Management and environment dictate tillering in grain sorghum, in combination with genetics.

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Abstract

Tillering in grain sorghum can be either an advantage or a disadvantage, depending on the growing environment and the plant population. The challenge is to match the genetics and management to the site and expected environmental conditions. Commercial hybrids are marketed with information on the level of tillering likely to be expressed.

Three experiments were conducted in 2017-18 at Gurley, Mallawa and Breeza, in Northern NSW under rain-fed conditions, to compare the impact of plant density on tillering in four grain sorghum hybrids. Hybrids were selected based on their levels of tillering from low to high. The industry standard MR Buster was compared to Agitator, Brazen and Archer.

At Gurley and Breeza, four plant densities, 30, 60, 90 and 120,000 plants/ha were targeted. At Mallawa the 120,000 treatment was replaced with 45,000 plants/ha. The row spacing was 100cm at Breeza and Gurley and 150cm at Mallawa.

Total tiller number showed a negative correlation with increasing plant density. Differences in tillering were detected between hybrids, but their tiller level was not consistent with expectations. Archer produced the lowest number of tillers in all three experiments, and Agitator the highest. Differences (in tillering) between the hybrids were also smaller than anticipated. The difference in tillering was greatest at the lowest plant densities (1.5 tillers per plant, between hybrids) and these differences became smaller as plant density increased. There was no impact of plant density on yield at Gurley and Mallawa, or on harvest index across all sites. At Breeza; the mildest growing environment; Archer produced the highest grain yield.

Key Words

Grain sorghum, hybrid, tillering, yield and quality

Introduction

Grain sorghum is the main summer grain crop produced in Northern NSW with 135,000 ha grown in 2015-16 (ABS 2015-16). Sorghum provides important rotational and cash flow benefits to growers across a range of differing environments, from the marginal areas west of Moree, to the high yielding environments of the Liverpool Plains.

If sorghum production was increased, it could play a key role in meeting the demand for feed grains in NE Australia. To enable this to occur both the area planted to sorghum and the yield produced per unit area must be increased (Hammer 2011). Reducing yield gaps (between actual and the achievable rainfed yield) depends on farmers' capacity to identify combinations of hybrids (G) and management (M) that best suit location and seasonal conditions (the environment, E) (Clarke 2018). A key area for potential expansion of sorghum production area is of North West NSW. In addition, increasing the grain yield from the northern slopes and plains of Northern NSW could play an important role in improving the stability of production.

The selection of an appropriate hybrid to optimise performance in each of the production environments is one of the main agronomic decisions which growers make. Hybrid selection is based around a number of criteria including potential yield, maturity and tillering, as well as resistance to disease and insects. Tillering can make a significant contribution to grain yield in sorghum, but is strongly affected by the interaction between the genotype (G), management (M) and the environment (E) (Alam *et al* 2009).

The tillering potential of sorghum hybrids is receiving more attention, particularly in marginal growing environments, where growers are seeking more certainty in relation to the likely number of tillers, and resultant panicles, that will be produced. Tillers can have both positive and negative effects on grain yield and screenings. In more marginal sorghum production environments there is greater interest in hybrids with low tillering, or the possibility of a uniculm ideotype, to reduce the amount of water; utilized during vegetative stages. There is also a greater perceived risk of crop failure or uneconomic yields for high tillering hybrids. The current suite of commercial hybrids is largely classified as moderate to high tillering. Excessive tillering can lead to high tiller abortion, poor grain set and small panicle size, which cause reduced grain yield (Alam *et al* 2009). In contrast, in the more favorable sorghum production zones such as the Liverpool Plains and north east NSW, there is a greater ability to support tillers due to the combination of higher rainfall and lower temperatures.

The primary question in this study was whether hybrids with lower levels of tillering produce improved yields in marginal growing environments and conversely if these hybrids are yield limited in favorable environments. To answer this question we conducted a series of experiments in contrasting environments for heat at flowering and seasonal soil water supply. As plant density and hybrid selection are two of the primary management decisions which growers make prior to sowing, it was decided to test the interactions of these two factors. A group of four hybrids were selected to provide contrasting levels of tillering and included the industry standard MR Buster. Plant densities were selected to provide a range of populations suited to all three environments plus the extremities. Commercially sorghum plant populations range from 40,000 to 60,000 plants/ha in most regions.

Methods

Three rain-fed experiments that investigated the interactions between plant density and hybrid tillering across a range of different environments were conducted in 2017-18. Experiment locations were Gurley (south east of Moree), Mallawa (west of Moree) and Breeza, (Liverpool Plains) in northern NSW.
The three sites chosen are representative of the diversity of sorghum growing environments; Breeza on the favorable Liverpool Plains which has mild temperatures; Gurley; a moderate environment; and Mallawa, an environment prone to heat and moisture stress (Table 1).

Table 1 Rainfall and temperature at three site locations in 2017-18

Location	No. days > 36°C during Dec- Jan (2017-2018)	In-crop rainfall (mm) Sept 2017- March 2018
Breeza	20	261
Gurley	37	296
Mallawa	46	222

Plots were sown with a precision planter on 100cm row spacing at Breeza and Gurley and on 150cm row spacing at Mallawa. Each experiment included four replicates and was designed as a split plot, with population blocked and hybrid(s) randomised.

Four hybrids of contrasting tillering were selected based on company information, MR Buster, Archer, Brazen and Agitator. Public information rates MR Buster as high tillering, Archer as medium, Brazen as low and Agitator as very low tillering. Four plant densities were targeted at Gurley and Breeza (30, 60, 90 and 120,000 plants/ha), while at Mallawa, the highest population (120,000 plants/ha) was replaced with 45,000 plants/ha to recognise the marginal growing environment.

In crop measurements

Plant establishment counts were conducted as well as tiller and head counts at maturity. Dry matter production and harvest index were measured samples taken from two linear metres of row at physiological maturity. Samples were dried in a dehydrator and then weighed.

Grain yield and quality

Grain was harvested using a KEW small plot header. A sub sample was collected from each plot for determination of grain protein, screenings; thousand grain weight and hectolitre weight.

Results

Plant establishment

Significant differences were achieved between actual plant populations at all sites except Mallawa for the 45 and 60,000 plants/ha treatments. At Gurley, the actual plant density was lower than the targeted plant density for all populations. At Breeza, the target population was exceeded except for the 120,000 plants/ha treatment.

Tiller production
The number of tillers per plant varied between treatments and sites (Figure 1). The highest number of tillers (still per plant) was measured at Gurley and the lowest at Breeza. All three sites showed the same trend of reduced tillers per plant as plant density increased.

Archer consistently produced the lowest number of tillers per plant, while Agitator produced the highest number of tillers per plant. The differences in the number of tillers between hybrids at the same population density were small, at most, a difference of 1.5 tillers/ plant.

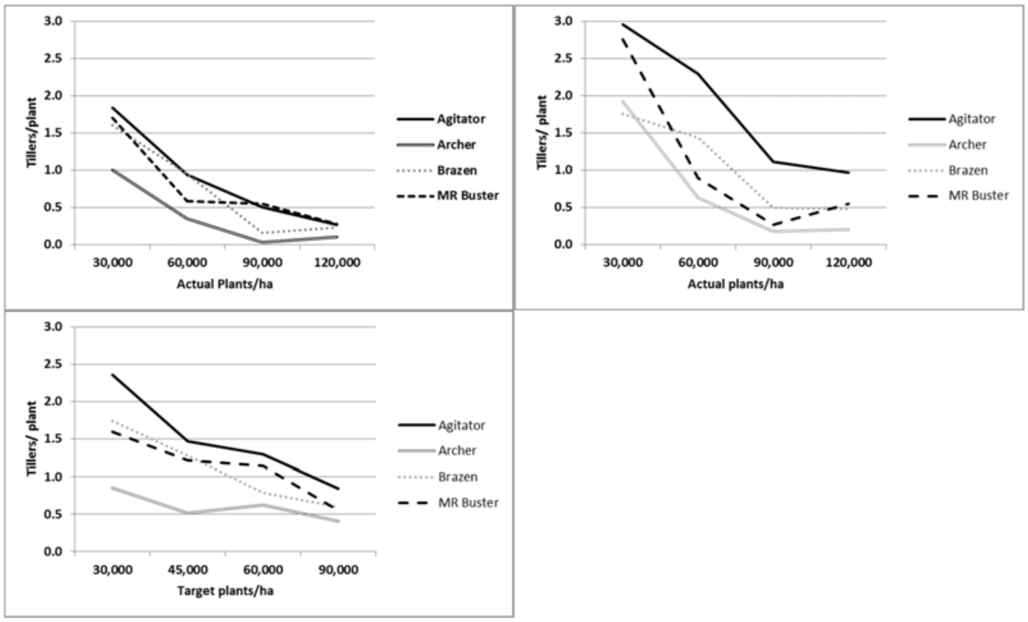

Figure 1. Tillers/plant at the target plant populations, Breeza (top left), Gurley (top right) and Mallawa (bottom)

Comparing tiller number per plant at the 30,000 plants/ha target gave the best indication of the tillering potential for each hybrid (Figure 2). Tiller number per plant at all three sites was quite variable. Agitator and MR Buster, which are considered low and high tillering respectively, performed similarly at most sites. The highest level of tillering occurred at Gurley for all hybrids, except Brazen which was relatively unresponsive. This is consistent with an expectation of higher tillering where rainfall and sunlight are not limiting. In this study Gurley received 296mm of in-crop rainfall, and multiple hot, sunny days to promote tiller production.

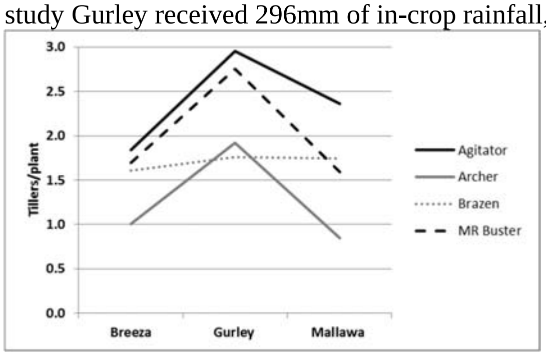

Figure 2 Response of hybrids to tillering at 3 locations using 30,000 plants/ha

Grain yield and harvest index
Average yields of 4.23 t/ha, 4.16 t/ha and 1.08 t/ha were recorded at Breeza, Gurley and Mallawa, respectively. No significant differences were found between any of the treatments or their interactions at Gurley and Mallawa. In contrast, at Breeza, Archer produced higher yields (5.12 t/ha) than the other three hybrids, MR Buster (4.30 t/ha), Agitator (3.78 t/ha) and Brazen (3.70 t/ha).
The harvest index of each plot was measured using biomass samples collected at physiological maturity. At all three sites, there was no significant difference in the harvest index between differing plant densities. However, there were differences in the harvest index between hybrids (Table 2) at all three sites. The Gurley and Breeza sites had similar harvest indexes, all of which were high. At Breeza and Gurley, MR Buster and Archer had a higher harvest index than the other two hybrids. The Mallawa site had a much lower harvest

index than the other two sites, which is consistent with the lower grain yields and the observations of moisture stress at the site during the growing season.

Table 2. Effect of hybrid on harvest index at Breeza, Gurley and Mallawa

Hybrid	Breeza	Gurley	Mallawa
Archer	0.53a	0.48a	0.27ab
MR Buster	0.52a	0.54a	0.26ab
Agitator	0.49b	0.46b	0.31a
Brazen	0.44c	0.46b	0.21b
LSD(P=0.05)	0.03	0.02	0.06

Conclusion

These results show that there are relatively small differences in the tillering capacity of the four commercial hybrids used in this experiment (MR Buster, Agitator, Archer and Brazen), even though they are described as hybrids with very low through to high tillering. Further, the genetic differences in tillering can be manipulated by altering plant densities. For the four hybrids tested here, the number of tillers produced declined as plant density increased at all three experimental sites.

The inherent plasticity in sorghum provided by tillering resulted in stable grain yields across varying plant densities, meaning no significant differences in grain yield for almost all treatments and sites.
The ability to select hybrids with defined levels of tillering is not yet possible in the Australian sorghum industry. Interactions between genetics, environment and management prevent this. There were greater differences in the level of tillering produced between the experimental sites than there was within each site, even though established plant densities varied more than three-fold.

While seed companies provide indications of the tillering capacity of a hybrid, these results indicate that these tillering scales should be considered with caution as they are subject to change in individual situations, sometimes significantly. Also, commercial scales cannot be used to compare hybrids as the definition methods are not consistent between companies.

In conclusion, growers should seek additional information on the likely tillering of hybrids in their local environment, and under their management, prior to planting. Ultimately, in current commercial hybrids, a combination of management, environment and genetics is what dictates the level of tillering in sorghum, not one aspect alone. Further analysis of this data set is required to investigate the relationships between established plant populations, hybrid genetic tillering potential and environmental factors such as the availability of water to the crop, in crop rainfall and median temperatures to flowering for example.

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