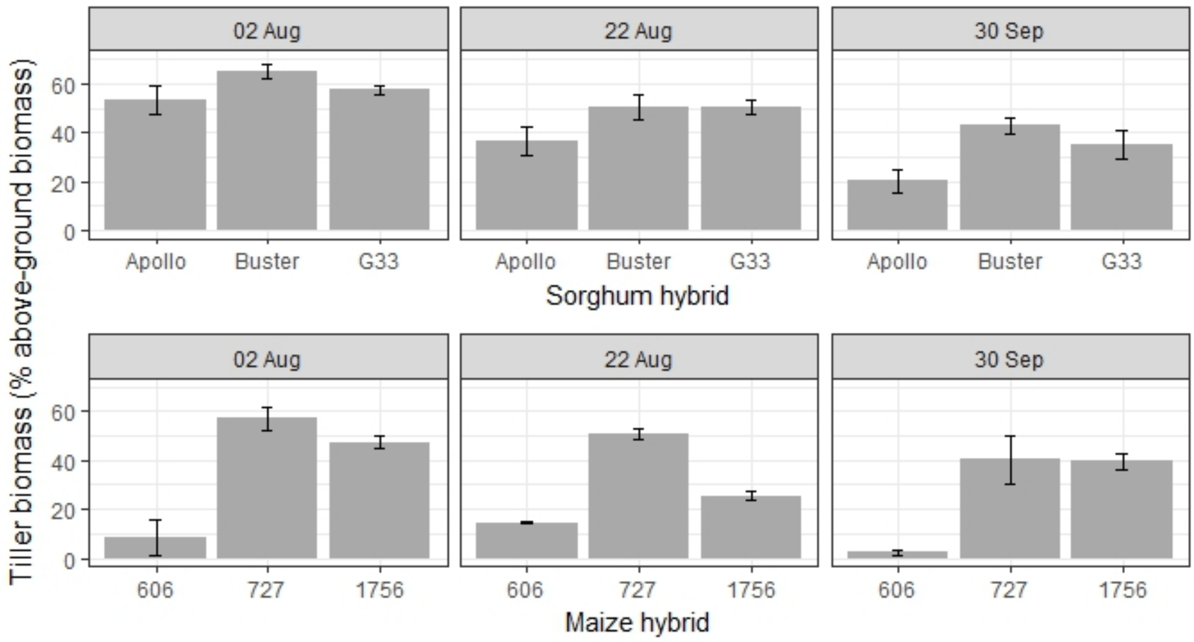

Figure 3. The effect of hybrid and sowing time on tiller biomass. The error bars represent ± one standard error.

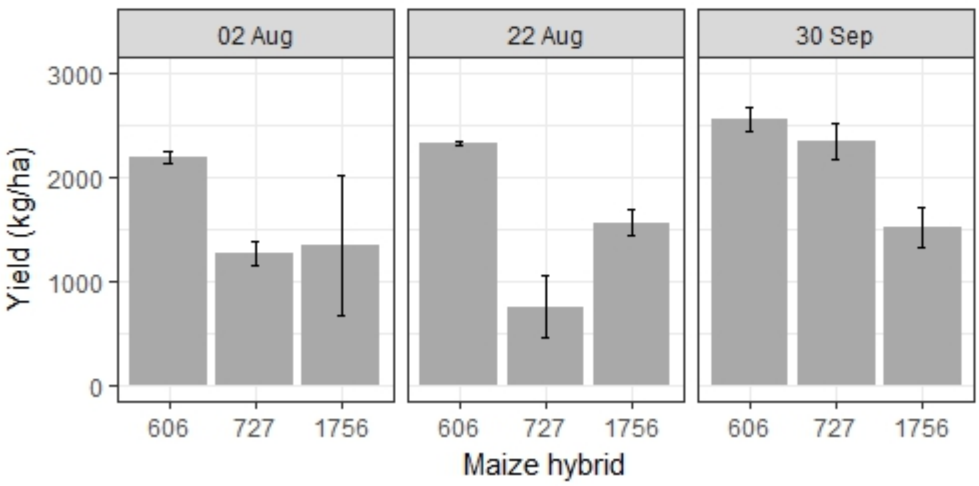

Figure 4. The effect of sowing time and hybrid on yield for maize (sorghum data omitted due to pest damage and failure of MR-Apollo heads to emerge in the first two sowings).

- Three frosts (which damaged the upper two nodes of a neighbouring chickpea crop) occurred after emergence of both the early sowings (2 and 22 August). In August, four frosts are typical for Jimbour, and later frosts are rare (< 17 % of years, climateapp.net.au). No frosts were registered after the crop had eight leaves i.e. 1st October for the first sowing; Figure 1). At the V8 stage, the developing flower head is above the soil: overseas research shows frosts after this stage can significantly reduce yield.

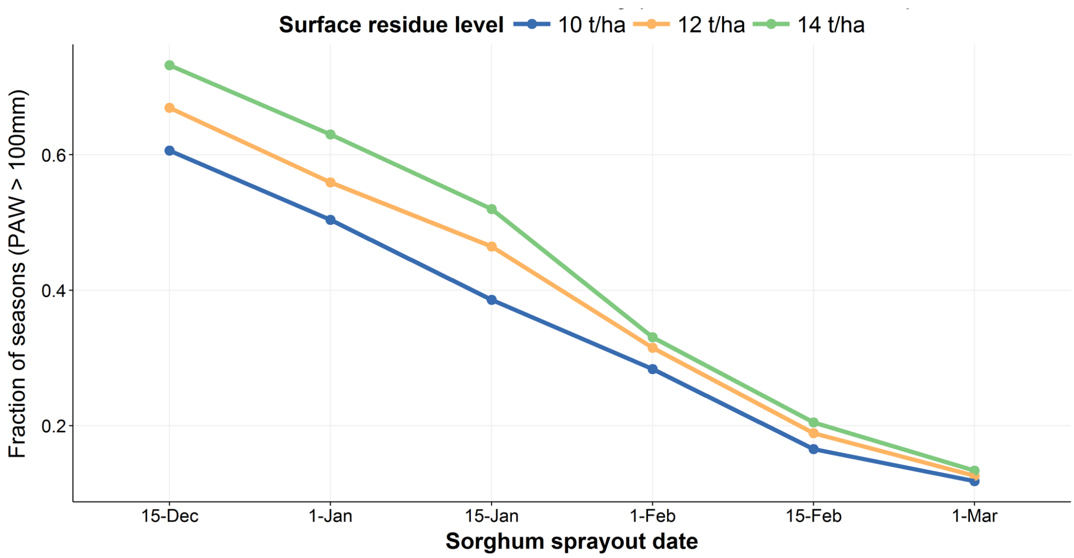

Figure 5. The effect of sorghum spray out date and surface residue level on likelihood of storing 100 mm of plant available water (PAW) before chickpea sowing.

- Sorghum
  - Irrespective of sowing time, the harvest plant stand for MR-Buster was ~80 %.
  - For MR-Apollo and G33 plant stands were ~80 % for the earliest sowing, and between 90-100 % with later sowing dates (Figure 1).
  - Irrespective of the hybrid, the earliest sowing of sorghum flowered before the first heat stress event (maximum temperature of > 38 °C) (Figure 2).
  - Tiller biomass decreased with later sowing times regardless of sorghum hybrid (Figure 3).
  - Sorghum yields were affected by a constant Rutherglen bug infestation that was impossible to control (Figure 4).
  - For the first two sowing times, MR-Apollo yields were further reduced by failure of the head to emerge from the flag leaf.

What does this mean?

- Yields were greatly limited by in-crop rainfall, but the trial is nonetheless important for demonstrating it is possible to establish a crop in cool soils, and provides an example of how sowing early can time flowering to occur before heat stress events. Sowing early will delay the development of both crops, but to a greater extent for sorghum than for maize: sowing approximately two months earlier than standard practice brought harvest forward approximately one month.

- Further research is needed to fully characterise the response of germination, emergence, growth and development to cool and freezing temperatures in order to understand the long-term benefits and risks of sowing into cool soils for the immediate crop and following crop rotations

Low tillering sorghum hybrids by population at Macalister, Qld

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Key Findings

⇒ Yields ranged between 1.3 and 3.3 t/ha.
⇒ Yields increased with population density for all hybrids except the Pioneer experimental hybrid.
⇒ MR-Apollo was low yielding because the head didn't emerge.
⇒ There is a narrow range of tillering diversity in the evaluated hybrids.

What is the problem?

- Previous results showed that low tillering sorghum hybrids were higher yielding in drier sites and seasons. There is no information on the diversity of tillering potential in commercial and experimental hybrids, or the agronomy best suited to these hybrids.

What did we do?

- Six sorghum hybrids with relative tillering potentials ranging from low (Archer, and DAF and Pioneer experimental lines), to moderate (MR-Apollo and G44), to moderately-high (MR-Buster) were sown at four densities at Macalister, Queensland. Trial details are provided in Table 1.

- Jason and Leanne Schelburg were the collaborating farmers.

Table 1. Context for sorghum hybrid by population trial at Macalister

Attribute	Value
Soil type	Black Vertosol (PAWC = 292 mm)
Initial soil water	167 mm
Initial soil nitrogen	67 kg N/ha
Fertilisation	100 kg N/ha and 37 kg/ha Starter Z
Sowing date	11 Oct 2016
Harvest date	27 Feb 2017
Hybrids	Archer, G44, MR-Apollo, MR-Buster, DAF experimental, Pioneer experimental
Population densities	30, 50, 70 and 100 k plants/ha
Row configurations	Solid
Row spacing	0.75 m
Replications	3
In-crop rainfall (mm)	336 mm (229 mm fell after Jan 15 2017)

What did we find?

- Across the trial, yields ranged from 1.3 to 3.3 t/ha (Figure 1).

- There was a strong effect of hybrid on yield, with G44, MR-Buster, Archer and the DAF experimental hybrid yielding relatively high (Figure 1). MR-Apollo heads did not emerge in approximately ¼ of plants.

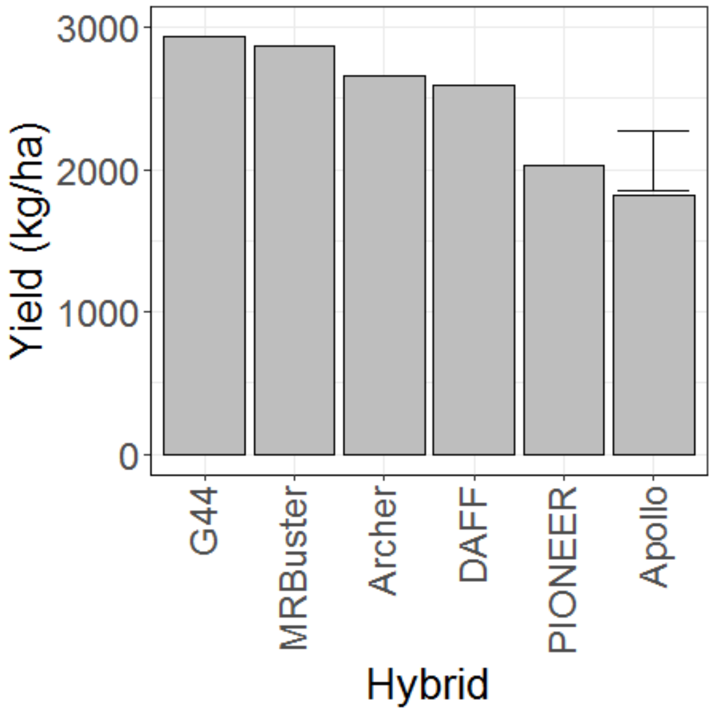

Figure 1. The average effect of hybrid on yield across all plant populations. Treatment differences are only statistically significant when greater than the error bar.

- There was also a strong effect of plant population on yield, with target populations of 30 and 50 k plants/ha yielding less than target populations of 70 and 100 k plants/ha (Figure 2).

- There were significant differences between the hybrids in biomass, with MR-Buster, G44 and MR-Apollo showing greater biomass than the other hybrids (Figure 3).

- There was also a significant effect of population on biomass, with greater biomass at higher target populations (Figure 4).

- There were hybrid differences in harvest index (yield relative to total above-ground biomass), with MR-Apollo having a lower harvest index than the other hybrids (Figure 5).

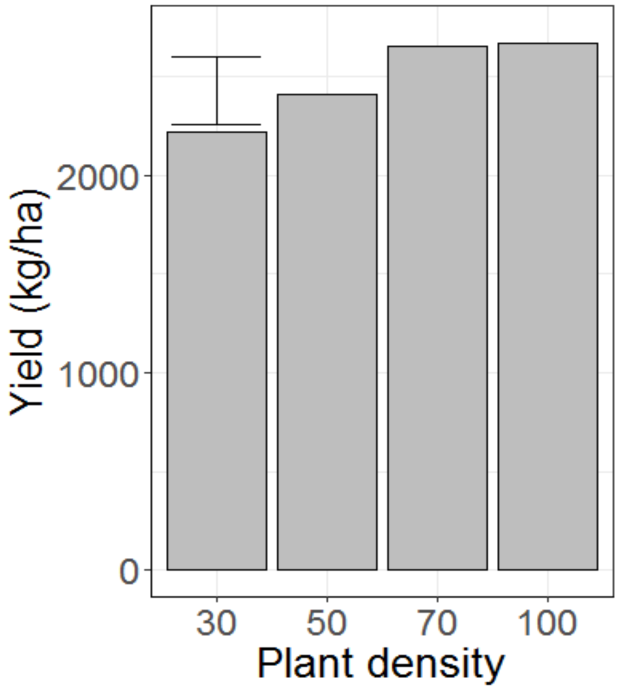

Figure 2. The average effect of target plant population on yield across all hybrids. Treatment differences are only statistically significant when greater than the error bar.

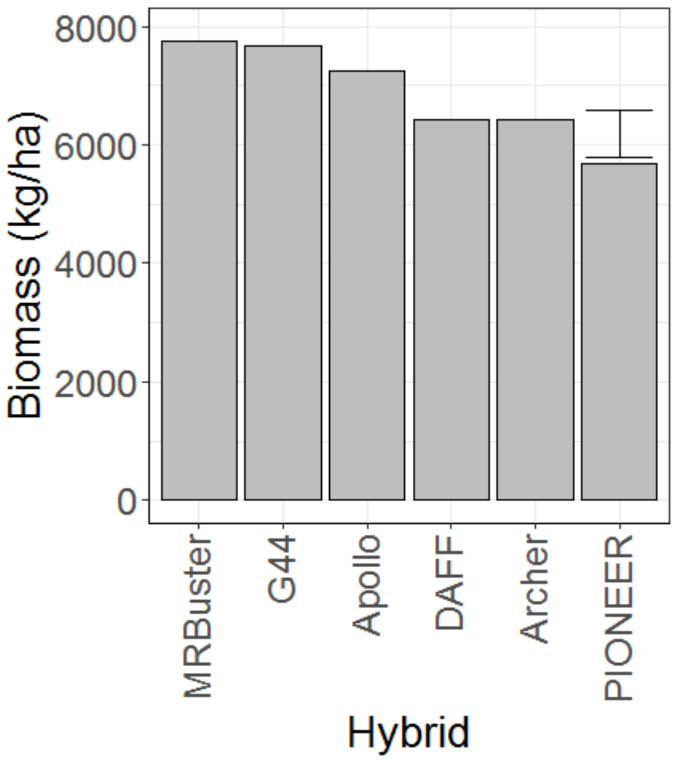

Figure 3. The average effect of hybrid on total above-ground biomass across all target plant populations. Treatment differences are only statistically significant when greater than the error bar.

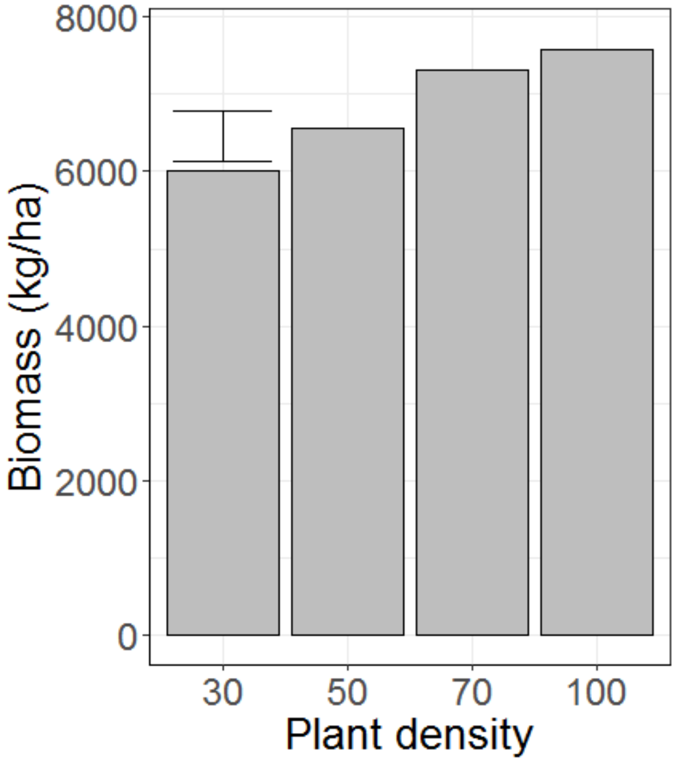

Figure 4. The average effect of target plant population ('000 plants/ha) on total above-ground biomass across all hybrids. Treatment differences are only statistically significant when greater than the error bar.

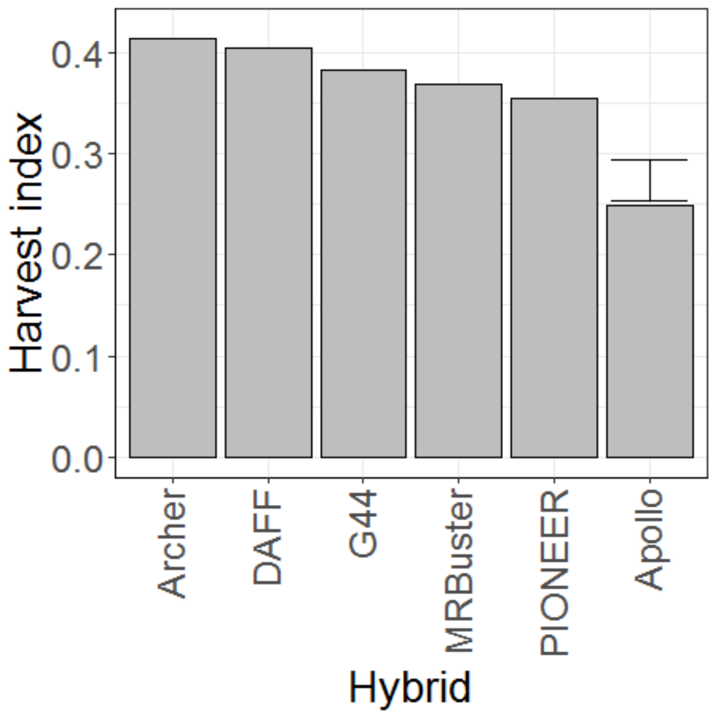

Figure 5. The average effect of hybrid on the harvest index (yield/biomass) across all plant populations. Treatment differences are only statistically significant when greater than the error bar.

- The economic implications of the treatments were estimated using gross margins (Figure 6). Gross margins ranged between -$100 and $350/ha. In-line with the effects of treatments on yield, gross margins can be expected to vary between hybrids (Figure 1), and be highest with target populations of 70 and 100 k pl/ha.

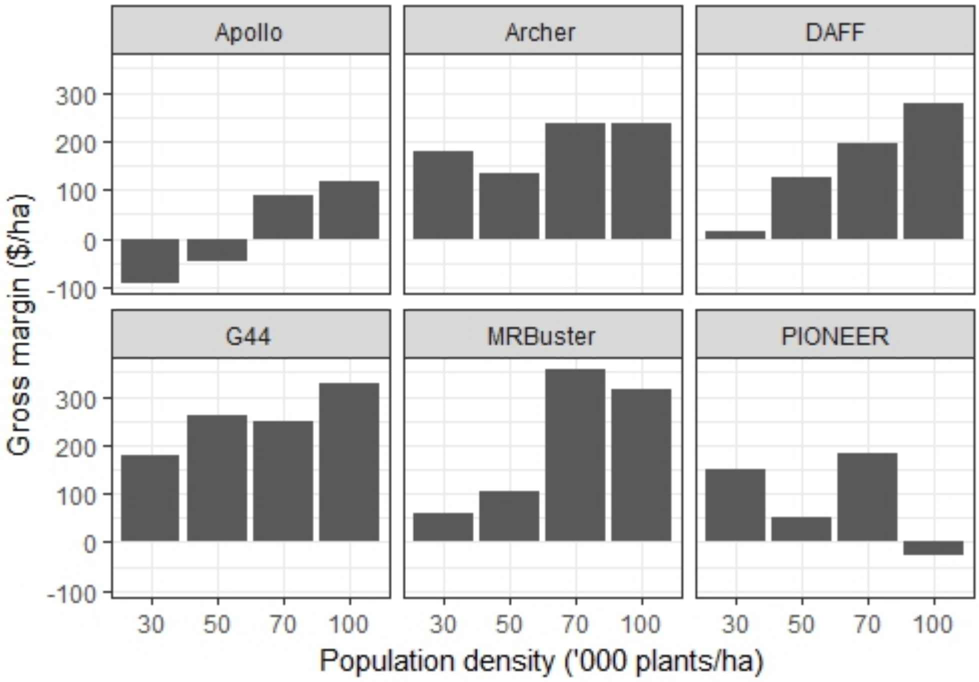

Figure 6. The effect of hybrid and population on gross margins. Gross margins calculated using estimated trial yields, and prices and costs (Darling Downs, 2017) from agmargins.net.au

What does this mean?

- The Macalister trial provided a good site and season for assessing low-tillering sorghum, because it is low-yielding environments where this trait is expected to be most beneficial.

- However, the ubiquitous presence of tillers on all plants in low populations at this site demonstrates the narrow range of tillering diversity in the evaluated hybrids.

- Lower-tillering Archer and the DAF experimental hybrid showed similar yields and harvest index to moderate (G44) and moderately-high (MR-Buster) tillering hybrids. With the exception of the Pioneer experimental hybrid, all hybrids showed an increase in yield with increasing population (results not shown but can be inferred from Figure 6). A stronger yield-population response is expected for non-tillering hybrids, and the population at which their yield is optimised is expected to be relatively high.

- There is a need to repeat this research on populations of hybrids from the pre-breeding program with greater tillering diversity (i.e. non-tillering to high tillering) from known backgrounds, thereby avoiding confounding effects of background genetics on crop physiology and yield.

Low tillering sorghum hybrids by population trial at Emerald, Qld

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Key Findings

⇒ Relative to MR-Buster, the tested commercial and experimental hybrids showed (i) a propensity to tiller less than MR-Buster at low population densities, and (ii) greater control over heads m^{-2} and yield by changing population density.

⇒ Yields were potentially confounded by reduced seed set due to chilling temperatures around flowering.

⇒ More diversity in the hybrid tillering propensity was expressed at Emerald compared to Macalister

What is the problem?

- Given the adoption of perfect singulation planters, increasing interest in timing sowing to avoid heat stress at flowering (which may promote tillering), and the availability of low tillering hybrids, there is a need to develop agronomic packages for low tillering sorghum hybrids.

What did we do?

- We ran a trial where low tillering commercial and experimental hybrids were sown at four different target population densities at Emerald, Central Queensland. These treatments are identical to those applied at the Macalister trial reported above.

Table 1. Context for sorghum hybrid by population trial at Emerald.

Attribute	Value
Soil type	Black Vertosol (PAWC 287 mm)
Initial soil water	194 mm
Initial soil nitrogen	150 kg N/ha
Fertilisation	70 kg N/ha
Sowing date	27 Mar 2017
Harvest date	24 Aug 2017
Hybrids	Archer, G44, MR-Apollo, MR-Buster, DAF experimental, Pioneer experimental
Population densities	30, 50, 70 and 100 K plants/ha
Row configurations	Solid
Row spacing	1 m
Replications	3
In-crop rainfall (mm)	97 mm

What did we find?

- G44, MR-Apollo, Archer and the Pioneer experimental hybrid had yields in the range of approximately 2 – 4 t/ha. However, MR-Buster and the DAF hybrid yielded less than 2 t/ha (Figure 1). Yields of all hybrids responded positively to increases in targeted plant population density (Figure 1). The response was strongest for the Pioneer experimental hybrid, which yielded 6 t/ha at 100 k plants/ha.

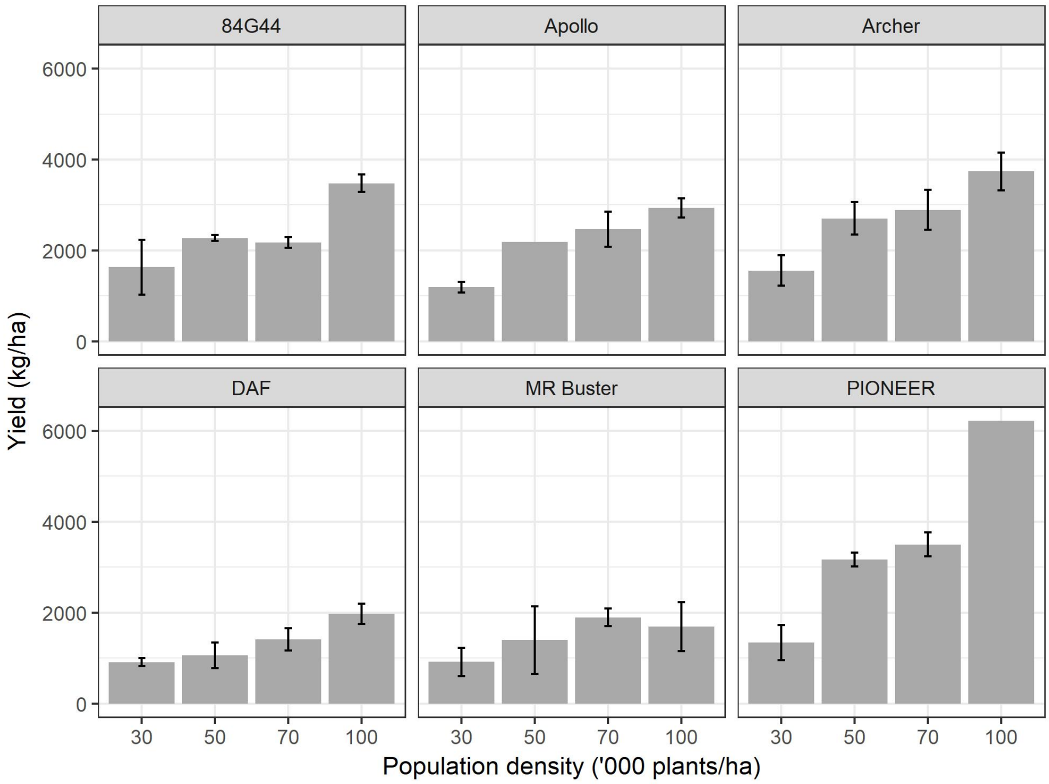

Figure 1. The effect of hybrid and population density on yield. The error bars represent ± one standard error.

- The observed yield trend was affected by low temperatures during a critical period for pollen development (i.e. from the emergence of the last leaf until flowering). Low temperature reduced the number of grains/head (Figure 2) because of reduced seed set (Figure 3). The hybrids with high seed set mostly avoided, rather than tolerated low temperatures, because they flowered 1 – 9 days earlier than MR-Apollo and the DAF experimental hybrid. However, minimum temperatures ranging from 5 to 10 °C occurred during the critical period of pollen development for both MR-Apollo and the DAF hybrid (Figure 4), yet seed set was halved for the latter hybrid (Figure 3). It is thus possible that there is a genetic influence on grain set to cool temperatures.

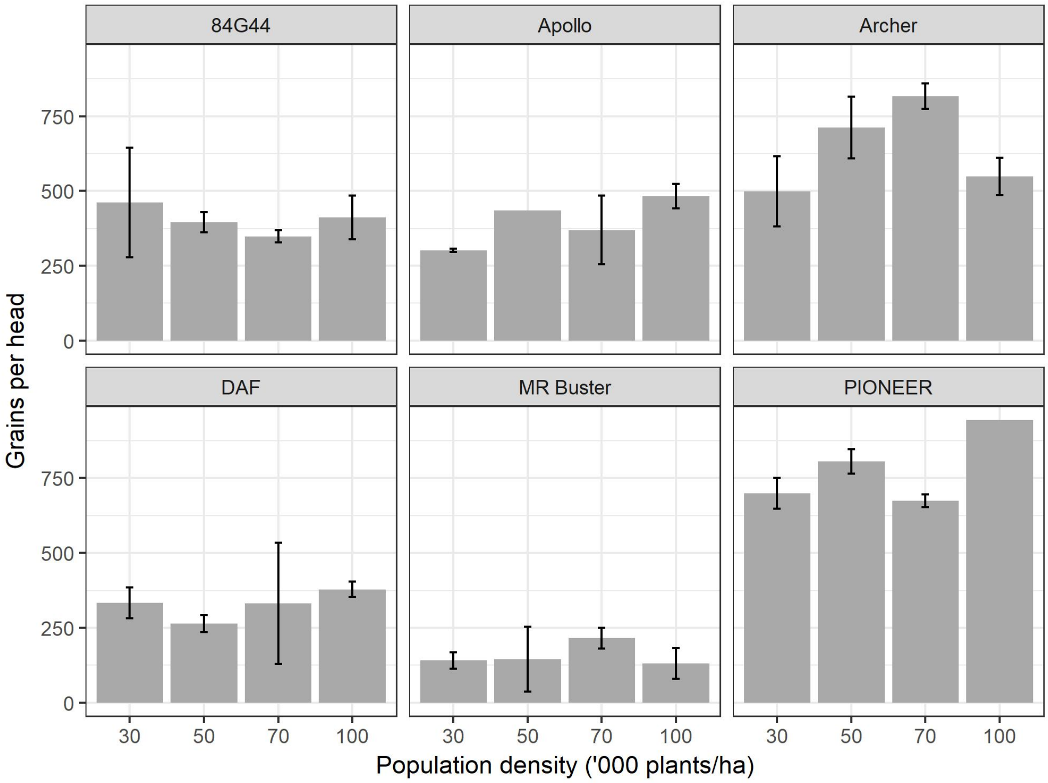

Figure 2. The effect of hybrid and population density on the number of grains per head. The error bars represent ± one standard error.

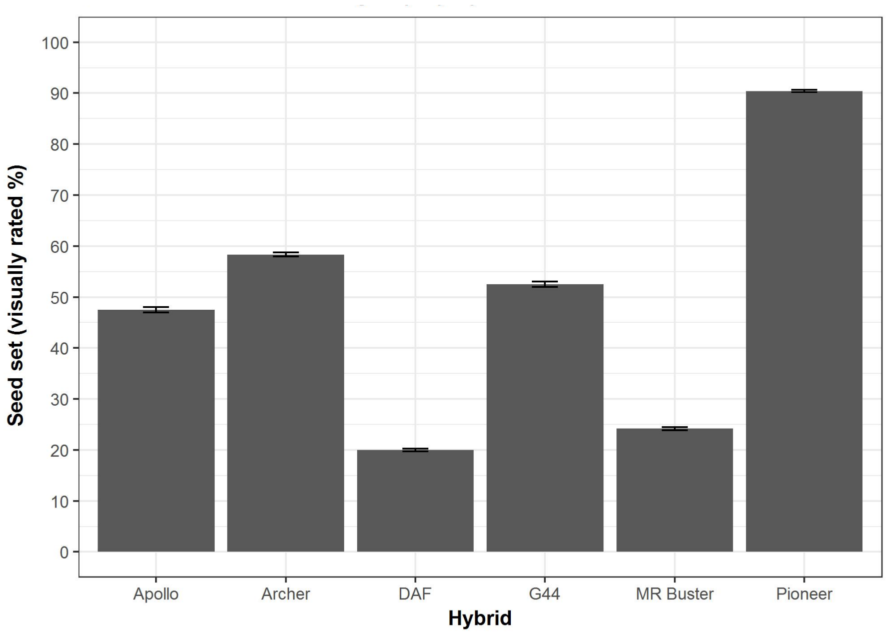

Figure 3. The effect of hybrid on proportion of seeds set per head. The error bars represent ± one standard error.

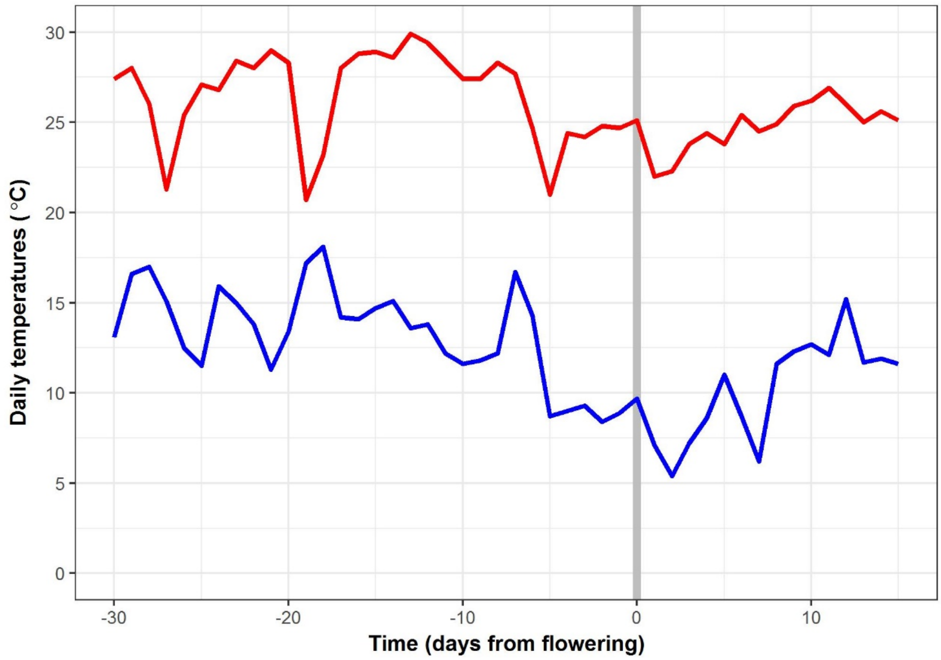

Figure 4. The daily maximum (red line) and minimum (blue line) for period 30 days before and 15 days after flowering (day = 0; grey vertical line) forhigh (MR-Apollo) and low (DAF) seed set hybrids that flowered on the same day.

- At a target population of 30 k pl/ha, MR-Buster produced approximately twice as many heads as the other hybrids due to a high number of fertile tillers. In contrast, the Pioneer and DAF experimental hybrids, along with Archer, showed the lowest number of heads and propensity to tiller in the 30 k pl/ha treatment (Figure 5).

- At a target population of 100 k pl/ha, MR-Buster produced approximately three fertile tillers per plant, whereas one or fewer fertile tillers per plant were typical for the other hybrids (Figure 5).

What does this mean?

- The Emerald low tillering trial is important because it provides a clear example of contrasts in tillering between MR-Buster (a hybrid that has been common in the seed market since the early 1990s) and hybrids being tested for their ability to express the low tillering trait. There is a need to repeat this research on populations of hybrids from the pre-breeding program with greater tillering diversity (i.e. non-tillering to high tillering) from known backgrounds, thereby avoiding confounding effects of background genetics on crop physiology and yield

- Comparison between the Emerald and Macalister low tillering trials demonstrates the important interaction between growing environment and genetic propensity to tiller on the observed number of tillers.

- Due to the impact of chilling on seed-set, yield comparison is only valid between hybrids that flowered on the same day. However, treatment impacts on tillering across hybrids are valid.

- The different seed set percentage between MR-Apollo and the DAF experimental hybrid suggest large differences in chilling tolerance. Further research should quantify this tolerance across a wider range of hybrids.

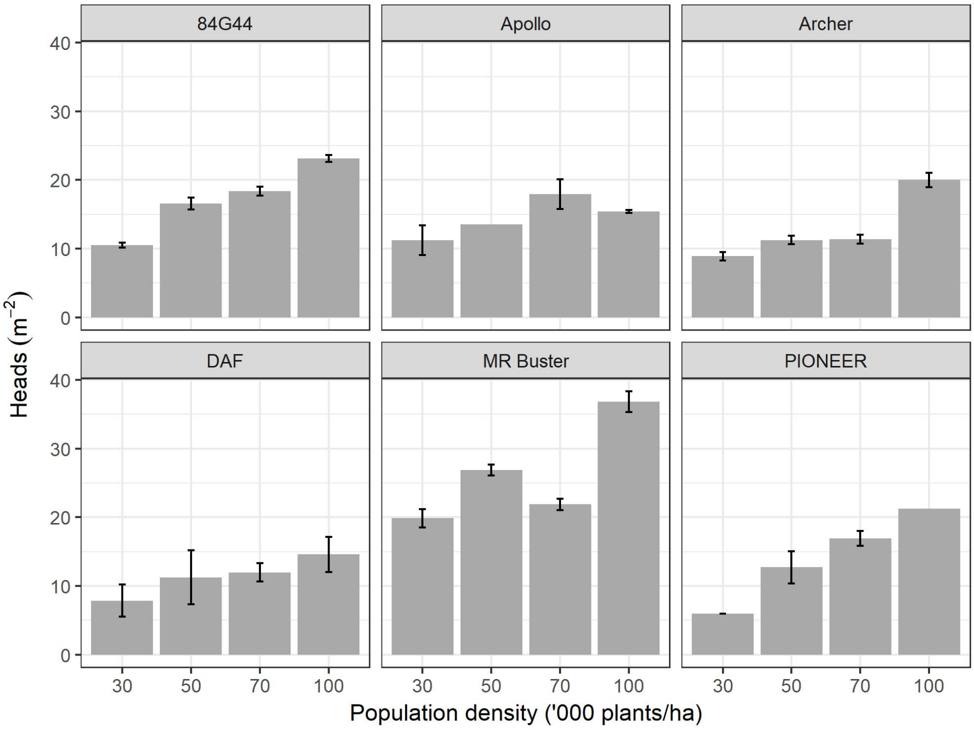

Figure 5. The effect of hybrid and population density on heads per square metre. The error bars represent ± one standard error.