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Manipulating maize genetics and agronomy for improved yield and reliability in northern NSW – Breeza 2017/18

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Key findings

- Early planting into a soil temperature of less than 10 °C, which is lower than the industry recommendation of 12° C, did not affect plant establishment at this site in this season. Further research is needed to validate these results and allow for consideration of the effects in different seasons when frosts can occur around sowing.
- Varying the sowing date from early August to late August or to mid-September did not affect grain yield.
- There was no significant difference in grain yield between the three hybrids included in this experiment: Pioneer® P1467, Pioneer® P1756 and PAC 606IT.
- The optimum plant density for all hybrids was determined as 8.4 plants/m^2 where the predicted yield for the three times of sowing was 7.2–7.7 t/ha.

Introduction

Dryland maize is a minor summer grain crop in northern NSW, due to the high risk of crop failure or uneconomic yields due to variable seasonal conditions. The major challenges that growers currently face relate to a lack of information on how to mitigate these risks through optimising agronomic decisions such as sowing time, plant population, hybrid type and crop nutrition. Ensuring that the crop can reliably produce an economic yield is a critical factor influencing growers' decisions to plant maize and also affects industry size.

This research focuses on two key factors that influence crop reliability and performance:

1. silking and tasselling synchronisation in an environment prone to extreme heat and moisture stress during the summer
2. trying to manipulate the interactions between crop genetics and agronomic decisions to improve grain yield and quality.

This experiment was designed to evaluate options to manipulate pollination and grain fill timing to avoid peak heat windows. It also aimed to provide information on ways to improve the crop's harvest index (HI – the ratio of grain produced compared with the amount of dry matter produced) through managing unproductive biomass accumulation and water used.

The experiment can be posed as the following question: Can maize reliability and yield be improved through selecting more suitable hybrid types (e.g. varying multi-cobbing and tillering propensity) and biomass management (e.g. through varying sowing time and plant population)?

The same experiment was conducted at Mallawa, west of Moree and Gurley, east of Moree to provide data on the responses to varying sowing time, population and hybrid type in different environments.

Site details

Location	Breeza – Liverpool Plains Field Station
Co-operator	NSW Department of Primary Industries.

Soil type and nutrition	The site was cored before sowing to establish starting nutrition and water. The starting soil water was 188, 220 and 218 mm of plant available water for times of sowing date (SD) one, two and three respectively.

Table 1 Site soil chemical characteristics – Breeza 2017/18.

Characteristic	Depth (cm)				
	0–10	10–30	30–60	60–90	90–120
pH_{Ca}	7.7	7.4	8.0	8.0	8.2
Nitrate nitrogen (mg/kg)	11	18	11	5	4
Phosphorus (Colwell) (mg/kg)	37	17	14	20	27
Potassium (Colwell) (mg/kg)	454	268	226	234	265
Sulfur (mg/kg)	4.9	10.8	13.0	16.3	26.6
Organic carbon (OC) (%)	1.11	0.77	0.68	0.56	0.39

Rainfall	A total of 272 mm rainfall was recorded at the site from August 2017 through to the end of February 2018 (Table 2). There was very little rain during August and September, so there was little difference in the in-crop rainfall regardless of the sowing date. SD1 and SD2 received 258 mm of in crop rain, whilst SD3 received 253 mm.

Table 2 Rainfall (mm) during the growing season – Breeza 2017/18.

Month	Aug 2017	Sept 2017	Oct 2017	Nov 2017	Dec 2017	Jan 2018	Feb 2018	Total (mm)
Rainfall (mm)	14.0	5.0	92.0	56.0	54.0	10.0	41.0	272.0

	Experiment design	A split, split plot design was used with sowing date blocked, plant population blocked and hybrid randomly allocated. Three replications were used.
	Fertiliser	50 kg/ha Granulock Supreme Z was applied with the seed at planting. 200 kg/ha urea applied as a side band at planting.
	Harvest dates	SD1: 9 March 2018 SD2: 9 March 2018 SD3: 12 March 2018
Treatments	Sowing time (3)	Three target soil temperatures at sowing: 10 °C, 14 °C and 16–18 °C were used. This resulted in the following sowing dates and soil temperatures (presented as an average of seven days post sowing) in 2017. SD1: 9 August 2017 at 9.7 °C SD2: 28 August 2017 at 10.8 °C SD3: 20 September 2017 at 15.8 °C
	Plant populations (4)	Four plant populations targeting 1.5, 3.0, 6.0 and 12.0 plants/m^2.
	Hybrids (3)	Pioneer® P1467, Pioneer® P1756, PAC 606IT

Results

Plant establishment

There was no difference in plant establishment between sowing date or hybrids. Established populations were higher than the target except for the 12 plants/m^2 treatment, which achieved 9.3 plants/m^2 (Figure 1). The reduced establishment for the highest population target was due to an inability to achieve a higher sowing rate on the planter, so only 11 seeds/m^2 could be sown with the highest setting.

The lack of statistical difference in plant establishment between the three SDs indicates that soil temperatures as low as 10 °C can be successfully used to establish maize.

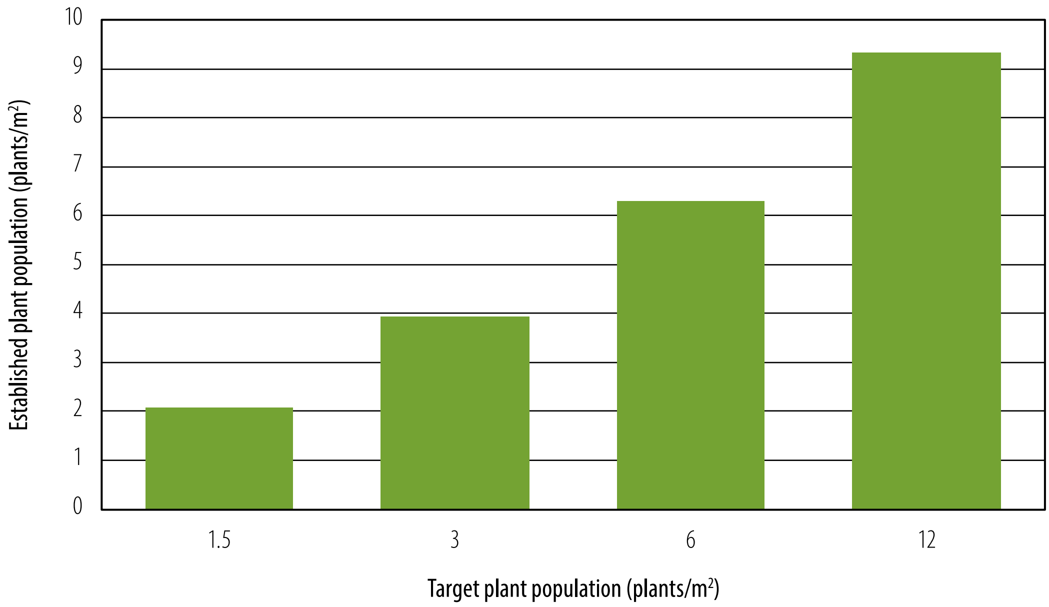

Figure 1 Target versus established plant population in maize – Breeza 2017/18.

Frost risk needs to be considered for the next stage of plant growth – from seedlings to flowering. Planting earlier in the season could expose the crop to higher frost risks, thereby increasing the chances of plant damage or death. In this season, there were 21 frosts (below 0 °C at screen height) in the 40 days following SD1 (Figure 2). There was no effect on maize plants, even though a –2.2 °C frost was recorded on 15 September, 10 days after the first plants from SD1 were starting to emerge.

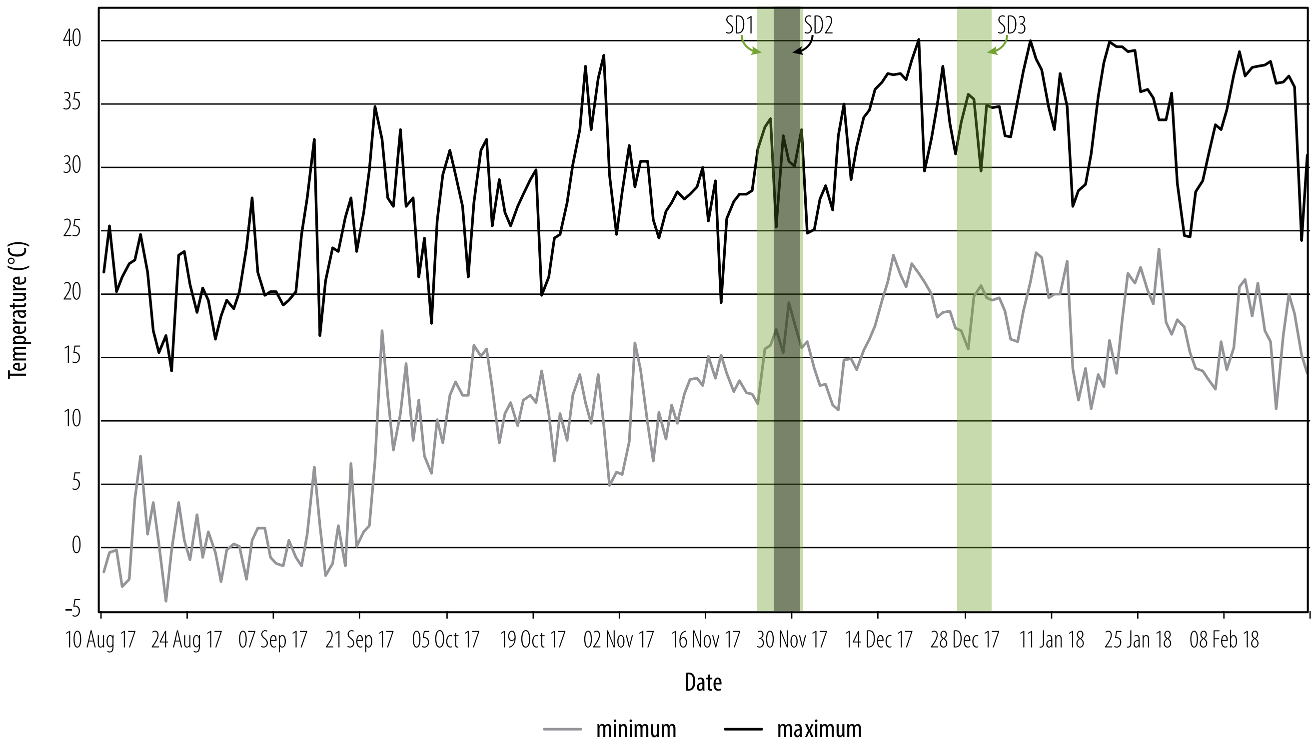

Figure 2 Maximum and minimum temperatures at screen height – Breeza 2017/18.

Flowering

The number of days taken to reach 50% flowering was recorded for each treatment (Table 3). There was a significant reduction in the time taken to reach flowering between SD1 and SD2 from 112 days to 97 days respectively, and then a lengthening for SD3 back to an average of 102 days. The three hybrids differed in their length to flowering with PAC 606IT being the quickest.

Table 3 Days to 50% flowering of maize treatments – Breeza 2017/18.

Sowing date	Target plant population (plants/m²)	Pioneer® P1467	Pioneer® P1756	PAC 606IT
SD1	1.5	118	112	109
	3	117	112	108
	6	117	115	109
	12	115	109	109
SD2	1.5	98	98	94
	3	98	95	93
	6	98	98	95
	12	98	98	97
SD3	1.5	105	104	98
	3	105	104	98
	6	105	102	99
	12	105	101	99

Sowing at either SD1 or SD2 allowed the crop to flower before the peak heat of the season as shown by the shaded boxes in Figure 2. For SD3 however, the critical stages of silking and tasselling were reached during the heat of late December when temperatures were in the mid to high °C 30s.

Grain yield

There was no difference in grain yield between the three SDs or between the hybrids. However, there was a significant response to plant density for all treatments (Figure 3). Based on this, a common optimum plant density was determined at 8.4 plants/m^2 at this yield level for the three SDs, which were predicted to yield between 7.2–7.7 t/ha. Established populations above or below the optimum produced reduced yields.

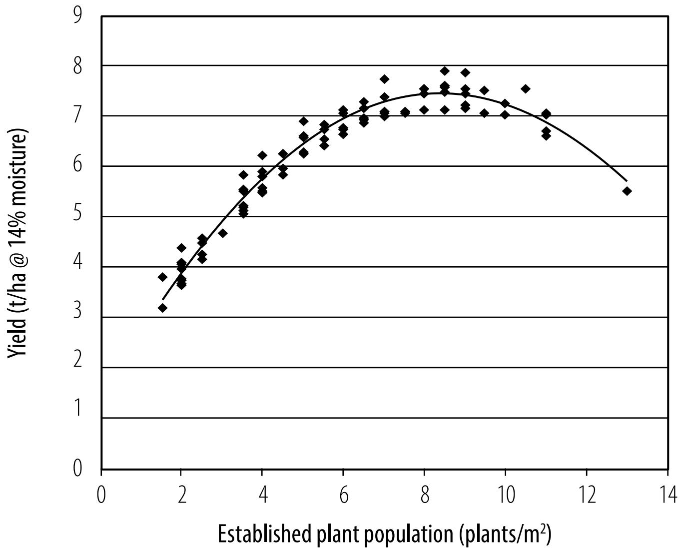

Figure 3 Grain yield response to varying plant population and sowing time in maize – Breeza 2017/18.

Grain quality

Grain quality testing was conducted for the following factors: protein content, screenings, test weight and 1000 grain weight.

Protein

Sowing dates had a significant effect on grain protein, with the protein content declining as the sowing date became earlier. Sowing in September produced a significantly higher protein of 11.3% than sowing in early or late August, which produced grain of 10.7% and 11.0% protein respectively. There was also an interaction between hybrid and plant population on grain protein, with protein levels declining as population increased (Figure 4).

Screenings and 1000 grain weight

Sowing date had no effect on screenings levels; however, there was a response to plant population (data not shown). The highest population, a target of 12 plants/m^2 had significantly higher screenings levels than all other plant populations, however, all levels were still below 1%. Similarly, there were differences between the hybrids tested, with Pioneer® P1756 having higher screenings, but again all screenings were below 1%. The highest population also had significantly higher 1000 grain weight.

Test weight (kg/hL)

There was an interaction between SD, hybrid and plant population. Pioneer® P1756 had the highest test weight of the three hybrids and PAC 606IT the lowest. Test weight also tended to increase with plant population up to 6 plants/m^2 and then reached a plateau, with the exception of PAC 606IT, which showed a trend of continued increase (Figure 5).

Harvest index (HI)

There was a very strong correlation between HI and grain yield; as grain yield increased so did HI (Figure 6). There was no clear correlation between either SD, plant population or hybrid to explain the HI results.

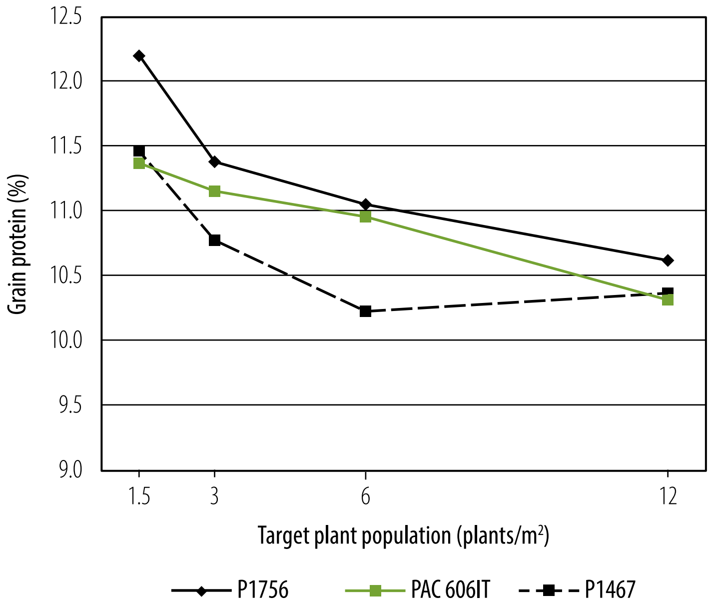

Figure 4 Effect of plant population and hybrid on grain protein – Breeza 2017/18.

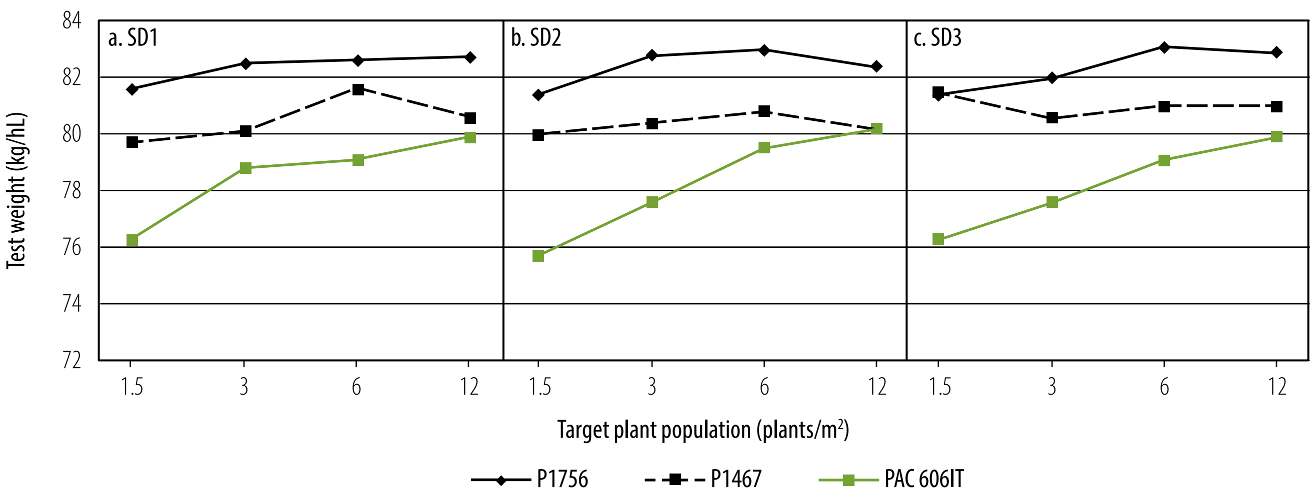

Figure 5 Interaction between hybrid and target plant population at each sowing date: (a. SD1, b. SD2, c. SD3) – Breeza 2017/18.

Conclusions

The results from the Breeza site support the possibility of moving the sowing window for maize forward to allow planting in cooler soil conditions than currently recommended, without suffering establishment losses. Additional experiments conducted over multiples seasons with more frosts and having greater intensity would help to build confidence in these results.

In this environment in this season, moving the sowing window forward did not affect grain yield. Therefore, the decision to plant earlier this year would be largely based on access to good sowing moisture without needing to wait for soil temperatures to reach 12° C and rising. The experiment produced a significant response to varying plant population with grain yield being optimised at 8.4 plants/m^2.

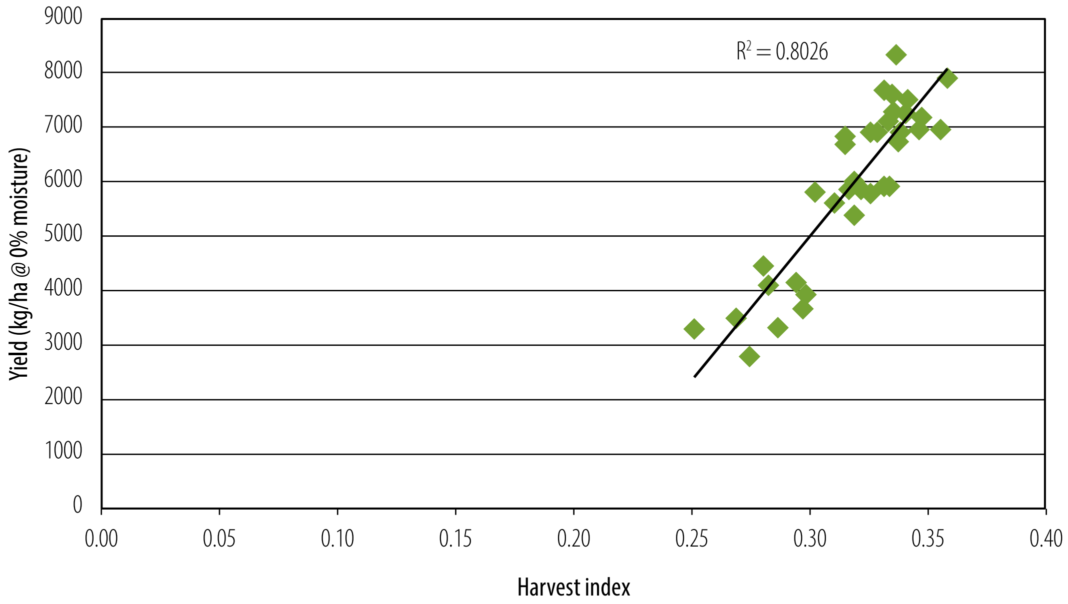

Figure 6 Correlation between grain yield and harvest index – Breeza 2017/18.

Varying plant population did affect grain quality attributes, with screenings and test weight being higher at the target population of 12 plants/m^2.

There was also an effect on grain protein, with levels increasing as sowing was delayed from early to the recommended time. There was a range in the HIs found at this site; however, no trends with SD, plant population or hybrid could be identified.

Importantly, these results show that sowing earlier than traditionally planned moved the flowering and grain fill window forward to late November/early December, which allowed the crop to avoid the main period of high temperatures. Long-term seasonal data indicates generally lower temperatures in late November than in late December. Realistically however, climate variability means there is no guarantee of average conditions in every season.

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