BSES Limited

FINAL REPORT – SRDC PROJECT BSS296

EVALUATION OF GENOTYPES FOR A CONTROLLED TRAFFIC FARMING SYSTEM

by

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SD12001

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SUMMARY

The Sugar Yield Decline Joint Venture concluded that, in order to improve soil health, the sugar industry should break the monoculture using fallow legume crops, adopt controlled traffic and reduce soil cultivation. Controlled traffic can be achieved on any row configuration as it requires the matching of machinery and row spacing. Currently, however, the majority of harvesting machinery has a track/wheel spacing of 1.8 - 1.9 m. With many growers adopting these wide-row configurations there was a concern that the available cultivars would not be suitable. This was due to the majority of selection in the plant-breeding program being conducted on a 1.5 m single-row configuration and recent evidence of a significant cultivar-by-row-configuration interaction.

BSS296 was undertaken to determine whether a cultivar's performance did change significantly over different row configurations, understand the physiological mechanisms of the response, identify genotypes in the final stages of selection that performed well on wide-row configurations, and ultimately further the adoption of controlled traffic. This was done by establishing two types of experiments. Firstly, the performance of current commercial cultivars was assessed over three row configurations at five sites throughout the sugar industry (Bundaberg, Mackay, Burdekin, Ingham and Meringa). Secondly, a large number of un-released genotypes were assessed over three row configurations at three sites with different environmental conditions (Meringa, Ingham and the Burdekin).

It was clear from all experiments that current cultivars are suitable for different row configurations. No cultivar-by-row configuration interaction was found in any experiment. This suggested that if you select a cultivar that performs well at a particular site, it will perform well on all row configurations. It also indicated that cultivars that perform well on wide-row configurations would make it through the selection system in the plant-breeding program. Clearly, a significant interaction effect reported previously does not always occur. In addition to this, the genotype term was shown to consistently account for substantially more variation than the genotype-by-row-configuration interaction term in all experiments. This indicated that there were large differences among genotypes but only a small difference as to how the genotypes performed over different row configurations. Genotypes that performed well at a site did so across row configurations. Therefore, selection of genotypes could be conducted on any row configuration.

Row-configuration effects were found at some sites. This was mostly attributed to low yield on the 1.8 m single-row configuration, associated with low stalk numbers when environmental conditions were limiting. While low stalk numbers were compensated for by increased stalk weight, in some cases the compensation was not sufficient to prevent a yield effect. Dual-row configurations maintained yield at wide row spacings. They consistently produced greater stalk populations than the two single-row configurations, particularly early in development, but this did not translate into increased yield. Low planting rates in experiments may have contributed to row-configuration effects, particularly when unfavourable environmental conditions were encountered during establishment. These issues need to be addressed in order to achieve greater adoption of controlled traffic.

Cultivars were shown to grow in different ways. Some were characterised by vigorous early growth, often associated with high stalk numbers, whereas others developed more slowly and consistently during the crop. No evidence was found to suggest that any one particular growth pathway (trait) would be best suited to a certain row configuration. It is likely that different growth pathways would be suited to different environments or harvesting times. Understanding how cultivars develop and what development pathways allow for better adaptation to particular environments may offer some gains to the industry.

1.0 BACKGROUND

The Sugar Yield Decline Joint Venture (SYDJV) concluded that, in order to improve soil health, the sugar industry should break the monoculture using fallow legume crops, adopt controlled traffic and reduce soil cultivation. These measures were designed to improve the soil physical, chemical and biological characteristics leading to improved production and reduced costs over time. Controlled traffic confines compaction to the inter-row region leaving the region occupied by the crop un-compacted. Reduced compaction results in improved soil physical/structural characteristics (Bell *et al.,* 2001; Braunack *et al.,* 2003).

Controlled traffic can be achieved on any row configuration as it requires the matching of machinery and row spacing. Currently, however, the majority of harvesting machinery has a track/wheel spacing of 1.8 - 1.9 m. This does not match ~ 1.5 m row spacings that dominate the industry. Therefore, in order to achieve controlled traffic, either the machinery would need to be altered to match the 1.5 m row spacing or the row spacing should be altered to match the machinery. Changing the row spacing was the most likely option.

Maintaining yield on row spacings wider than 1.5 m was the cause of some concern and has limited adoption of controlled traffic in some regions. Ridge and Hurney (1994) showed that there was a significant loss in yield if single rows were planted wider than 1.65 m. This could be overcome by planting dual-row configurations. More recent work has shown that wide row spacings do not result in a significant loss in yield (Garside *et al.,* 2005; Garside *et al.,* 2006; Bell *et al.,* 2007). However, single rows planted on wide row spacings with double-disc-opener planters sometimes produce slightly lower yields (often not statistically significant) in the plant crop (Garside *et al.,* 2005; Garside *et al.,* 2006). Some growers have overcome this concern by widening the planting boards on conventional planters.

Given the concern with yield on wide row configurations, it was hypothesised that some cultivars may perform better on wide-row configurations than others. Garside *et al.* (2006) found a highly significant cultivar-by-row-configuration effect at a trial near Gordonvale which was grown under supplementary irrigation. This was due mainly to the poor performance of Q200$^{\phi}$ on 1.8 m row spacings compared with Q201$^{\phi}$. The performance of the two cultivars was very similar when grown on 1.5 m single and 2.3 m dual-row configurations. This result suggested that 1.5 m row spacings cannot be used to select clones for wider configurations. Conversely, Bell *et al.* (2007) did not find a significant cultivar-by-row-configuration interaction when four clones were grown on five configurations under full irrigation in a trial near Bundaberg. Roach (1977) also reported a non-significant cultivar-by-row-configuration effect when four clones were grown on 1.5 m single and 1.5 m dual-row configurations. Results such as these suggest that the row configuration used during the selection process may not have any impact on which genotypes are eventually released.

Many sugarcane growers have now adopted wider row configurations in order to reduce compaction and on-farm costs. An estimated 10% of cane is currently produced using controlled traffic and the proportion is increasing (Salter *et al*., 2010a). However, the BSES plant-breeding program uses 1.5 m single rows during the selection process. Would different genotypes get released if the breeding program was using wider row configurations and are the current cultivars suitable for the wide-row configurations required in order to achieve controlled traffic?

2.0 OBJECTIVES

The project aimed to:

- Assess whether there is an interaction between cultivar and row spacing in the dominant/newly released sugarcane cultivars grown in the Northern, Herbert, Burdekin, Central and Southern regions
- Determine which dominant/newly released cultivars are best suited to controlled traffic (1.8 - 1.9 m) row spacing in each region
- Identify the physiological mechanisms that are important in determining varietal response to row spacing
- Identify traits associated with high productivity in standard (1.5 m) and controlled traffic (1.8 - 1.9 m) row spacings
- Facilitate further adoption of controlled traffic by promoting cultivars that perform well on 1.8 - 1.9 m row spacings
- Carry out an exploratory assessment of clones in the final stages of assessment (FAT) to develop suitable procedures for selection for controlled traffic row spacing

The following potential outputs and outcomes were highlighted in the project proposal:

Outputs

- Knowledge of the performance of key cultivars on different row formats in each region
- A better understanding of the physiology that controls performance on different row formats
- Identification of clones in FATs that perform well on wider row spacings
- An understanding of the genotype (cultivar/clone)-by-row-format interaction
- An understanding of which traits may be used to predict performance on wider row formats
- Cultivars that further enhance the profitability of the new farming system will be identified
- Clones nearing release will be rated for their response to different row spacings

Outcomes

- Cultivars with the necessary traits for wider row farming will be available
- Greater adoption of improved farming systems will occur through facilitating adoption of controlled traffic
- Control traffic will reduce soil compaction of the cropping area which will facilitate soil health improvements, better timeliness of operations, reduce fossil fuel use, less labour input and generally more sustainable and environmentally responsible cropping system
- The plant-breeding program will be able to assess whether the current system of selection is suitable for wider row farming systems
- Social benefits would follow from a more sustainable and profitable farming system

3.0 METHODOLOGY

3.1 Experimental program

The experimental program initially consisted of three proposed components:

1. **Cultivar experiments**: Four to six cultivars in each region (Meringa, Ingham, Burdekin, Central and South) were assessed on 1.5 m single, 1.8 m single and 1.8 m dual-row configurations. Cultivars differed among regions. Prominent, new and where possible smut resistant cultivars were selected. In the Burdekin region Q117 and Tellus$^{\Phi}$ were specifically included in the experiment due to their particular growth traits: Q117, large erect stalks; Tellus$^{\Phi}$, slow early development. An intensive sampling program was implemented to allow adequate interpretation of differences that emerged.

2. **Clone experiment**: 48 clones from Final Assessment Trials (FATs) were assessed on three row configurations at Meringa. This allowed a better assessment of possible genotype-by-row-configuration interactions and may have identified clones that required further evaluation for wider row planting.

3. **Physiology experiment**: Six clones, three each for positive and negative interactions from the clone trial at Meringa were to be assessed in a trial to identify physiological traits for more effective selection of clones adapted to wide row configurations.

Following analysis of the plant-crop data from the Meringa clone experiment, the program was altered. This was done after discussions were held at a meeting of the project researchers and grower reference group. The physiology experiment was not established as there was no indication of a significant genotype-by-row-configuration interaction term. It was therefore not possible to specifically select clones that had performed better on controlled-traffic row configurations and compare their physiological attributes to clones that did not perform well on controlled-traffic row configurations. A further two experiments containing 20 clones, selected from the Meringa trial, were planned, one in a wet rain-fed environment and the other in a dry irrigated environment (Burdekin). These new experiments were proposed in order to test a large set of genotypes in different environmental conditions to those experienced at Meringa. These experiments would determine whether the result obtained at Meringa was stable across environments.

A description of the experimental and management practices at all experiments is shown in Tables 1 and 2. Planting rates were not uniform for all configurations. The dual-row configuration received twice the planting material of the 1.85 m single-row configuration. The same planting rate per linear metre of row was used for the two single-row configurations. This resulted in a higher planting rate on the 1.52 m single configuration per unit area. For all experiments, billets were effectively planted end to end as only 1 linear metre of cane was planted for each linear metre of row, as is the case for most plant-breeding trials. Experiments were fertilised according to 'Six Easy Steps' recommendations for each region (Wood *et al*., 2003; Schroeder *et al*., 2005), using regional yield potentials of 120, 120, 180, 130 and 120 t/ha for Meringa, Ingham, the Burdekin, Mackay and Bundaberg, respectively. The Burdekin crop also received an application of mill-mud prior to planting (150 wet t/ha). Row configurations received nutrient at the same rate per unit area. Herbicide applications were uniform across row configurations and varied at each site depending on weed species pressure.

Table 1 − Description of cultivar experiments

Trial*	Genotype	Row config.	Planter	Land prep.	Design	Plot size	Planting date
Bundaberg -24^{o}54′46.5″ 152^{o}04′29.8″	Q151 Q190$^{\Phi}$ Q208$^{\Phi}$ Q232$^{\Phi}$	1.5 m single 1.8 m single 1.8 m dual (500)	DDOP DDOP DDOP	Planted flat + hill-up	Split block	6 rows x 25 m	13 – 17 September 2007
Mackay -21^{o}18′5.3″ 149^{o}00′7.5″	Q190$^{\Phi}$ Q200$^{\Phi}$ Q208$^{\Phi}$ Q209$^{\Phi}$	1.5 m single 1.8 m single 1.8 m dual (500)	DDOP DDOP DDOP	Pre-formed beds	Split block	6 rows x 25 m	13 – 15 September 2006
Burdekin -19^{o}33′41.2″ 147^{o}19′16.1″	Q117, Q171$^{\Phi}$ Q200$^{\Phi}$ Q208$^{\Phi}$ KQ228$^{\Phi}$ Tellus$^{\Phi}$	1.85 m single 1.85 m dual (450)	DDOP DDOP	Pre-formed beds	Split block	9 rows x 23 m	9 – 14 May 2007
Ingham -18^{o}45′31.3″ 146^{o}09′37.5″	Q135 Q174$^{\Phi}$ Q183$^{\Phi}$ Q200$^{\Phi}$	1.63 m single 1.83 m single 1.83 m dual (450)	Mouldboard DDOP DDOP	Planted flat + hill-up	Split plot	6 rows x 25 m	1 – 9 August 2006
Meringa -17^{o}04′20.7″ 145^{o}47′42.8″	Q186$^{\Phi}$ Q200$^{\Phi}$ Q201$^{\Phi}$ Q220$^{\Phi}$	1.52 m single 1.85 m single 1.85 m dual (500)	Mouldboard Mouldboard Mouldboard	Planted flat + hill up	Split block	6 rows x 30 m	15 – 24 August 2006

* Co-ordinates for actual trial site
Value in brackets represents spacing (mm) between dual rows
Double-disc-opener planter (DDOP)

Table 2 − Description of clone experiments

Trial*	Genotype	Row config.	Planter	Land prep.	Design	Plot size	Planting date
Meringa - 17°04′26.6″ 145°47′41.8″	46 clones + Q208$^{\Phi}$ and Q200$^{\Phi}$	1.52 m single 1.85 m single 1.85 m dual (500)	Mouldboard Mouldboard Mouldboard	Planted flat + hill up	Randomised block	4 rows x 15 m	1 – 10 August 2007
Ingham - 18°37′14.7″ 146°10′7.7″	19 clones + Q208$^{\Phi}$	1.52 m single 1.85 m single 1.85 m dual (450)	DDOP DDOP DDOP	Planted flat + hill up	Split block	4 rows x 10 m	13 – 16 July 2009
Burdekin - 19°35′46.0″ 147°18′16.4″	19 clones + Q208$^{\Phi}$	1.52 m single 1.85 m single 1.85 m dual (450)	DDOP DDOP DDOP	Pre-formed beds	Split block	4 rows x 10 m	10 – 12 August 2009

* Co-ordinates for actual trial site
Value in brackets represents spacing (mm) between dual rows
Double-disc-opener planter (DDOP)

3.1.1 Cultivar experiment methodology

In general, the same sampling procedure was followed at all experimental sites. Stalk counts and biomass samples were collected over time during the plant crop. First-ratoon crops were sampled at final harvest.

3.1.1.1 Stalk population

Sub-plots (15 m^2) were marked out in the centre of two rows. Regions with even germination were chosen within the plot. Shoots were counted in these sub-plots over time.

3.1.1.2 Biomass sampling

At ~ 4 months after planting, stalks in a 15 m^2 sub-plot, that had been marked soon after germination, were counted, cut at the base by hand, and weighed to ascertain fresh biomass. A sub-sample was taken from each plot, mulched, weighed and placed in an oven set at 70°C until a constant dry weight was attained. This was used to determine moisture content. A similar procedure was followed at 8 and 12 months (final harvest) after planting.

However, additional data were collected from a 20-stalk sub-sample that was taken from the harvested sub-plot. These 20 stalks were partitioned into two components: millable stalk, and green leaf and cabbage. This was done by removing the top of the stalk between the fifth and sixth dewlap. Dead leaves were stripped from the millable stalk and discarded, green leaves were included with the green leaf and cabbage component. Each component was weighed separately and used to calculate percent millable stalk. This percent was then applied to the plot biomass to get a millable stalk weight for the plot. A sub-sample of each of these components was mulched, weighed and placed in an oven set at 70°C until a constant dry weight was attained.

A six-stalk sample was also collected for quality component analysis during the 12-month biomass sampling. Quality components were determined using either the SpectraCane system (Berding *et al.,* 2003) or the small-mill technique.

3.1.2 Clone experiment methodology

Due to the size of the clone experiments, sampling in a similar manner to the cultivar experiments was not possible given the resources available.

3.1.2.1 Stalk population

In the plant crops, a stalk count was conducted close to the maximum shoot population and again at final harvest. This was done by counting stalks in two 2 m section of row within each plot.

3.1.2.2 Yield components

At final harvest, 10 sound stalks were cut from each plot (plant crops only). The fresh mass of these stalks was recorded. Stalks were then partitioned into two components: millable stalk, and green leaf and immature stalk. This was done by cutting tops between the 5^{th} and 6^{th} dewlap or the 8^{th} and 9^{th} dewlap (counting the flag leaf) if the stalk had flowered. The fresh mass of each component was measured and percent millable stalk was calculated. Stalk length (cm) and diameter (mm) of each millable stalk was recorded at Meringa and Ingham. Stalk diameter was measured at the middle of the internode half way up the stalk. Heavy lodging of the Burdekin crop made stalk length and diameter measurements impractical. Each plot in the Burdekin was given a lodging rating (1 erect – 5 completely lodged). This was not necessary at Meringa and Ingham as all plots were erect.

3.1.2.3 Mechanical harvest

Cane yield (TCH) at harvest was measured by weighing the middle two rows of each plot using a commercial cane harvester and a haul-out bin mounted on load cells. Commercial cane sugar (CCS) was measured from a six-stalk subsample using near infra-red spectroscopy (NIR) at Meringa (Berding *et al*., 2003; Berding and Marston 2010) and the small-mill technique at Ingham and the Burdekin. Sugar yield (TSH) was calculated as

$$TSH = CCS*TCH/100$$

3.2 Extension of research outputs

Extension activities conducted throughout the project are documented in section 4.

A grower reference panel was formed at the beginning of the project. The members of this panel were from different cane production regions, and were chosen due to an interest in new farming systems activities. Meetings were held with this group during the initial phases of the project. They provided valuable comment on the project's direction, which was particularly evident when the planned experiments where changed following the assessment of early results at a meeting at BSES Meringa in January 2009. During the later stages of the project annual summaries of the results were sent to the grower group.

3.3 Project evaluation

A survey was conducted when the project commenced and when it was near completion. It was mainly designed to assess the degree to which the project had changed knowledge in regard to the performance of varieties on controlled traffic row configurations. The survey was sent to plant breeders, agronomists, variety officers, plant-breeding technicians and extension staff from both within BSES and also external agencies (CSIRO, DEEDI, productivity boards).

4.0 RESULTS

4.1 Experimental program

4.1.1 Cultivar experiments

4.1.1.1 Stalk population development

Analysis of stalk count data revealed highly significant ($p < 0.01$) configuration and cultivar effects at all sites, except in the Burdekin where the configuration effect was not significant.

At Bundaberg, significantly ($p < 0.05$) more stalks were produced on the dual-row configuration (Table 3). The cultivars performed in the following manner: Q190$^{\Phi}$ = Q232$^{\Phi}$ < Q151 = Q208$^{\Phi}$.

At Mackay (Table 4), the 1.8 m single rows produced fewer stalks than the 1.5 m single and 1.8 m dual rows. This appeared to be due to poor germination, a result of a dry period following planting which was probably exacerbated by planting too deep into a newly formed bed. The problem was possibly compounded by a crusting soil surface which probably resulted in water-shedding. The 1.8 m single rows were in the worst position as they were located on the top of the bed, compared to the duals which were on the edges. The 1.5 m single row beds were flatter and therefore less prone to shedding water. The cultivars performed in the following manner: Q190$^{\Phi}$ < Q208$^{\Phi}$ = Q209$^{\Phi}$ < Q200$^{\Phi}$.

In the Burdekin (Table 5), there was no statistical difference between the stalk population produced on the single and dual-row configurations. However, there was a strong trend for greater stalk numbers on the dual-row configuration ($P = 0.06$). Cultivar differences were as follows: Q117 = Tellus$^{\Phi}$ < KQ228$^{\Phi}$ = Q171$^{\Phi}$ = Q208$^{\Phi}$ <Q200$^{\Phi}$.

At Ingham (Table 6), stalk populations were as follows: 1.63 m singles < 1.83 m singles < 1.83 m duals. This unusual result for the narrow row configurations may be linked to different style planters used for the two single-row treatments. It is likely the mouldboard planter positioned the billets deeper in the soil, which may have reduced tillering. The cultivars performed in the following manner: Q183$^{\Phi}$ < Q135 = Q174$^{\Phi}$ < Q200$^{\Phi}$.

At Meringa (Table 7), the 1.85 m dual-row configuration produced more stalks than the 1.52 m single-row configuration, which produced more than the 1.85 m single-row configuration. The cultivars performed in the following manner: Q220$^{\Phi}$ = Q201$^{\Phi}$ < Q186$^{\Phi}$ < Q200$^{\Phi}$.

These main effects changed significantly over time. Cultivar-by-time effects were found at all sites. This showed that cultivars develop there stalk population in different ways. In some cases, more shoots were produced followed by large shoot losses later in development. Other cultivars develop fewer shoots but tend to retain those that are produced. Q190$^{\Phi}$ at Mackay increased rapidly but started to shed shoots earlier than the other cultivars. Q174$^{\Phi}$ at Ingham shed a large number of shoots relative to Q135. At Meringa the shoot population of Q186$^{\Phi}$ increased rapidly but was followed by a period when a large number of shoots were lost. However, Q201$^{\Phi}$ had a steady, slow development, as has been previously reported (Garside *et al.,* 2006). Q220$^{\Phi}$ appeared to set its stalk population early and lost few relative to Q186$^{\Phi}$ and Q200$^{\Phi}$. In all trials Q200$^{\Phi}$ produced the most stalks and was often able to maintain a higher population throughout the crop.

Row-configuration-by-time effects were also found at all sites. This was mainly due to dual-row configurations producing more shoots than the other single-row configurations early in crop development. Later in development this difference declined as greater numbers of shoots were shed from the dual-row configurations. This may indicate that low tillering cultivars or lower planting rates could be used when planting dual-row systems. Similarly in seasons where crop emergence is poor, it may also indicate that single-row configurations, particularly wide single rows, may require higher planting rates to ensure good even establishment.

Table 3 − Stalk population development for cultivars Q151, Q190$^{\Phi}$, Q208$^{\Phi}$ and Q232$^{\Phi}$ grown on three row configurations at Bundaberg

Effect		Time (days after planting)							Mean
		57	86	128	164	196	239	365	
Cultivar									
Q151		10.4	16.9	14.2	10.9	9.8	9.6	9.0	11.5
Q190		10.1	15.8	10.7	7.9	7.2	7.0	6.6	9.3
Q208		8.9	13.5	14.5	12.5	11.9	11.9	11.0	12.0
Q232		7.1	12.7	12.0	9.8	9.4	9.2	8.9	9.9
Row configuration									
	1.5 m single	7.9	12.8	11.7	9.6	9.1	9.0	8.6	9.8
	1.8 m single	7.3	12.9	11.6	9.4	9.0	8.8	8.4	9.6
	1.8 m dual	12.2	18.3	15.1	11.8	10.7	10.6	9.6	12.6
Cultivar x row configuration									
Q151	1.5 m single	9.1	14.5	12.9	10.3	9.5	9.4	8.9	10.6
	1.8 m single	8.5	14.9	13.0	9.4	8.6	8.5	8.6	10.2
	1.8 m dual	13.5	21.2	16.8	13.0	11.4	10.9	9.4	13.7
Q190	1.5 m single	8.9	14.3	10.0	7.3	6.9	6.5	6.5	8.6
	1.8 m single	8.0	13.7	10.0	7.6	7.0	6.7	6.3	8.5
	1.8 m dual	13.3	19.4	12.1	8.7	7.8	7.9	7.2	10.9
Q208	1.5 m single	7.7	11.7	13.6	11.8	11.2	11.3	10.7	11.1
	1.8 m single	6.8	12.3	12.9	11.5	11.1	11.1	10.4	10.9
	1.8 m dual	12.3	16.5	17.0	14.3	13.4	13.4	11.8	14.1
Q232	1.5 m single	5.8	10.9	10.6	9.2	8.9	8.8	8.3	8.9
	1.8 m single	6.0	10.9	10.7	9.2	9.1	8.8	8.2	9.0
	1.8 m dual	9.7	16.3	14.5	11.1	10.3	10.1	10.2	11.7

LSD$^{(0.05)}$: Cult. 1.07; Config. 0.94; Cult. x time 1.35; Row config. x time 1.34

Table 4 − Stalk population development for cultivars Q190$^{\Phi}$, Q200$^{\Phi}$, Q208$^{\Phi}$ and Q209$^{\Phi}$ grown on three row configurations at Mackay

Effect		Time (days after planting)						Mean
		52	74	137	167	249	381	
Cultivar								
Q190		3.7	10.1	8.3	7.0	6.2	5.9	6.9
Q200		5.8	13.7	14.3	12.2	10.2	10.8	11.2
Q208		2.9	8.4	10.8	10.1	9.3	9.4	8.5
Q209		3.7	9.1	11.7	10.3	8.3	8.5	8.6
Row configuration								
	1.5 m single	4.1	11.0	12.0	10.4	9.0	9.1	9.3
	1.8 m single	2.2	5.9	8.4	8.0	7.2	7.1	6.5
	1.8 m dual	5.7	14.1	13.4	11.3	9.2	9.7	10.6
Cultivar x row configuration								
Q190	1.5 m single	3.7	10.6	8.6	7.2	6.5	6.1	7.1
	1.8 m single	2.5	6.4	6.1	5.6	5.2	4.9	5.1
	1.8 m dual	4.9	13.3	10.1	8.2	7.0	6.7	8.4
Q200	1.5 m single	6.2	15.1	15.2	13.1	11.3	11.7	12.1
	1.8 m single	3.1	7.9	11.0	10.3	8.9	8.9	8.3
	1.8 m dual	8.2	18.2	16.7	13.3	10.4	12.0	13.1
Q208	1.5 m single	2.8	8.0	11.3	10.2	9.3	9.5	8.5
	1.8 m single	1.5	4.9	8.2	8.1	7.9	7.4	6.3
	1.8 m dual	4.4	12.3	12.8	12.0	10.8	11.2	10.6
Q209	1.5 m single	4.0	10.1	13.0	11.3	9.1	9.3	9.4
	1.8 m single	1.8	4.5	8.3	7.9	7.0	7.2	6.1
	1.8 m dual	5.2	12.7	14.0	11.8	8.7	9.0	10.2

$LSD^{(0.05)}$: Cult. 0.50; Row config. 0.55; Cult. x time 0.61; Row config. x time 0.63

Table 5 − Stalk population development for cultivars KQ228$^{\Phi}$, Q117, Q171$^{\Phi}$, Q200$^{\Phi}$, Q208$^{\Phi}$ and Tellus$^{\Phi}$ grown on two row configurations in the Burdekin

Effect		Time (days after planting)						Mean
		53	75	105	174	333	417	
Cultivar								
KQ228		2.8	5.0	13.7	15.3	8.1	8.2	8.8
Q117		3.2	3.6	9.5	12.9	7.4	7.3	7.3
Q171		2.9	3.5	10.5	17.4	10.2	9.5	9.0
Q200		3.4	5.2	13.6	20.0	11.7	11.1	10.8
Q208		3.4	4.1	11.9	15.4	10.8	10.5	9.4
Tellus		2.6	2.9	4.1	15.3	9.5	9.7	7.3
Row configuration								
	1.83 m single	2.4	3.1	8.7	14.6	9.2	9.0	7.8
	1.83 m dual	3.7	5.0	12.4	17.5	10.0	9.8	9.7
Cultivar x row configuration								
KQ228	1.83 m single	2.2	3.4	10.9	15.0	7.6	7.8	7.8
	1.83 m dual	3.4	6.6	16.5	15.6	8.5	8.7	9.9
Q117	1.83 m single	2.7	3.4	8.8	12.2	7.2	7.2	6.9
	1.83 m dual	3.7	3.8	10.3	13.6	7.6	7.3	7.7
Q171	1.83 m single	2.2	2.6	7.8	15.3	9.4	9.0	7.7
	1.83 m dual	3.6	4.4	13.1	19.6	11.1	10.0	10.3
Q200	1.83 m single	2.9	4.4	11.8	17.8	11.2	10.5	9.8
	1.83 m dual	3.8	6.0	15.3	22.3	12.2	11.7	11.9
Q208	1.83 m single	2.4	2.7	8.9	14.6	10.5	10.2	8.2
	1.83 m dual	4.5	5.6	14.9	16.2	11.1	10.7	10.5
Tellus	1.83 m single	2.0	2.2	3.8	12.9	9.4	9.1	6.6
	1.83 m dual	3.2	3.5	4.4	17.7	9.6	10.2	8.1

$LSD^{(0.05)}$: Cult. 1.07; Cult. x time 1.82; Row config. x time 1.63

Table 6 − Stalk population development for cultivars Q135, Q174$^{\phi}$, Q183$^{\phi}$ and Q200$^{\phi}$ grown on three row configurations at Ingham

Effect		Time (days after planting)						Mean
		97	120	156	189	238	438	
Cultivar								
Q135		9.0	12.5	12.1	10.3	9.6	9.0	10.4
Q174		13.2	14.6	13.1	8.9	8.1	8.0	11.0
Q183		7.7	10.4	9.8	7.7	6.5	6.2	8.0
Q200		15.8	17.6	15.4	12.0	10.3	9.9	13.5
Row configuration								
	1.63 m single	7.5	9.8	9.5	8.4	8.0	7.7	8.5
	1.83 m single	10.3	12.4	11.3	9.3	8.2	8.1	9.9
	1.83 m dual	16.4	19.2	17.1	11.3	9.5	9.0	13.8
Cultivar x row configuration								
Q135	1.63 m single	5.7	8.6	8.4	9.1	8.4	8.1	8.0
	1.83 m single	6.2	9.9	9.9	9.5	9.4	8.4	8.9
	1.83 m dual	15.0	19.0	18.0	12.5	11.0	10.5	14.3
Q174	1.63 m single	10.6	12.0	11.2	8.3	8.1	8.0	9.7
	1.83 m single	10.3	12.2	11.7	8.4	7.4	7.6	9.6
	1.83 m dual	18.7	19.6	16.4	9.9	8.8	8.3	13.6
Q183	1.63 m single	3.7	5.9	6.6	5.8	5.6	5.4	5.5
	1.83 m single	9.0	11.0	10.1	7.7	6.7	6.4	8.5
	1.83 m dual	10.4	14.5	12.7	9.6	7.2	6.8	10.2
Q200	1.63 m single	10.0	12.6	11.7	10.6	10.1	9.2	10.7
	1.83 m single	15.7	16.4	13.4	11.9	9.5	9.8	12.8
	1.83 m dual	21.6	23.7	21.1	13.5	11.2	10.5	16.9

LSD$^{(0.05)}$: Cult. 0.82; Row config. 0.88;Cult. x Row config. 1.42; Cult. x time 1.45; Row config. x time 1.30

Table 7 − Stalk population development for cultivars Q186$^{\phi}$, Q200$^{\phi}$, Q201$^{\phi}$ and Q220$^{\phi}$ grown on three row configurations at Meringa

Effect		Time (days after planting)							Mean
		78	112	159	182	211	251	398	
Cultivar									
Q186		13.7	12.2	9.5	8.6	8.2	8.3	8.0	9.8
Q200		14.6	14.9	12.5	11.5	11.2	10.8	10.5	12.3
Q201		6.2	9.5	10.4	9.5	9.2	8.8	8.7	8.9
Q220		10.9	10.1	8.7	7.7	7.6	7.9	7.3	8.6
Row configuration									
	1.52 m single	10.5	11.1	9.9	9.0	8.9	9.0	8.7	9.6
	1.85 m single	8.7	9.1	8.9	8.4	8.1	7.9	7.8	8.4
	1.85 m dual	14.9	14.8	12.1	10.7	10.2	9.9	9.5	11.7
Cultivar x row configuration									
Q186	1.52 m single	11.7	11.3	8.8	8.1	7.9	8.2	8.1	9.1
	1.85 m single	11.6	10.4	8.5	7.9	7.6	7.7	7.2	8.7
	1.85 m dual	17.7	15.1	11.2	9.7	9.2	8.9	8.7	11.5
Q200	1.52 m single	14.8	15.0	12.8	11.6	11.4	11.1	10.6	12.5
	1.85 m single	10.9	11.1	10.6	10.2	9.8	9.2	9.6	10.2
	1.85 m dual	18.2	18.5	14.0	12.9	12.3	12.2	11.5	14.2
Q201	1.52 m single	5.1	8.3	9.6	9.0	8.8	8.8	8.8	8.3
	1.85 m single	4.2	6.9	9.2	8.6	8.2	7.8	7.7	7.5
	1.85 m dual	9.4	13.2	12.5	11.1	10.6	9.9	9.6	10.9
Q220	1.52 m single	10.3	9.8	8.5	7.4	7.4	8.1	7.2	8.4
	1.85 m single	8.0	8.0	7.3	6.8	6.7	7.0	6.8	7.2
	1.85 m dual	14.3	12.4	10.4	9.0	8.8	8.5	8.0	10.2

LSD$^{(0.05)}$: Cult. 0.61; Row config. 0.75;Cult. x Row config. 0.96; Cult. x time 1.07; Row config. x time 1.06

A significant cultivar-by-row-configuration interaction was found at Ingham and Meringa but not at any other site. At Ingham, this effect appeared to be due to cultivars Q183$^{\phi}$ and Q200$^{\phi}$ having lower stalk populations on the 1.63 m single configuration whereas cultivars Q135 and Q174$^{\phi}$ had similar stalk populations on both single-row configurations. At

Meringa, the effect appeared to be due to cultivars Q186$^{\Phi}$ and Q201$^{\Phi}$ producing similar stalk populations on the two single-row configurations whereas Q200$^{\Phi}$ and Q220$^{\Phi}$ produced larger stalk populations on the 1.52 m single row than the 1.85 m single-row configuration.

Outputs from the stalk population data:

- There are genetic differences in the number of stalks produced by different cultivars and the way in which the stalk population develops.
- Row configuration has a significant effect on stalk population development, with dual-row configurations producing large numbers of shoots early in development often followed by large shoot losses.
- Cultivars tend to respond to changes in row configuration in a similar manner, even though some statistically significant differences were found.

4.1.1.2 Biomass accumulation

Biomass accumulation (dry t/ha) was dependent on cultivar at each site. There were also significant differences in a cultivars pattern of biomass development over time at all sites, except at the Burdekin where no significant cultivar effects or interactions were found (Figure 1). At Bundaberg, there was no difference among cultivars initially, 4 months after planting, but Q208$^{\Phi}$ and Q232$^{\Phi}$ produced significantly greater biomass at final harvest. The growth of Q151 also slowed down between the 8 and 12 month samples relative to Q208$^{\Phi}$ and Q232$^{\Phi}$. This was possibly due to severe, early lodging of Q151. Although the cultivar-by-time interaction was not significant in the Burdekin due to large variation, there was an indication that cultivars were developing differently over time. In particular, Tellus$^{\Phi}$ and Q117 appeared to be gaining more biomass relative to the other cultivars late in the season. The biomass of Q200$^{\Phi}$ and Q171$^{\Phi}$ increased very little in the final months of the season. The highly significant cultivar-by-time interaction at Ingham was most likely due to the growth of Q183$^{\Phi}$ slowing down relative to the other cultivars. At Meringa, Q186$^{\Phi}$ growth slowed down relative to the other cultivars between the 8 and 12 month samples. Q186$^{\Phi}$ is an early season CCS cultivar and this slow down most likely represented early maturation. Q201$^{\Phi}$ produced less biomass than the other cultivars early in development, particularly Q200$^{\Phi}$ and Q220$^{\Phi}$, but was gaining biomass relative to these cultivars late in the season. This was a similar result to that reported by Garside *et al.* (2006). However, the difference in growth for Q200$^{\Phi}$ and Q201$^{\Phi}$ in the final 4 months of development was not as pronounced in this experiment. Data from Mackay was not presented as the 4 month biomass sample could not be conducted due to very wet conditions.

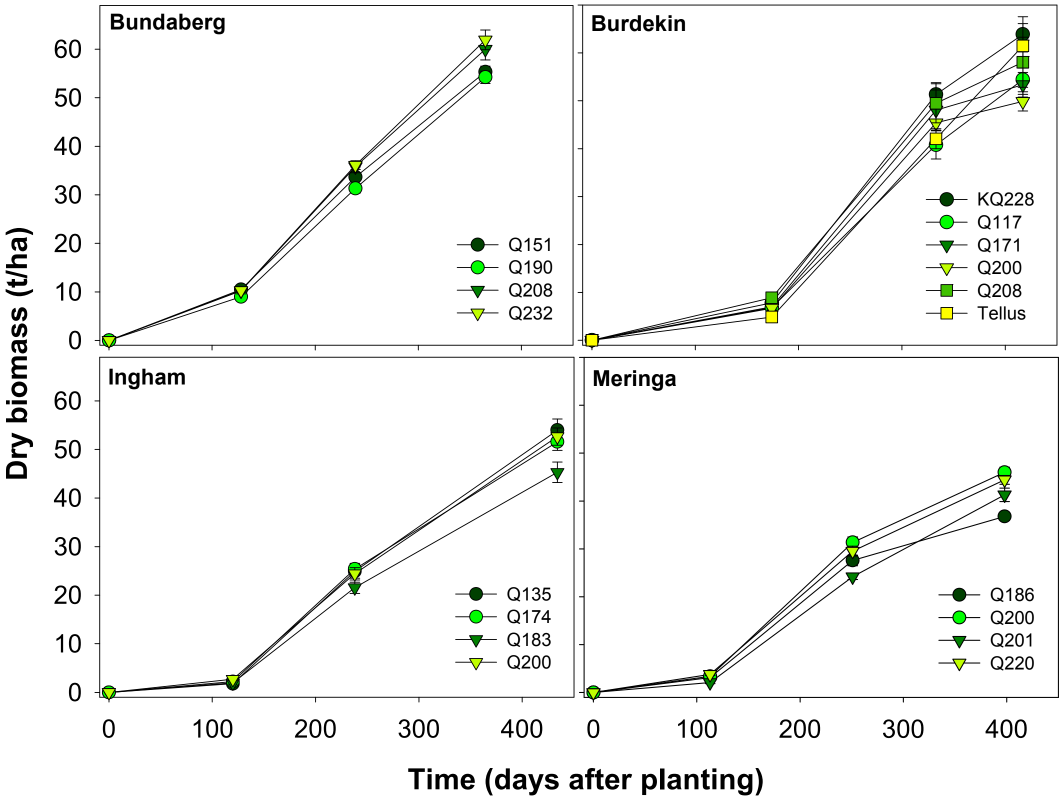

Figure 1 − Biomass accumulation at Bundaberg, Ingham, Burdekin and Meringa for different cultivars

Row configuration did not have any effect on biomass accumulation, except at Mackay where the 1.85 m single-row configuration produced significantly less biomass than the 1.52 m single and the 1.85 m dual-row configurations (not shown). Although not statistically significant, there was an indication at the Burdekin that the 1.85 m dual-row configuration accumulated biomass quicker than the 1.85 m single-row configuration. However, in the last 4 months of development the single-row configuration 'caught up' to the dual-row configuration (Figure 2). This appeared to be associated with lodging and smaller individual stalks on the dual-row configuration (section 4.1.1.3). Park *et al.* (2005) reported a slow-down in biomass accumulation in sugarcane despite favourable growing conditions. Flowering, lodging and a number of other factors could be associated with this observation. No significant cultivar-by-row-configuration effects were found.

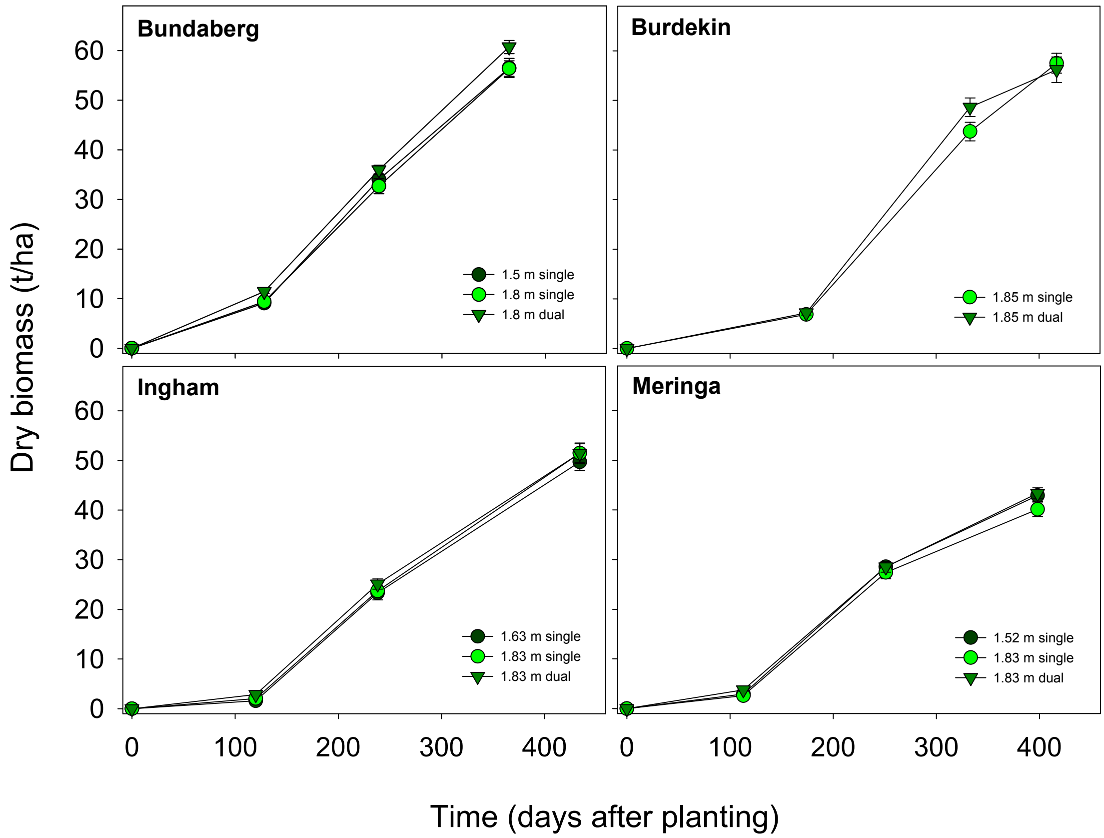

Figure 2 − Biomass accumulation at Bundaberg, Ingham, Burdekin and Meringa for different row configurations

Outputs from the biomass accumulation data:

- Further evidence for differences in growth patterns among cultivars.
- Biomass accumulation was similar on different row configurations, but there was some evidence of reduced biomass on the wide single-row configuration at some sites.
- No significant cultivar-by-row-configuration interactions were found. Cultivars accumulated biomass in a similar manner across row configurations.

4.1.1.3 Crop traits at final harvest

Cultivars had significantly different crop traits at final harvest. At Bundaberg (Table 8), Q151 had a significantly lower percent millable stalk than Q232$^{\Phi}$. There were also significant cultivar differences for individual stalk weight Q208$^{\Phi}$ = Q151 < Q232$^{\Phi}$ < Q190$^{\Phi}$. This relationship was the inverse of the stalk population at final harvest (Table 3). Bell and Garside (2005) showed that stalk size increases with a decline in stalk population. No significant cultivar-by-row-configuration interactions were found for any crop trait at final harvest.

Table 8 − Yield components at final harvest of cultivars Q151, Q190$^{\Phi}$, Q208$^{\Phi}$ and Q232$^{\Phi}$ grown on three row configurations at Bundaberg

Effect		Fresh biomass (t/ha)	% millable stalk	Stalk weight (kg)	Crop % DM
Cultivar					
Q151		155.7	85.8	1.6	35.5
Q190		146.7	86.2	2.3	37.0
Q208		162.4	86.8	1.4	36.9
Q232		167.7	88.1	1.9	36.9
Row configuration					
	1.5 m single	156.3	86.5	1.8	36.2
	1.8 m single	154.1	86.8	1.8	36.6
	1.8 m dual	164.0	86.8	1.8	37.0
Cultivar x row configuration					
Q151	1.5 m single	157.2	85.3	1.5	35.5
	1.8 m single	154.4	86.9	1.6	35.5
	1.8 m dual	155.4	85.2	1.6	35.5
Q190	1.5 m single	144.3	86.4	2.3	36.2
	1.8 m single	141.2	85.5	2.2	37.9
	1.8 m dual	154.6	86.6	2.2	36.9
Q208	1.5 m single	159.1	86.7	1.4	36.6
	1.8 m single	155.9	86.5	1.5	37.3
	1.8 m dual	172.1	87.1	1.4	36.9
Q232	1.5 m single	164.5	87.6	1.9	36.4
	1.8 m single	164.8	88.4	2.0	35.7
	1.8 m dual	173.8	88.2	1.8	38.8

$LSD^{(0.05)}$: Cult. % millable stalk 1.075; Cult. stalk wt. 0.12

Q190$^{\Phi}$ produced less fresh biomass than the other cultivars at Mackay (Table 9). It also had significantly heavier stalks and lower crop percent dry matter than other varieties. The larger stalks was associated with low stalk number at final harvest (Table 4). Less fresh biomass and a lower percent millable stalk was produced on the 1.8 m single-row configuration.

At the Burdekin (Table 10), significant differences among cultivars were found for stalk weight. There were no other statistically significant effects.

Table 9 − Yield components at final harvest of cultivars Q190$^{\Phi}$, Q200$^{\Phi}$, Q208$^{\Phi}$ and Q209$^{\Phi}$ grown on three row configurations at Mackay

Effect		Fresh biomass	% millable	Stalk weight	Crop % DM
Cultivar					
Q190		102.5	88.5	1.7	32.3
Q200		133.2	88.8	1.2	34.6
Q208		129.6	88.4	1.3	33.7
Q209		123.9	85.4	1.4	33.5
Row configuration					
	1.5 m single	127.9	88.2	1.4	33.8
	1.8 m single	109.9	87.2	1.5	33.4
	1.8 m dual	129.1	87.9	1.3	33.5
Cultivar x row configuration					
Q190	1.5 m single	104.8	89.2	1.7	32.1
	1.8 m single	95.2	87.9	1.8	32.5
	1.8 m dual	107.6	88.5	1.6	32.4
Q200	1.5 m single	138.8	89.7	1.1	35.2
	1.8 m single	120.0	87.4	1.2	34.2
	1.8 m dual	140.6	89.3	1.2	34.3
Q208	1.5 m single	135.2	88.8	1.4	33.8
	1.8 m single	108.9	88.6	1.4	33.3
	1.8 m dual	144.7	87.9	1.2	34.1
Q209	1.5 m single	132.8	85.2	1.3	33.9
	1.8 m single	115.4	84.9	1.5	33.4
	1.8 m dual	123.4	86.0	1.3	33.1

$LSD^{(0.05)}$: Cult. fresh biomass 13.15; Cult. stalk wt 0.11; Cult. % millable stalk 1.53; Cult. Crop % DM 0.54; Row config. fresh biomass 15.38; Row config. % millable 0.56

Table 10 − Yield components at final harvest of cultivars KQ228$^{\Phi}$, Q117, Q171$^{\Phi}$, Q200$^{\Phi}$, Q208$^{\Phi}$ and Tellus$^{\Phi}$ grown on two row configurations in the Burdekin

Effect		Fresh biomass (t/ha)	% millable stalk	Stalk weight (kg)	Crop % DM
Cultivar					
KQ228		190.1	91.7	2.4	33.6
Q117		176.9	90.7	2.5	30.9
Q171		166.8	89.4	1.8	32.0
Q200		159.2	89.0	1.5	31.6
Q208		192.9	92.3	1.8	30.1
Tellus		187.4	92.2	1.9	32.8
Row configuration					
	1.83 m single	177.2	90.9	2.1	32.5
	1.83 m dual	180.6	90.8	1.9	31.1
Cultivar x row configuration					
KQ228	1.83 m single	181.6	91.0	2.5	33.8
	1.83 m dual	198.7	92.3	2.3	33.3
Q117	1.83 m single	178.2	91.2	2.5	32.4
	1.83 m dual	175.6	90.2	2.4	29.3
Q171	1.83 m single	165.6	89.2	1.9	32.5
	1.83 m dual	168.0	89.6	1.7	31.5
Q200	1.83 m single	154.4	89.5	1.5	33.0
	1.83 m dual	164.0	88.4	1.5	30.1
Q208	1.83 m single	198.9	92.7	1.8	30.9
	1.83 m dual	186.9	92.0	1.8	29.3
Tellus	1.83 m single	184.4	91.9	2.1	32.2
	1.83 m dual	190.4	92.5	1.7	33.3

$LSD^{(0.05)}$: Cult. stalk wt. 0.23

Table 11 − Yield components at final harvest of cultivars Q135, Q174$^{\Phi}$, Q183$^{\Phi}$ and Q200$^{\Phi}$ grown on three row configurations at Ingham

Effect		Fresh biomass (t/ha)	% millable stalk	Stalk weight (kg)	Crop % DM
Cultivar					
Q135		162.3	87.6	1.7	33.2
Q174		154.4	87.1	1.9	33.4
Q183		134.9	87.7	2.1	33.5
Q200		147.6	89.4	1.5	35.7
Row configuration					
	1.63 m single	146.2	86.6	1.9	34.0
	1.83 m single	150.3	88.5	1.8	34.2
	1.83 m dual	152.8	88.6	1.7	33.6
Cultivar x row configuration					
Q135	1.63 m single	156.2	87.0	1.9	33.6
	1.83 m single	150.8	87.3	1.6	32.7
	1.83 m dual	179.8	88.5	1.7	33.4
Q174	1.63 m single	166.0	84.3	2.0	33.0
	1.83 m single	154.8	88.3	2.0	34.5
	1.83 m dual	142.3	88.6	1.7	32.7
Q183	1.63 m single	128.3	86.8	2.2	33.8
	1.83 m single	142.1	88.0	2.1	33.8
	1.83 m dual	134.3	88.2	2.0	32.9
Q200	1.63 m single	134.5	88.6	1.5	35.7
	1.83 m single	153.5	90.1	1.6	35.7
	1.83 m dual	154.7	89.3	1.4	35.6

$LSD^{(0.05)}$: Cult. fresh biomass 13.55; Cult. % millable stalk 1.66; Cult. stalk wt 0.16; Cult. Crop % DM 0.82; Cult. x Row config. fresh biomass 23.5

Significant cultivar effects were also found at Ingham (Table 11). Q183$^{\Phi}$ produced significant less fresh biomass than Q174$^{\Phi}$ and Q135, and it also had significantly heavier stalks than Q135 and Q200$^{\Phi}$. Q200$^{\Phi}$ had significantly higher percent millable stalk and a higher crop percent dry matter than the other cultivars.

A significant cultivar-by-row-configuration interaction was found for total fresh biomass at Ingham. This effect was mainly due to Q174$^{\Phi}$ producing less biomass on the dual-row configuration compared to the 1.63 m single-row configuration, whereas Q135 produced significantly more biomass on the dual-row configuration than the 1.63 m single-row configuration. This effect was associated with Q135 maintaining larger numbers of stalks to final harvest on the dual-row configuration. Although these stalks were of lower weight, it resulted in significant greater fresh biomass being produced on the dual-row configuration. Q174$^{\Phi}$ produced similar stalk numbers on all three row configurations, but stalk size was lower on the dual-row configuration, resulting in lower fresh biomass.

Unfortunately, the significant interaction effect may be confounded with differences in planting techniques used at the site. The 1.63 m single-row configuration was planted with a mouldboard planter whereas the dual-row configuration was planted with a double-disc opener planter. Therefore, the effect could be associated with planter type rather than row configuration. The stalk populations early in development, particularly Q135 and Q183$^{\Phi}$ on the 1.63 m single-row configuration appear to be low (Table 6). This could be due to differences in planting depth associated with the different style planters.

Table 12 − Yield components at final harvest of cultivars Q186$^{\Phi}$, Q200$^{\Phi}$, Q201$^{\Phi}$ and Q220$^{\Phi}$ grown on three row configurations at Meringa

Effect		Fresh biomass (t/ha)	% millable stalk	Stalk weight (kg)	Crop % DM
Cultivar					
Q186		111.8	88.2	1.3	32.9
Q200		133.7	87.1	1.2	34.4
Q201		126.2	86.6	1.3	32.8
Q220		141.4	87.6	1.9	31.4
Row configuration					
	1.52 m single	130.7	87.0	1.4	32.9
	1.85 m single	122.0	87.5	1.5	32.9
	1.85 m dual	132.1	87.6	1.4	32.9
Cultivar x row configuration					
Q186	1.52 m single	116.5	88.5	1.3	32.6
	1.85 m single	103.3	88.4	1.3	32.8
	1.85 m dual	115.5	87.8	1.3	33.3
Q200	1.52 m single	134.5	85.9	1.2	34.1
	1.85 m single	130.5	87.9	1.2	34.5
	1.85 m dual	136.2	87.6	1.2	34.6
Q201	1.52 m single	129.3	86.9	1.4	33.1
	1.85 m single	116.3	86.1	1.4	32.8
	1.85 m dual	133.0	86.8	1.2	32.5
Q220	1.52 m single	142.4	87.0	1.9	31.6
	1.85 m single	138.0	87.7	1.9	31.5
	1.85 m dual	143.7	88.1	1.8	31.1

$LSD^{(0.05)}$: Cult. fresh biomass 10.65; Cult. stalk wt 0.14; Cult. Crop % DM 1.08; Row config. stalk wt. 0.07

Significant cultivar effects were found for fresh biomass, stalk weight and crop percent dry matter at Meringa (Table 12). Q186$^{\Phi}$ produced significantly less fresh biomass than other cultivars particularly Q200$^{\Phi}$ and Q220$^{\Phi}$. Q220$^{\Phi}$ produced significantly heavier stalks than the other cultivars and Q200$^{\Phi}$ had a higher crop percent dry matter than other cultivars. Significantly heavier stalks were produced on the 1.85 m single-row configuration, associated with lower stalk numbers (Table 7).

Outputs from the crop traits at final harvest data:

- Cultivars were shown to have different stalk traits at final harvest at all sites
- Some crop traits were influenced by row configuration at some sites
- A cultivar-by-row-configuration interaction for fresh biomass was found at one site. However, apart from this one exception, no other significant cultivar-by-row-configuration interactions were found. The crop traits expressed by different cultivars appeared to be influenced in a similar manner across row configurations, if at all.
- The relationship, described Bell and Garside (2005), between stalk population and stalk size was evident at all sites

4.1.1.4 Crop yield and sugar content

At Bundaberg (Table 13) there was no difference in yield (TCH and TSH) among row configurations. Differences were found among cultivars with Q232$^{\Phi}$ and Q208$^{\Phi}$ performing well.

Table 13 − Cane (TCH) and sugar yield (TSH) of cultivars Q151, Q190$^{\Phi}$, Q208$^{\Phi}$ and Q232$^{\Phi}$ grown on 1.5 m single, 1.8 m single and 1.8 m dual rows near Bundaberg

Bundaberg			Cultivar				
Crop	Yield	Row config.	Q151	Q190$^{\Phi}$	Q208$^{\Phi}$	Q232$^{\Phi}$	*Mean*
Plant	TCH	1.5 m single	134.1	124.7	138.1	144.2	*135.3*
		1.8 m single	134.2	120.6	134.8	145.6	*133.8*
		1.8 m dual	132.5	134.0	149.9	153.4	*142.4*
		Mean	*133.6*	*126.4*	*140.9*	*147.7*	
	TSH	1.5 m single	18.4	17.3	18.6	20.0	*18.6*
		1.8 m single	19.1	16.7	19.1	21.6	*19.1*
		1.8 m dual	18.8	18.3	21.1	23.0	*20.3*
		Mean	*18.8*	*17.5*	*19.6*	*21.6*	
1st ratoon	TCH	1.5 m single	124.9	116.8	145.3	120.5	*126.9*
		1.8 m single	108.9	108.8	140.5	127.2	*121.4*
		1.8 m dual	95.7	112.7	139.5	126.0	*118.5*
		Mean	*109.8*	*112.8*	*141.8*	*124.6*	
	TSH	1.5 m single	21.1	19.5	25.3	19.8	*21.4*
		1.8 m single	18.6	17.9	24.7	21.4	*20.6*
		1.8 m dual	15.9	18.8	23.6	20.5	*19.7*
		Mean	*18.5*	*18.7*	*24.5*	*20.6*	

$LSD^{(0.05)}$ Plant crop: Cult. TCH 15.06; Cult. TSH 1.96
$LSD^{(0.05)}$ 1st ratoon: Cult. TCH 13.97; Cult. TSH 2.44

No statistically significant cultivar-by-row-configuration interactions were found in either the plant or first-ratoon crops at Bundaberg. All cultivars responded to the different row configurations in a similar manner.

Table 14 − Cane and sugar yield of cultivars Q190, Q200$^{\Phi}$, Q208$^{\Phi}$ and Q209$^{\Phi}$ grown on 1.5 m single, 1.8 m single and 1.8 m dual rows near Mackay

Mackay			Cultivar				
Crop	Yield	Row config.	Q190$^{\Phi}$	Q200$^{\Phi}$	Q208$^{\Phi}$	Q209$^{\Phi}$	Mean
Plant	TCH	1.5 m single	93.4	124.6	120.1	113.3	*112.8*
		1.8 m single	83.6	104.9	96.4	98.0	*95.7*
		1.8 m dual	95.2	125.6	127.1	106.1	*113.5*
		Mean	*90.7*	*118.4*	*114.6*	*105.8*	
	TSH	1.5 m single	15.4	21.9	20.9	20.6	*19.7*
		1.8 m single	13.9	18.1	16.6	17.9	*16.6*
		1.8 m dual	16.1	21.9	22.6	19.3	*19.8*
		Mean	*15.1*	*20.6*	*19.8*	*19.3*	

$LSD^{(0.05)}$: Cult. TCH 12.3; Cult. TSH 2.05; Row config. TCH 13.25; Row config.TSH 2.50

The 1.8 m single-row configuration produced significantly less cane (15 %) and sugar than the 1.5 m single and 1.8 m dual-row configurations at Mackay (Table 14). Q190$^{\Phi}$ also produced significantly less yield than the other cultivars. The cultivar-by-row-configuration interaction was not statistically significant.

Despite large variation for cane and sugar yield among cultivars, no statistically significant differences were found at the Burdekin (Table 15). There was also no difference in yield between row configurations and the cultivar-by-row-configuration was not significant in either the plant or first-ratoon crops.

Table 15 − Cane and sugar yield of cultivars KQ228$^{\Phi}$, Q117, Q171$^{\Phi}$, Q200$^{\Phi}$, Q208$^{\Phi}$ and Tellus grown on 1.8 m single and 1.8 m dual rows in the Burdekin

Burdekin			Cultivar						
Crop	Yield	Row config.	KQ228$^{\Phi}$	Q117	Q171$^{\Phi}$	Q200$^{\Phi}$	Q208$^{\Phi}$	Tellus$^{\Phi}$	*Mean*
Plant	TCH	1.85 m single	165.3	162.6	147.7	138.3	184.5	169.9	*161.4*
		1.85 m dual	183.3	158.4	150.6	145.2	172.2	176.6	*164.4*
		Mean	*174.3*	*160.5*	*149.1*	*141.8*	*178.3*	*173.2*	
	TSH	1.85 m single	27.8	25.7	24.1	22.7	30.6	26.9	*26.3*
		1.85 m dual	28.8	25.9	24.6	23.1	25.9	28.6	*26.1*
		Mean	*28.3*	*25.8*	*24.3*	*22.9*	*28.3*	*27.7*	
1st ratoon	TCH	1.85 m single	140.2	135.5	138.2	148.8	148.3	160.8	*145.3*
		1.85 m dual	137.9	147.0	136.0	149.7	161.1	159.3	*148.5*
		Mean	*139.1*	*141.3*	*137.1*	*149.3*	*154.7*	*160.0*	
	TSH	1.85 m single	22.5	21.5	23.5	22.6	21.2	23.6	*22.5*
		1.85 m dual	21.4	22.6	22.8	21.1	22.5	23.0	*22.2*
		Mean	*22.0*	*22.0*	*23.2*	*21.9*	*21.9*	*23.3*	

LSD$^{(0.05)}$: NA

Significant cultivar effects were found at Ingham (Table 16) mostly associated with the poor performance of Q183$^{\Phi}$ at the site. No significant row configuration or cultivar-by-row-configuration interactions for cane and sugar yield were found in either the plant or first-ratoon crops.

Significant cultivar and configuration effects were found at Meringa (Table 17). The cultivar effect was mainly due to the poor performance of Q186$^{\Phi}$ and Q201$^{\Phi}$ at the site in comparison to Q200$^{\Phi}$ and Q232$^{\Phi}$. The 1.8 m single-row configuration produced significantly less cane and sugar than the 1.5 m single and 1.8 m dual-row configurations in the first-ratoon crop. Although not statistically significant, this effect was also evident in the plant crop. In the first-ratoon crop the yield reduction on the 1.85 m single-row configuration was approximately 11%. As at other sites, no statistically significant cultivar-by-row-configuration interactions for cane or sugar yield were found in either the plant or first-ratoon crops.

Table 16 − Cane and sugar yield of cultivars Q135, Q174$^{\Phi}$, Q183$^{\Phi}$ and Q200$^{\Phi}$ grown on 1.63 m single, 1.83 m single and 1.83 m dual rows near Ingham

Ingham Crop	Yield	Row config.	Cultivar Q135	Q174$^{\Phi}$	Q183$^{\Phi}$	Q200$^{\Phi}$	*Mean*
Plant	TCH	1.63 m single	135.8	140.0	111.4	119.3	*126.6*
		1.83 m single	131.9	136.8	125.0	138.3	*133.0*
		1.83 m dual	159.0	126.0	118.3	138.0	*135.3*
		Mean	*142.2*	*134.3*	*118.2*	*131.9*	
	TSH	1.63 m single	21.8	22.2	17.9	19.4	*20.3*
		1.83 m single	21.5	21.9	20.3	22.2	*21.5*
		1.83 m dual	25.0	20.0	19.4	22.6	*21.8*
		Mean	*22.8*	*21.4*	*19.2*	*21.4*	
1st ratoon	TCH	1.63 m single	104.6	103.4	92.9	101.4	*100.6*
		1.83 m single	99.1	96.6	87.5	97.7	*95.2*
		1.83 m dual	113.0	104.0	82.6	113.2	*103.2*
		Mean	105.6	101.3	87.7	104.1	
	TSH	1.63 m single	16.0	17.2	15.3	16.7	*16.3*
		1.83 m single	15.6	15.5	13.8	16.1	*15.2*
		1.83 m dual	17.5	17.4	13.6	18.7	*16.8*
		Mean	16.3	16.7	14.2	17.2	

$LSD^{(0.05)}$ Plant crop: Cult. TCH 12.11 ; Cult. TSH 2.18
$LSD^{(0.05)}$ 1st ratoon: Cult. TCH 7.74 ; Cult. TSH 1.40

Table 17 − Cane and sugar yield of cultivars Q186$^{\Phi}$, Q200$^{\Phi}$, Q201$^{\Phi}$ and Q220$^{\Phi}$ grown on 1.52 m single, 1.85 m single and 1.85 m dual rows near Meringa

Meringa			Cultivar				
Crop	Yield	Row config.	Q186$^{\Phi}$	Q200$^{\Phi}$	Q201$^{\Phi}$	Q220$^{\Phi}$	*Mean*
Plant	TCH	1.52 m single	103.0	115.7	112.3	123.6	*113.7*
		1.85 m single	91.4	114.8	100.2	121.0	*106.8*
		1.85 m dual	101.4	119.3	115.6	126.5	*115.7*
		Mean	*98.6*	*116.6*	*109.3*	*123.7*	
	TSH	1.52 m single	16.5	18.9	17.7	19.5	*18.1*
		1.85 m single	14.4	18.0	15.6	19.2	*16.8*
		1.85 m dual	15.6	19.2	18.1	19.7	*18.2*
		Mean	*15.5*	*18.7*	*17.1*	*19.5*	
1st ratoon	TCH	1.52 m single	104.0	116.8	110.3	131.4	*115.6*
		1.85 m single	95.1	105.1	91.5	117.8	*102.4*
		1.85 m dual	105.1	117.2	102.2	132.6	*114.3*
		Mean	*101.4*	*113.0*	*101.4*	*127.3*	
	TSH	1.52 m single	18.9	21.1	19.2	23.0	*20.6*
		1.85 m single	16.9	19.3	16.1	20.7	*18.2*
		1.85 m dual	19.1	21.8	17.4	23.6	*20.5*
		Mean	*18.3*	*20.7*	*17.6*	*22.4*	

LSD$^{(0.05)}$ Plant crop: Cult. TCH 9.70; Cult. TSH 1.60

LSD$^{(0.05)}$ 1st ratoon: Cult. TCH 10.38; Cult. TSH 1.90; Row config. TCH 10.29; Row config. TSH 2.08

Outputs from the crop yield data:

- Some cultivars outperformed others at each site.
- In some environments, significantly less yield was produced on the wide single-row configuration
- Dual-row configurations maintained yield on a wide row spacing in all environments
- No cultivar-by-row-configuration effects were found at any site

4.1.1.5 Discussion of cultivar experiments

It was clear from all the experiments that current cultivars are suitable for different row configurations. No cultivar-by-row-configuration interaction was found in any experiment. This suggests that if you select a cultivar that performs well at a particular site, it will perform well on all row configurations. It also indicates that cultivars that perform well on wide row configurations will make it through the selection system in the plant-breeding program.

The presence of a significant interaction effect, with cultivars changing rankings on different row configurations, was reported by Garside *et al.* (2006). Clearly, this does not always occur. Trials reported by Roach (1977) and Bell *et al.* (2007) also failed to find a significant interaction. It is possible that the interaction reported by Garside *et al*. (2006) was due to particular environmental conditions that were not present when other experiments were conducted.

While cultivars showed different growth pathways, there was no clear relationship between performance on any row configuration and a particular growth pathway. Q200$^{\Phi}$ and Q220$^{\Phi}$ produced similar yields at Meringa. One cultivar achieved this by having many small stalks (Q200$^{\Phi}$). The other had a small number of large stalks (Q220$^{\Phi}$). Intuitively, low-tillering thick-stalked cultivars would seem to suit dual-row configurations, but there was no evidence to suggest that this was advantageous. At the Burdekin trial, Q117 had these stalk traits. However, it produced similar yields across configurations. In Mauritius, cultivars that performed significantly better on dual-row configurations were found (Sundara, 2003; Ismael *et al*., 2008). Cultivars with erect stalk and leaf were considered to potentially perform better on dual-rows than those that lodged. This was not evident in our experiments.

Harvest timing may be an important issue when looking at the different growth pathways exhibited by cultivars. If the experiments were harvested a month earlier or a month later would the results have changed? Some cultivars had virtually stopped growing, whereas others were still gaining yield.

In two trials (Mackay and Meringa) the wide single-row configuration produced significantly lower yields than the narrow single and wide dual-row configurations. This was mainly due to low stalk numbers on this configuration at both sites. Experiments that had access to irrigation (Bundaberg and Burdekin) did not show any loss of yield on the wide single-row configuration. Even though irrigation was available at Mackay, the soil surface sealed and water was shed off the beds resulting in very dry soil conditions during establishment. It appears that if any significant stress (drought, water-logging, etc.) is encountered the wide single-row configuration can have too few stalks to reach maximum yield. Environmental stress can also prevent the stalks that are present from increasing in size to compensate for low numbers. Bell *et al.* (2007) speculated that the stalk size-number compensation effect would require favourable environmental conditions during the stalk filling period. Planting rates on the wide single-row configuration may also be too low and contributing to this issue, particularly in experiments where billets are often placed end to end. Growers planting wide single rows with billet planters and higher planting rates do not appear to be suffering this yield loss (Hussey 2009).

The cultivar effects found in the experiments are likely to be site specific. As an example, the poor performance of Q183$^{\Phi}$ at the site near Ingham may just indicate that it was not suited to that particular soil type rather than indicating that Q183$^{\Phi}$ will not perform well in the Ingham region in general.

4.1.2 Clone experiments

4.1.2.1 Meringa

Row configuration had a significant effect on the average phenotypic characteristics of the 48 genotypes grown at Meringa (Table 18). These characteristics also varied significantly among genotypes (Appendix 1). The range among genotypes for each characteristic was: stalks/m^2 4.7 - 8.4; stalk length 192 - 325 cm; stalk diameter 20.5 - 28.8 mm; stalk weight 1.1 - 2.4 kg; percent millable stalk 76.1 - 88.7. These ranges indicate the variability in growth traits for the genotypes tested in the experiment. It is likely that if a particular growth characteristic allowed better performance on wider row configurations then one or more of the genotypes in the experiment would have possessed this characteristic (large stalk population, low stalk population, etc.).

Table 18 − Effect of row configuration on the phenotypic characteristics of 48 sugarcane genotypes at Meringa (average of all genotypes)

Phenotypic characteristic	Row configuration			
	1.52 m single	1.85 m single	1.85 m dual	LSD (0.05)
Stalks/m^2	6.69	5.60	6.62	0.15
Stalk length (cm)	275.6	266.4	263.8	3.25
Stalk diameter (mm)	23.2	24.0	23.0	0.21
Stalk weight (kg)	1.60	1.65	1.51	0.03
Percent millable stalk	83.4	82.9	83.2	*ns*

ns – not statistically significant (P > 0.05)
LSD –Least significant difference

There were significant differences among genotypes for all yield traits (Appendix 2). The genotype-by-row-configuration interaction was not significant for any trait. Genotype accounted for significantly more variation than the genotype-by-row-configuration interaction (Table 19). The genotype variance component was 70.1, 56.1 and 24.7 times the genotype-by-row-configuration interaction variance component for TCH, CCS and TSH, respectively. This showed that there were large differences among genotypes but only a small difference as to how the genotypes performed over the different row configurations.

Significantly more cane and sugar was produced on the 1.52 m single-row than the 1.85 m single-row configuration (Appendix 2). Although significant, this difference in yield among configurations was relatively small (7%) and it should not be considered in isolation as new farming systems, of which 1.85 m row spacings or wider are an important component, have a lower cost of production (Poggio *et al*., 2007; Schroeder *et al*., 2009). Further, with new farming systems there is the opportunity to reduce tillage operations and improve soil condition.

The yield of the first-ratoon crop was significantly greater than the plant crop (not shown). There also was a greater increase in yield from plant to first ratoon on the two single-row configurations, particularly the 1.85 m single, when compared to the dual-row system. This may be due to greater harvester damage on the dual-row system and/or better stool development in the first-ratoon crop under the wide single-row spacing. A similar result for dual-row configurations was reported by Garside *et al*. (2009).

Table 19 − Variance component estimates for the combined analysis of plant and 1st ratoon crops at Meringa

Term[1]	Variance component estimate		
	TCH	CCS	TSH
Rep	3.96	0.0139	1.01
G	69.37	0.6005	31.11
RC	6.94	0.0005	2.77
G.RC	0.99	0.0107	1.26
Rep.G.RC	24.78	0.1287	18.26
Crop	14.87	0.0429	8.31
G.Crop	34.69	0.0107	11.84
RC.Crop	4.96	0.0016	1.64
G.RC.Crop	0.99	0.0440	0.76
Residual	53.52	0.1180	0.50

[1] Genotype (G); row configuration (RC); replicate (R)

The aerial view of the experiment at Meringa supports the statistics (Figure 3). Each rectangular plot visible within the block contained a genotype growing on all three row configurations. It is easy to distinguish genotypes from each other due to large genotypic differences in flowering. It is not possible to distinguish the genotype-by-row-configuration interaction as the effect was too small. If a genotype was flowering, it did so across all row configurations. Similarly, it produced similar yield across row configurations.

Figure 3 − Aerial view of genotype-by-row-configuration experiments at Meringa

4.1.2.2 Ingham

The trial at Ingham was conducted to test a large number of genotypes in a wet, rain-fed environment. Unfortunately, the conditions following planting in July 2009 were dry. The lack of irrigation infrastructure resulted in some areas of poor establishment.

Row configuration had a significant effect on the average phenotypic characteristics of the 20 genotypes (Table 20). The larger number of stalks on the dual-row configuration was most likely associated with the higher planting rate on this configuration. This planting rate effect also may explain some of the difference between the two single-row systems. The dry conditions after planting most likely contributed to the difference in stalk population. Tillering was reduced, thus limiting the chance of the systems with lower planting rates from compensating for low primary shoot populations. Further, there was not sufficient compensation for lower stalk numbers with increased stalk weights (Table 20), probably due also to relatively dry growing conditions. Stalk diameter was reduced in the dual-row system.

Significant differences for all phenotypic characteristics were found among genotypes (Appendix 3). The range for each trait was: stalks/m^2 5.7-10.2; stalk length 219.6-329.5 cm; stalk diameter 18.6-25.1 mm; stalk weight 1.10-1.84 kg; percent millable stalk 77.3-88.5. A significant genotype-by-row-configuration interaction was found for stalks/m^2 (not shown).

As was the case at Meringa, the genotype term accounted for substantially more variation than the genotype-by-row-configuration interaction (Table 21). The genotype variance component was 579, 151 and 10 times the genotype-by-row-configuration interaction variance component for TCH, CCS and TSH, respectively. In addition to this, the genotype-by-row-configuration interaction was not significant for any trait (TCH, CCS and TSH) in either the plant or first-ratoon crops.

Table 20 − Effect of row configuration on phenotypic characteristics of 20 sugarcane genotypes at Ingham and the Burdekin

Location	Phenotypic characteristics	1.52 m single	1.85 m single	1.85 m dual	LSD
Ingham	Stalks/m^2	7.3	6.6	8.4	0.67
	Stalk length (cm)	278.1	276.2	282.1	ns
	Stalk diameter (mm)	21.7	22.0	21.2	0.33
	Stalk wt. (kg)	1.45	1.48	1.39	ns
	% millable stalk	85.3	84.8	85.9	ns
Burdekin	Stalks/m^2	11.4	9.9	11.4	1.15
	Stalk wt. (kg)	1.31	1.40	1.27	0.09
	% millable stalk	84.8	84.3	85.0	*ns*
	Lodging	3.08	2.54	2.34	0.5

ns – not statistically significant (P > 0.05); LSD – least significant difference (P < 0.05)

The dual-row configuration produced significantly more cane and sugar (Appendix 4) than the two single-row configurations, in the plant crop but not the first-ratoon, which was severely affected by sugarcane smut and Cyclone Yasi. This difference in the plant crop was most likely due to stalk population (Table 20) as discussed previously. No difference was found between single-row configurations.

Table 21 − Variance component estimates for the combined analysis of plant and 1st ratoon crops at Ingham

Term	Variance component estimate		
	TCH	CCS	TSH
Rep	0.0001	0.0034	0.0001
G	11.6391	0.1356	0.0992
Rep.G	33.1112	0.0068	0.5952
RC	17.0573	0.0001	0.4960
Rep.RC	13.0438	0.0056	0.2976
G.RC	0.0201	0.0009	0.0099
Rep.G.RC	0.0001	0.0001	0.0001
Crop	871.9300	0.0001	21.8222
Rep.Crop	0.0010	0.0226	0.0198
G.Crop	47.1583	0.0678	1.4879
Rep.G.Crop	59.1987	0.0678	1.4879
RC.Crop	12.0404	0.0002	0.2976
G.RC.Crop	0.0001	0.0001	0.0001
AR(1)	0.3000	-0.0800	0.2500
Residual	66.2223	0.2260	1.6863

Genotype (G); row configuration (RC); replicate (R)

There were highly significant differences among genotypes in the plant crop, mostly due to the poor performance of Q208[Ⓟ], QN97-1111, QN97-1866, QN97-2173, QN97-670, QN97-2024 and the good performance of QN92-1234 (now Q241[Ⓟ]), QN97-1229 and QN97-2198. The poor performance of Q208[Ⓟ] was most likely associated with slow emergence, an undesirable trait when the soil profile was drying out. In the first-ratoon crop genotypes with low smut ratings performed well, particularly QN97-23 (now Q237[Ⓟ]), QN92-1234 (now Q241[Ⓟ]) and Q208[Ⓟ].

4.1.2.3 Burdekin

Row configuration had a significant effect on the average phenotypic characteristics of the 20 genotypes in the Burdekin (Table 20). The 1.85 m single-row configuration in the Burdekin had the fewest stalks. However, this configuration also produced significantly larger stalks than those produced on the two other configurations. Further evidence for compensation mechanisms among stalk number and stalk weight (Bell and Garside, 2005). Interestingly, the 1.52 m single-row configuration had a significantly higher lodging rating than the two 1.85 m configurations. This was mainly due to two genotypes QN89-2208 and QN97-2198. This is contrary to the assumption that there would be greater lodging on the dual-row configuration. There were no other significant interaction terms for phenotypic characteristics.

Despite the lower stalk numbers on the 1.85 m single-row configuration this did not result in a significant configuration effect for TCH, CCS, or TSH, in either the plant or first-ratoon crops (Appendix 5). There was a highly significant genotype effect for TSH in the plant and TCH and TSH in the first-ratoon crops. The significant TSH effect in the plant crop was mainly due to QN95-1700, QN95-289 and QN97-2198 performing better than QN97-1105, QN97-1889 and QN97-633. In the first-ratoon crop, the significant TCH and TSH effects were mainly due to QN92-1234 (now Q241[Ⓟ]), QN95-289, QN97-2024 and QN95-1700 producing more cane and sugar than QN97-1866, QN97-315, QN97-1889 and QN97-2198.

The genotype-by-row-configuration interaction effect was not significant for any trait (TCH, CCS and TSH) in the plant crop. However, a significant genotype-by-row-configuration interaction was found for TCH and TSH in the first-ratoon crop. This was the only occasion a significant interaction effect for a yield trait was found in the project. The significant interaction was mainly due to the following results:

- QN92-1234 (Q241⫯) produced more sugar on the 1.5 m single than the 1.85 m dual-row configuration
- QN95-289 produced more sugar on the 1.5 m single than the 1.85 m single-row configuration
- QN97-1889 produced more sugar on the 1.5 m single than the 1.85 m dual-row configuration
- QN97-2177 produced more sugar on the 1.85 m dual than the 1.85 m single-row configuration
- QN97-2198 produced more sugar on the 1.85 m single than the 1.85 m dual-row configuration

The yields in the experiment were relatively poor for the Burdekin region, most likely due to planting in August as a plough-out replant crop.

As was the case at Meringa and Ingham, genotype accounted for more variation than the genotype-by-row-configuration interaction (Table 22). However, the difference between the variance components in the Burdekin was not as large as at the two other sites. The genotype variance component was 2.5, 60 and 1.8 times the genotype-by-row-configuration interaction variance component for TCH, CCS and TSH, respectively. This was mainly due to the significant cultivar-by-row-configuration interaction in the first-ratoon crop.

Table 22 − Variance component estimates for the combined analysis of plant and 1st ratoon crops in the Burdekin

Term	Variance component estimate		
	TCH	CCS	TSH
Rep	0.0001	0.0001	0.000
G	33.9424	0.3014	0.502
Rep.G	46.9204	0.0502	1.005
RC	0.0001	0.0131	0.000
Rep.RC	5.5905	0.0271	0.181
G.RC	13.4771	0.0050	0.281
Rep.G.RC	2.2961	0.0001	0.000
Crop	0.0001	4.3197	5.223
Rep.Crop	1.9966	0.1306	0.018
G.Crop	3.2944	0.5023	1.185
Rep.G.Crop	0.0001	0.0201	0.000
RC.Crop	0.0001	0.0261	0.045
G.RC.Crop	0.0001	0.0211	0.000
AR(1)	0.0600	-0.1400	0.100
Residual	196.6700	0.8037	5.223

Genotype (G); row configuration (RC); replicate (R)

4.1.2.4 Discussion of clone experiments

The lack of significant interaction terms for yield and the relatively small amount of variation accounted for by the genotype-by-row-configuration interaction at all three sites, showed that genotypes tend to perform similarly over the row configurations tested. The significant interaction term found in the first-ratoon crop at the Burdekin was the only contradictory observation. However, the genotypes responsible for this observation at the Burdekin did not show similar responses in the plant crop at the Burdekin or at Ingham and Meringa in either the plant or first-ratoon crops. While this could indicate an environment by cultivar-by-row-configuration by crop interaction, it is more likely that it was a random result.

The results from all three experiments confirm that the plant-improvement program could be performed on any row configuration. There does not appear to be a need for any specific changes to the selection system in order to ensure genotypes that perform well on wide-row configurations are released. As adoption of wide-row configurations continues in the industry it is likely that an increasing number of FATs will be planted on these configurations. Either way, the results suggest that superior genotypes are likely to be selected for all row configurations.

In Mauritius, cultivars that performed significantly better on dual-row configurations were found (Sundara, 2003; Ismael *et al*., 2008). Cultivars with erect stalk and leaf were considered to potentially perform better on dual-rows than those that lodged. No evidence to support this hypothesis was found in these experiments. Experiments at Meringa and Ingham did not lodge and the dual-row configuration lodged less than the 1.52 m single-row configuration in the Burdekin. However, this suggested ideotype for dual-row configurations appears logical. Use of a more variable set of genotypes may reveal a trait or traits that would confer better performance on wide row configurations. However, this appears unlikely given the large range of phenotypic traits exhibited by the genotypes in these experiments.

Significant row configuration effects were found at Meringa and Ingham but not at the Burdekin. These row configuration effects were not consistent. At Meringa the 1.85 m single-row configuration was lower than the other two configurations. At Ingham the dual-row configuration was greater than the other two configurations. The difference between the 1.52 m single and 1.85 m single-row configuration was ~ 8% at each site, although not significant at Ingham and the Burdekin. Garside *et al*. (2005) reported yield differences over row configurations but, often in row configuration trials, no differences are detected (Bell *et al*., 2007; Salter *et al*., 2008; Garside *et al*., 2009; Salter *et al*., 2010). Row-configuration effects were also discussed previously in section 4.1.1.5.

4.2 Extension and development

The research staff published much of the work conducted in the project. This included two ASSCT papers, two *BSES Bulletin* articles (section 8) as well as general industry publications (newsletters, etc.). A paper is also being prepared for publication in a scientific journal, most likely *Crop & Pasture Science*. The project results were also discussed at numerous industry meetings. This included meetings, together with projects BSS268 and BSS286, in May 2010 at Mackay, Ayr, Ingham and Innisfail.

The following is a summary of the communication activities that were undertaken during the project. These activities were directed at growers, researchers and industry extension officers.

- 3 October 2006 - Meeting of project grower and research group at CSIRO Davies Laboratory, Townsville.
- 4 March 2007 - Salter presented results from previous variety by row spacing work conducted as part of BSS286 and outlined new project to a meeting of FutureCane and SYDJV researchers and extension officers at Illawong Beach Resort, Mackay.
- 16 October 2007 - Salter presented trial data from the project at the sugarcane physiology workshop at the CSIRO Davies Laboratory, Townsville.
- 22 January 2008 - Salter presented data at Mackay trial information day at Bakers Creek Community Hall, Mackay.
- 27 March 2008 - Salter presented data at a FutureCane meeting in Cairns.
- 1 May 2008 - Paper presented at ASSCT, Townsville:

  Salter B; Garside AL; Berding N (2008) Performance of cultivars on different row configurations. *Proceedings of the Australian Society of Sugarcane Technologists* 30, 220-230.
- 22 and 23 May 2008 – Trial results displayed on a poster at Mackay BSES field day.
- 8 October 2008 - Salter presented trial data to BSS286 grower reference group at Tully BSES.
- 27 November 2008 - Salter presented trial data to sugarcane physiology workshop at CSIRO Davies Laboratory, Townsville.
- August 2008 - BSES Burdekin Newsletter contained the following article:

  Varieties perform in a similar manner on single and dual rows at the BSES station
- 28 and 29 January 2009: Meeting with project grower group and researchers in Cairns to discuss project direction
- 16 March 2009 - Salter presented trial data at a BSES QCrops meeting in Mackay
- 20 May 2009 - Salter presented trial data at the Australian Cane Farmers Association conference at Wests Leagues Club, Mackay
- 28 October 2009 - Salter attended a sugarcane physiology workshop at CSIRO QBP, Brisbane.
- 24 November 2009 - Salter discussed results from the project with industry extension officers and researchers at a trial information day at BSES Mackay
- 2 February 2010 - Summary of the trial results was sent to the project Grower reference group.
- 17 February 2010 - Salter presented results to growers at a trial information day at Mackay
- April 2010 - *BSES Bulletin* article, Issue 25 pg. 3-6. Evaluation of varieties for a controlled traffic farming system (Appendix ?).
- 5 May 2011 - Paper presented at ASSCT, Mackay:

  Salter B; Garside AL ; Berding N; Perna J; Park G (2011) Are genotype-by-row-configuration interactions of consequence in cultivar development for wide row production. *Proceedings of the Australian Society of Sugarcane Technologists*

- 24 May 2010 – Salter presented project results to growers at joint meeting with BSS268 and BSS286, Wests Leagues Club, Mackay.
- 25 May 2010 – Salter presented project results to growers at joint meeting with BSS268 and BSS286, at Ayr.
- 26 May 2010 – Salter presented project results to growers at joint meeting with BSS268 and BSS286, at the Ingham BSES.
- 27 May 2010 – Salter presented project results to growers at joint meeting with BSS268 and BSS286, at the DEEDI Research Station, Innisfail.
- 1 August 2011: Summary of the trial results was sent to the project Grower reference group**.**
- August 2011 - *BSES Bulletin* article, Issue 31 pg. 4-6. Should we change the variety selection system to cater for wide row configurations? (Appendix ?).

4.3 Project evaluation

4.3.1 Baseline evaluation survey

A survey was conducted to establish opinions/views/knowledge in relation to changing farming systems, the plant-breeding program and the performance of varieties on wider row spacings prior to the project outcomes being known. People involved in plant-breeding or related activities (breeders, technicians, variety officers), agronomy and extension, particularly those who were involved in new farming systems, were targeted. The survey group contained 53 people from five organisations (BSES, CSIRO, DPI&F, CSR, MAPS). The survey questions can be found in Appendix 6 and the range of answers in Figure 4.

Twenty nine people responded to the survey (10 Agronomy, 6 Plant-breeding, 6 Extension and 7 Technical), which was 54 % of the group who received it.

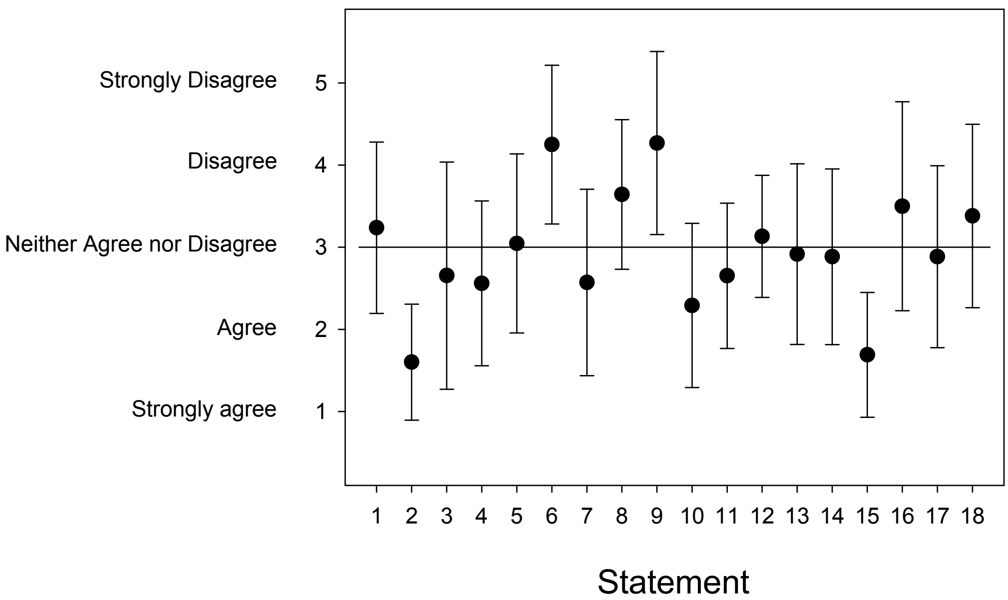

Figure 4 − Overall response to survey questions/statements. Error bars represent ± standard deviation.

The strongest opinions were found for statements 2, 6, 9 and 15. This meant that most people agreed that some selection trials needed to be conducted on wider row spacings. Most people thought that there was no need to wait for the majority of growers to use one specific system before making changes to the breeding program. Most people disagreed with the statement that the breeding program should remain on 1.5 m spacings because it allowed more clones to be assessed per unit area (compared to wider rows). There was also a strong opinion that varieties do have different growth pathways (early vigorous growth, slow and steady, etc.).

It was also important to note the lack of any strong opinions for just about all of the other questions/statements. This could have reflected a lack of knowledge. Furthermore, a large proportion of participants believed there was not sufficient evidence to comment on questions/statements 1, 5, 12 and 18 (Figure 5). These statements were in relation to the performance of varieties in the new farming system, whether clones that perform well in the new system are making it through the breeding program and whether dual-row cane generally has lower CCS than single 1.5 m rows.

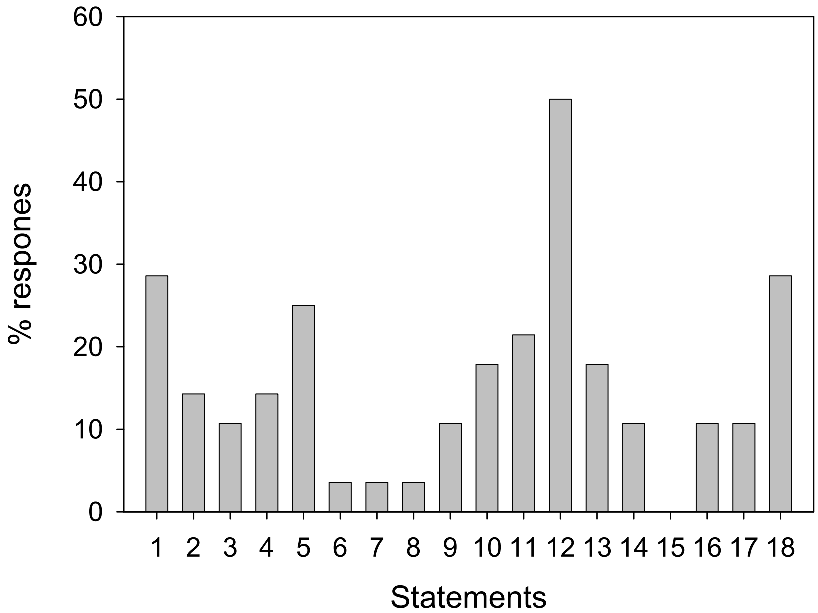

Figure 5 − Percentage of responses where the participant believed there was not sufficient evidence to make a comment.

4.3.2 Evaluation at completion of project

Following the completion of project activities a further survey was sent to the original survey group plus some additional industry personnel. The survey group contained 79 people from six organisations (BSES, CSIRO, DEEDI, Sucrogen, MAPS, and HCPSL) as well as some consultants. The survey questions can be found in Appendix 7 and the range of answers in Figure 6. Twenty-one responses to the survey were received.

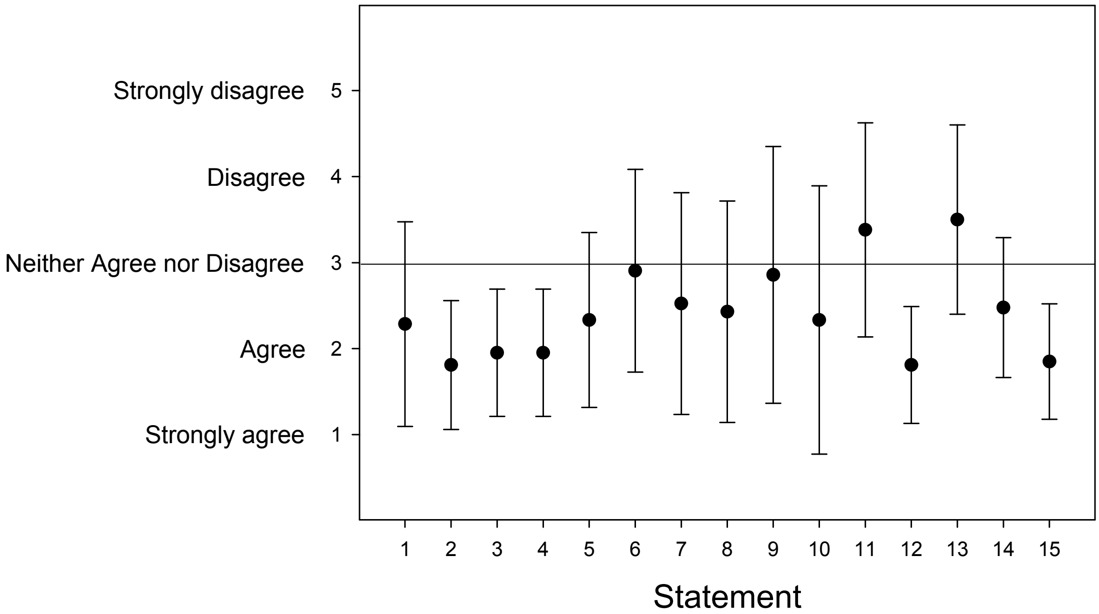

Figure 6 − Overall response to survey questions/statements. Error bars represent ± standard deviation.

The first six questions/statements on the survey related to project outputs. There was general agreement with these statements. This shows that participants were aware of the project results, the lack of any significant cultivar-by-row-configuration interactions and the performance of cultivars across row configurations. These responses also show that the uncertainty around whether clones suitable for wide row spacings were making it through the breeding program (Figure 6, Statement 12) has been addressed. Statements 7-11 related to project outcomes. The response to these statements was not as strong and was more variable than those to the project outputs. These statements were focussed on what changes, if any, should occur in the plant-breeding program and the management of BSES experiment stations. According to the project results, no specific changes would be required to the plant-breeding program for suitable cultivars to be selected for controlled-traffic row configurations. Some participants reflected this in their response. There also appeared to be a view that some changes to the plant-breeding program should be made, despite the project results. Interestingly these views differed depending on job function, particularly for statements 7, 9, and 10. Plant breeders believed that no changes were required to the selection system given the project results, whereas agronomists, and to a lesser extent those with an extension role, believed the selection system should be changed despite the project results (Table 23). The latter group appears to be responding based on feelings rather than the results from the project.

Table 23 − Project evaluation survey responses by job function

Statement	Agronomist	Breeder	Extension	Technical
1	2.2	1.0	2.8	1.8
2	1.6	1.5	2.0	1.8
3	2.2	1.0	1.9	2.3
4	2.2	1.0	1.9	2.3
5	2.6	1.0	2.3	2.8
6	3.2	4.5	2.8	2.0
7	2.8	1.0	2.7	2.5
8	1.4	2.5	2.5	3.5
9	1.4	4.5	3.0	3.5
10	1.4	4.0	1.9	3.8
11	3.6	3.0	3.7	2.5
12	1.2	1.5	2.1	2.0
13	3.3	3.5	3.5	3.8
14	3.0	2.5	2.4	2.0
15	1.3	1.5	2.0	2.3

1.Strongle agree; 2. Agree; 3. Neither Agree nor Disagree; 4 Disagree; 5. Strongly disagree

Statements 12-15 related to crop development. Strong responses were found for statements 12 and 15, showing that participants were aware that cultivars have different growth pathways and that low stalk populations are often compensated for by increased stalk weight.

Overall the evaluation survey shows that participants were aware of the project results. However, some differences in opinions as to how selection in the plant-breeding program should be conducted remained. It is unlikely that further experimental work could change these opinions, as the experimental evidence in the project was conclusive. The likely outcome is that as commercial farming systems change so will the plant-breeding program. This is because FATs in the selection program are conducted on farmers' properties under the farmer's management system.

5.0 OUTPUTS

The following major outputs were identified:

1. **Current commercial sugarcane cultivars perform in a similar manner over row configurations**
2. **Cultivars suitable for wide row configurations are currently available**

These two outputs are the result of project experiments conducted in Bundaberg, Mackay, Burdekin, Ingham and Meringa. In most experiments four major varieties were tested on the three row configurations (1.5 m single, 1.8 m single and 1.8 m dual). No cultivar-by-row-configuration interaction was found in these trials. If a variety performed well at a site it did so on all row configurations. Varieties tested include: Q117, Q135, Q151, Q171$^{\Phi}$, Q174$^{\Phi}$, Q183$^{\Phi}$, Q186$^{\Phi}$, Q190$^{\Phi}$, Q200$^{\Phi}$, Q201$^{\Phi}$, Q208$^{\Phi}$, Q209$^{\Phi}$, Q232$^{\Phi}$, KQ228$^{\Phi}$, Q237$^{\Phi}$, Q241$^{\Phi}$ and Tellus$^{\Phi}$. These outputs also show that the adoption of controlled traffic should not be hindered by the lack of adequate cultivars.

3. **The genotype-by-row-configuration interaction is very small in comparison to the genotype effect alone**
4. **Selection in the crop improvement program could occur on any row configuration**

These outputs are the result of the genotype-by-row-configuration experiments conducted at Meringa, Ingham and the Burdekin. In these experiments the genotype effect accounted for a substantially larger portion of the variation than the genotype-by-row-configuration interaction. This showed that there were large differences among genotypes but only small differences as to how the genotypes performed over the different row configurations. Given this result, selection of genotypes that performed well at a site would also result in the selection of the genotypes that would perform well over different row configurations.

5. **Crops develop differently on wide row configurations**

Row-configuration effects were found in some trials and not in others. When a significant effect was found it was often associated with low stalk numbers on the 1.8 m single-row configuration. While low stalk numbers were compensated for by increased stalk weight, in some cases the compensation was not sufficient to prevent a yield effect. This appeared to occur when environmental conditions were limiting. Dual-row configurations consistently produced greater stalk populations than the two single-row configurations, particularly early in development. This did not result in increased yield. Low planting rates in experiments may have contributed to row configuration effects, particularly when unfavourable environmental conditions were encountered during establishment. This may not be an issue for commercial cane fields as planting rates are significantly higher than those used in experiments.

6. **Cultivars have different growth pathways**

Cultivars grow in different ways. Some are characterised by vigorous early growth, often associated with high stalk numbers, whereas others develop more slowly and consistently during the crop. No evidence was found to suggest that any one particular growth pathway (trait) would be best suited to a certain row configuration. It is likely that different growth pathways would be suited to different environments or harvesting times. The popularity of Q200[⌽] in the Wet Tropics may be associated with its ability to germinate quickly, produce a large stalk population and form a canopy quicker than other varieties. These traits may be an advantage in an environment where the early onset of the wet season can severely affect growth. The outcome of these traits is expressed in terms of yield and CCS.

Some additional minor outputs were identified in section 4.

6.0 EXPECTED OUTCOMES

Many of the proposed outcomes shown in section 2 remain valid. Cultivars with the necessary traits for good performance on controlled traffic row configurations were shown to be currently available and would make it through the current plant-breeding selection system. This message should result in greater adoption of controlled-traffic farming systems, if the lack of suitable cultivars for wider row configurations was the real reason for not adopting new farming systems. There has now been considerable work showing that control traffic will reduce soil compaction of the cropping area, which will facilitate soil health improvements, better timeliness of operations, reduced fossil fuel use, less labour input and a generally more sustainable and environmentally responsible cropping system (Hussey 2009; Salter *et al*. 2010; Schroeder *et al*. 2009).

The results from all experiments confirmed that the crop improvement program could be performed on any row configuration. There does not appear to be a need for any specific changes to the selection system in order to ensure genotypes that perform well on wide-row configurations are released. Any additional or new selection protocol for wide-row configurations would have come at cost and not having to do it allows the industry's research investment to be directed into other areas. As adoption of wide row configurations continues in the industry it is likely that an increasing number of Final Assessment Trials will be planted on these configurations. This has already commenced in some regions. Either way, the results suggest that superior genotypes are likely to be selected for all row configurations.

7.0 FUTURE NEEDS AND RECOMMENDATIONS

Grower evidence from the field

If, in the future, evidence emerges that a cultivar is not performing on a particular row configuration we suggest that some trial work be conducted to establish whether the issue is real or not. This would most likely require commercial-scale strip trials and the involvement of farming systems and plant-breeding development officers.

Row configuration changes in the future

Row configurations are likely to change with changes in available machinery. It is possible that row configurations wider than those tested in this project could become popular. As an example, a 2.4 m dual-row configuration may be adopted if harvesters are available at this width. If this does eventuate, it may be necessary to reassess some of the issues addressed in this project. However, this is unlikely to occur in the next 10 years.

Cultivar growth pathways

Cultivars were shown to exhibit different growth pathways. Understanding how cultivars develop and what development pathways allow for better adaptation to particular environments may offer some gains to the industry. This type of crop physiology work needs to be conducted.

Crop establishment and wide-row configurations

The 1.8 m single-row configuration was shown to produce significantly lower yield than other configurations at some sites. This appeared to be due to low stalk populations, a consequence of planting rate, configuration width, and environmental conditions at the time of establishment as well as during development. These issues need to be addressed in order to achieve greater adoption of controlled traffic. Do the higher planting rates used during commercial operations eliminate this row configuration effect? BSS269 conducted a number of strip trials in the Central Region in order to address this issue. Similar effort may be required in other regions where adoption of controlled traffic has been slow, particularly the Wet Tropics. There is also concern that canopy closure on wide single-row configurations is too slow, allowing a greater period of time for weeds to establish in the crop. This could be addressed as part of the crop physiology work suggested above.

Barriers to adoption of new farming systems

Growers adopt or fail to adopt different management strategies for different reasons. There is a need to understand why new farming systems are being adopted at different rates in each region. This should include social factors, and could then be used to develop different farming system extension packages for each region.

8.0 PUBLICATIONS ARISING FROM THE PROJECT

The following publications were produced during the course of the project. A further scientific paper is planned for *Crop & Pasture Science*.

Salter B; Garside AL; Berding N (2008) Performance of cultivars on different row configurations. *Proceedings of the Australian Society of Sugarcane Technologists* **30**, 220-230. (Appendix 8)

Salter B; Garside AL; Berding N; Perna J; Park G (2011) Are genotype-by-row-configuration interactions of consequence in cultivar development for wide row production. *Proceedings of the Australian Society of Sugarcane Technologists* (Appendix 9)

Salter B (2010) Evaluation of varieties for a controlled traffic farming system. *BSES Bulletin*, Issue **25** pg. 3-6. (Appendix 10)

Salter B (2011) Should we change the variety selection system to cater for wide row configurations? *BSES Bulletin*, Issue **31** pg. 4-6. (Appendix 11)

Although not specifically part of this project, the following paper by Alan Garside, a project participant was published. This work was conducted as part of the Sugar Yield Decline Joint Venture and was the foundation for this project.

Garside AL; Bell MJ (2009) Row spacing and planting density effects on the growth and yield of sugarcane. 3. Responses with different cultivars. *Crop & Pasture Science* **60**, 555–565.

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A number of people contributed to the success of BSS296. Alan Garside and Nils Berding were influential in the development of the project. They made valuable contributions to the management of project activities and were a source of valuable feedback. Glen Park, Jason Perna, Michael Porta, Phillip Netz, Richard Cervellin, Ryan Matthews, Jeff Blackburn, Ross McIntyre, Jeff Smith, Emilie Fillols, Adam Royle and Tina Brieffies are thanked for significant effort conducting much of the trial work associated with the project. Emily Deomano and Jo Stringer are thanked for performing statistical analyses. Dino Volpi, Tom Gilbert, Mario Porta, Doug Lamb and Peter Melville generously allowed these trials to be conducted on their farms and assisted in trial management. The grower reference group, Dick Camilleri, Ian Haigh, Martin Thompson and Geoff McCarthy are thanked for their ability to provide practical advice to the researchers particularly during the early stages of the project. Members of the Sugar Yield Decline Joint Venture, as well as Robert Quirk, Peter Russo, Terry Granshaw and George Henry are thanked for providing useful feedback and advice.

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11.0 APPENDICES

APPENDIX 1 − Phenotypic characteristics of 48 genotypes at harvest of the plant crop at Meringa (average over all row configurations)

APPENDIX 2 − Cane (TCH) and sugar (TSH) yield for 48 genotypes grown on three row configurations at Meringa (average of plant and first-ratoon crops)

APPENDIX 3 − Phenotypic characteristics of 20 genotypes at harvest of the plant crop at Ingham (average over all row configurations)

APPENDIX 4 − Plant and first-ratoon cane (TCH) and sugar (TSH) yield for 20 genotypes grown on three row configurations at Ingham.

APPENDIX 5 − Plant and first-ratoon cane (TCH) and sugar (TSH) yield for 20 genotypes grown on three row configurations at Ayr

APPENDIX 6 − Baseline project evaluation for BSS296 'Evaluation of genotypes for controlled-traffic farming systems'

APPENDIX 7 − Project evaluation for BSS296 'Evaluation of genotypes for a controlled-traffic farming system'

APPENDIX 8 – Salter *et al*. (2008) Performance of cultivars on different row configurations

APPENDIX 9 – Salter *et al*. (2011) Are genotype-by-row-configuration interactions of consequence in cultivar development for wide row production

APPENDIX 10 – Salter (2010) Evaluation of varieties for a controlled traffic farming system

APPENDIX 11 – Salter (2011) Should we change the variety selection system to cater for wide row configurations

APPENDIX 1 − Phenotypic characteristics of 48 genotypes at harvest of the plant crop at Meringa (average over all row configurations)

Genotype	Phenotypic characteristics				
	Stalks/m^2	Stalk length (cm)	Stalk width (mm)	Indiv. Stalk wt	% millable stalk
Q200[Φ]	8.2	279.9	20.7	1.3	86.4
Q208[Φ]	6.2	297.2	23.2	1.7	84.7
QN89-	5.4	298.6	26.0	2.4	82.7
QN91-	5.2	283.3	23.8	1.7	82.1
QN92-	8.4	278.0	20.5	1.3	84.6
QN95-	6.9	256.6	21.7	1.4	86.1
QN95-	5.3	303.3	26.8	2.1	83.5
QN97-	6.4	296.2	22.5	1.6	82.9
QN97-	5.9	284.7	26.5	2.0	79.1
QN97-	7.0	254.2	24.0	1.5	87.9
QN97-	5.6	254.6	24.9	1.6	82.3
QN97-	8.0	254.8	20.8	1.2	82.6
QN97-	6.1	230.2	24.3	1.5	76.1
QN97-	7.5	255.5	20.5	1.3	69.9
QN97-	5.0	310.9	23.5	2.1	81.8
QN97-	6.8	281.7	21.5	1.4	80.4
QN97-	5.9	305.1	22.5	1.7	88.7
QN97-	5.2	310.1	23.8	2.0	86.5
QN97-	7.0	243.4	21.9	1.3	83.1
QN97-	5.9	324.8	22.7	1.7	84.7
QN97-	5.8	268.5	23.2	1.8	81.4
QN97-	5.2	298.9	25.0	1.9	83.1
QN97-	6.4	218.3	26.5	1.5	85.9
QN97-	7.8	231.7	21.4	1.2	80.1
QN97-	5.4	283.5	23.4	1.7	80.1
QN97-	5.1	250.6	24.9	1.7	83.7
QN97-	5.2	257.0	28.8	2.1	80.2
QN97-	6.8	258.9	22.3	1.5	86.6
QN97-	5.8	293.1	23.7	1.6	88.2
QN97-23	5.4	276.0	25.9	1.9	83.4
QN97-	5.4	301.2	22.8	1.5	87.3
QN97-	5.0	264.0	23.3	1.5	83.8
QN97-	6.5	234.2	24.7	1.4	82.5
QN97-	5.9	266.9	22.8	1.5	85.1
QN97-	6.7	287.7	22.2	1.6	85.6
QN97-	7.4	251.7	22.2	1.2	83.9
QN97-	7.4	192.0	23.8	1.1	81.5
QN97-44	6.3	270.9	23.2	1.6	82.4
QN97-	7.5	225.7	22.5	1.3	82.2
QN97-	7.4	262.4	22.3	1.4	79.2
QN97-	6.4	213.4	23.5	1.2	84.9
QN97-	5.0	317.7	25.8	2.3	83.6
QN97-	7.2	264.6	24.0	1.4	86.6
QN97-	7.1	276.9	22.0	1.4	85.0
QN97-	7.6	230.2	21.6	1.3	81.4
QN97-	5.9	233.6	25.0	1.8	80.8
QN97-	6.7	267.4	22.2	1.3	82.3
Unknown	4.7	292.3	22.8	1.6	86.3
LSD(0.05)	0.62	13.01	0.82	0.13	2.05

APPENDIX 2 − Cane (TCH) and sugar (TSH) yield for 48 genotypes grown on three row configurations at Meringa (average of plant and first-ratoon crops)

Genotype	TCH				TSH			
	1.52 m S	1.85 m S	1.85 m D	Mean	1.52 m S	1.85 m S	1.85 m D	Mean
Q200	106.3	101.0	101.1	102.8	17.9	17.0	16.8	17.2
Q208	109.6	95.7	100.3	101.9	18.4	16.1	16.9	17.1
QN89-2208	99.5	90.0	95.6	95.0	17.2	15.6	16.3	16.4
QN91-2967	74.3	70.7	68.9	71.3	12.4	11.6	11.3	11.7
QN92-1234	106.0	106.7	104.5	105.7	17.7	17.5	17.7	17.7
QN95-1700	94.9	94.0	89.3	92.7	16.0	16.0	14.9	15.6
QN95-289	91.1	95.9	92.7	93.2	15.6	16.5	15.7	15.9
QN97-1105	94.5	96.1	96.3	95.7	15.1	14.9	15.4	15.1
QN97-1111	95.9	88.2	91.4	91.8	15.4	13.8	14.7	14.6
QN97-1229	97.8	89.4	83.6	90.3	16.2	14.7	13.7	14.9
QN97-1250	74.6	71.5	75.0	73.7	11.1	10.8	11.1	11.0
QN97-140	93.9	85.8	82.5	87.4	15.4	14.0	13.7	14.4
QN97-1423	82.9	70.7	75.5	76.4	14.7	12.2	13.1	13.3
QN97-1434	75.4	71.4	76.5	74.5	11.3	10.6	11.4	11.1
QN97-1535	100.9	93.6	93.0	95.8	16.1	14.7	14.5	15.1
QN97-1538	83.3	80.9	79.8	81.3	13.3	13.0	12.8	13.0
QN97-1751	87.9	80.6	85.1	84.5	13.0	11.9	12.2	12.4
QN97-1866	84.0	80.9	83.1	82.6	12.3	12.1	12.2	12.2
QN97-1881	85.5	78.5	89.1	84.4	14.7	13.2	15.4	14.4
QN97-1889	88.6	80.2	88.3	85.7	13.7	12.6	13.9	13.4
QN97-1907	94.8	83.8	91.3	90.0	15.8	14.0	15.2	15.0
QN97-1972	93.7	87.3	83.6	88.2	15.2	14.0	13.5	14.2
QN97-2024	90.7	81.6	87.0	86.4	15.1	13.7	14.5	14.4
QN97-2097	85.2	76.0	78.0	79.7	13.7	12.2	12.7	12.9
QN97-2099	82.4	81.7	83.7	82.6	13.9	13.2	13.7	13.6
QN97-2122	81.9	80.4	80.1	80.8	14.7	14.4	14.3	14.5
QN97-2173	78.9	76.2	78.3	77.8	13.3	12.9	13.3	13.2
QN97-2177	83.5	76.7	80.2	80.1	14.2	12.9	13.8	13.6
QN97-2198	95.3	91.4	89.4	92.0	16.3	15.6	15.5	15.8
QN97-23	94.5	81.4	91.8	89.2	15.7	13.3	15.0	14.7
QN97-2312	74.7	72.5	74.4	73.9	12.2	11.6	12.1	12.0
QN97-2463	71.3	66.4	73.7	70.5	11.8	10.9	12.4	11.7
QN97-251	74.3	69.0	75.4	72.9	11.2	10.3	11.6	11.0
QN97-271	85.4	84.7	84.1	84.7	13.7	13.6	13.6	13.6
QN97-315	105.1	98.1	98.9	100.7	17.8	16.4	16.7	17.0
QN97-384	78.7	79.5	80.1	79.4	13.7	14.0	14.0	13.9
QN97-387	67.0	62.9	63.3	64.4	12.2	11.3	11.0	11.5
QN97-44	92.1	74.6	86.6	84.4	14.8	12.4	14.3	13.8
QN97-470	78.6	79.6	76.3	78.2	13.6	13.7	12.7	13.3
QN97-497	81.9	80.0	78.7	80.2	13.6	13.2	13.1	13.3
QN97-599	75.4	70.6	73.9	73.3	13.0	11.9	12.4	12.5
QN97-633	107.5	95.2	97.0	99.9	17.3	15.8	15.9	16.4
QN97-670	93.0	78.6	84.8	85.5	14.5	12.2	13.2	13.3
QN97-689	102.1	91.6	102.8	98.8	15.5	13.6	15.2	14.8
QN97-742	82.6	70.7	72.5	75.2	13.4	11.4	11.9	12.2
QN97-819	77.5	73.6	76.0	75.7	12.2	11.6	12.2	12.0
QN97-863	89.3	75.3	76.6	80.4	14.0	11.6	12.0	12.5
Unknown	80.4	71.2	81.7	77.8	12.7	10.8	12.9	12.1
Mean	88.0	81.9	84.4	84.8	14.4	13.4	13.8	13.9

$LSD^{(0.05)}$ Cult. TCH 7.1; Cult. TSH 1.2; Row config. TCH 1.8; Row config TSH 0.3

APPENDIX 3 − Phenotypic characteristics of 20 genotypes at harvest of the plant crop at Ingham (average over all row configurations)

Genotype	Phenotypic characteristic				
	Stalks/m^2	Stalk length (cm)	Stalk width (mm)	Indiv. Stalk wt. (kg)	% millable stalk
Q208	7.3	294.7	19.9	1.2	87.0
QN89-2208	6.2	291.8	23.6	1.8	86.0
QN92-1234	10.2	281.3	18.6	1.1	85.7
QN95-1700	8.2	269.2	20.3	1.2	86.3
QN95-289	5.8	280.1	23.5	1.7	82.8
QN97-1105	8.1	314.2	20.0	1.4	85.3
QN97-1111	5.6	250.8	24.8	1.6	77.3
QN97-1229	9.6	268.1	20.7	1.3	88.5
QN97-1535	6.4	303.1	21.6	1.6	87.1
QN97-1866	6.3	295.3	21.1	1.5	86.3
QN97-1889	7.5	329.5	20.2	1.5	86.0
QN97-2024	6.8	219.6	25.1	1.5	83.2
QN97-2173	5.7	256.3	24.9	1.6	84.9
QN97-2177	8.8	236.7	19.9	1.1	86.2
QN97-2198	8.4	302.5	20.2	1.4	85.8
QN97-23	6.7	265.3	23.6	1.6	84.5
QN97-315	8.6	274.1	19.9	1.3	86.7
QN97-44	7.9	278.9	21.7	1.5	87.4
QN97-633	6.0	311.7	23.0	1.8	84.9
QN97-670	8.8	253.1	20.4	1.1	85.1
Mean	7.5	278.8	21.7	1.4	85.3
LSD$^{(0.05)}$	1.02	22.7	0.74	0.14	1.79

APPENDIX 4 − Plant and first-ratoon cane (TCH) and sugar (TSH) yield for 20 genotypes grown on three row configurations at Ingham

Crop	Genotype	TCH				TSH			
		1.52 m S	1.85m S	1.85 m D	Mean	1.52 m S	1.85m S	1.85 m D	Mean
Plant	Q208	63.2	64.5	78.1	68.6	10.0	9.9	12.0	10.6
	QN89-2208	87.0	82.8	82.4	84.1	14.2	13.3	12.8	13.5
	QN92-1234	88.2	84.5	102.8	91.8	13.6	13.1	15.5	14.1
	QN95-1700	70.8	76.3	83.0	76.7	11.8	12.6	13.7	12.7
	QN95-289	66.3	67.0	86.1	73.1	11.0	11.1	13.7	11.9
	QN97-1105	86.8	69.7	95.3	83.9	13.1	10.8	14.6	12.8
	QN97-1111	70.1	56.8	68.2	65.0	11.7	9.5	11.6	10.9
	QN97-1229	91.1	88.5	99.0	92.9	14.4	13.7	15.6	14.6
	QN97-1535	73.0	69.7	74.9	72.5	11.2	10.7	11.8	11.3
	QN97-1866	70.1	59.9	75.7	68.6	11.2	9.4	11.6	10.7
	QN97-1889	77.8	66.3	84.5	76.2	11.9	10.4	12.8	11.7
	QN97-2024	60.9	67.6	74.4	67.6	9.4	10.6	11.7	10.6
	QN97-2173	65.5	52.4	78.4	65.5	10.7	8.7	12.8	10.7
	QN97-2177	74.4	62.7	80.5	72.6	12.1	10.1	13.5	11.9
	QN97-2198	93.6	82.1	98.0	91.2	15.0	13.4	16.1	14.9
	QN97-23	68.6	70.2	87.4	75.4	10.9	11.0	14.1	12.0
	QN97-315	70.1	68.9	94.1	77.7	11.6	11.3	15.8	12.9
	QN97-44	88.4	72.6	90.2	83.7	14.3	11.8	14.5	13.5
	QN97-633	77.0	74.7	90.5	80.7	11.9	12.1	14.3	12.8
	QN97-670	62.6	59.2	75.9	65.9	9.9	9.4	11.8	10.4
	Mean	75.3	69.8	85.0	76.7	12.0	11.1	13.5	12.2
1 Ratoon	Q208	38.6	42.4	49.2	43.4	6.3	6.9	8.1	7.1
	QN89-2208	42.1	36.8	41.8	40.3	6.9	6.0	6.8	6.6
	QN92-1234	47.0	44.5	49.7	47.1	7.7	7.3	8.2	7.7
	QN95-1700	29.7	33.0	36.7	33.1	4.8	5.2	5.8	5.3
	QN95-289	19.6	18.9	15.8	18.1	3.1	3.1	2.5	2.9
	QN97-1105	44.1	36.4	45.3	41.9	6.8	5.5	7.0	6.4
	QN97-1111	38.7	34.2	44.8	39.2	6.7	5.9	7.7	6.8
	QN97-1229	39.6	38.9	45.3	41.3	6.5	6.3	7.3	6.7
	QN97-1535	30.4	29.9	30.5	30.3	4.6	4.6	4.8	4.7
	QN97-1866	21.6	19.1	23.2	21.3	3.5	2.9	3.6	3.3
	QN97-1889	42.7	36.7	43.6	41.0	6.7	5.8	6.9	6.4
	QN97-2024	34.5	33.9	33.6	34.0	5.6	5.3	5.4	5.4
	QN97-2173	27.2	28.9	35.9	30.7	4.4	4.8	5.9	5.1
	QN97-2177	17.1	13.3	17.3	15.9	2.8	2.2	2.8	2.6
	QN97-2198	25.0	18.9	23.5	22.5	4.1	3.0	3.8	3.6
	QN97-23	53.6	48.6	56.6	52.9	8.9	8.1	9.4	8.8
	QN97-315	26.6	26.8	36.6	30.0	4.5	4.4	6.0	4.9
	QN97-44	41.1	35.8	42.4	39.8	6.6	5.7	6.8	6.4
	QN97-633	36.5	35.1	41.8	37.8	6.0	5.8	6.5	6.1
	QN97-670	35.2	33.1	39.7	36.0	5.4	5.0	6.4	5.6
	Mean	34.6	32.3	37.7	34.8	5.6	5.2	6.1	5.6

$LSD^{(0.05)}$ Plant crop: Cult. TCH 17.5; Cult. TSH 2.6; Row config. TCH 17.5; Row config TSH 1.3

$LSD^{(0.05)}$ 1st ratoon: Cult. TCH 12.5; Cult. TSH 2.0

APPENDIX 5 − Plant and first-ratoon cane (TCH) and sugar (TSH) yield for 20 genotypes grown on three row configurations at Ayr

Crop	Genotype	TCH				TSH			
		1.52 m S	1.85m S	1.85 m D	Mean	1.52 m S	1.85m S	1.85 m D	Mean
Plant	Q208	115.4	99.4	98.2	104.3	15.8	12.4	11.7	13.3
	QN89-2208	109.5	104.8	96.6	103.7	14.9	13.5	14.0	14.1
	QN92-1234	128.4	120.3	118.4	122.4	15.0	13.5	14.7	14.3
	QN95-1700	111.6	109.7	106.6	109.3	16.2	15.6	15.5	15.8
	QN95-289	125.5	105.7	114.9	115.4	18.0	14.0	16.4	16.1
	QN97-1105	108.6	96.3	104.1	103.0	13.0	10.7	11.8	11.8
	QN97-1111	104.2	85.7	104.0	98.0	15.5	12.5	15.8	14.6
	QN97-1229	104.2	99.5	92.2	98.6	14.8	12.7	12.6	13.4
	QN97-1535	99.8	92.0	101.6	97.8	13.7	13.4	13.5	13.5
	QN97-1866	98.3	102.6	90.3	97.1	12.9	14.2	11.8	13.0
	QN97-1889	86.8	98.0	96.4	93.7	9.1	12.0	11.6	11.1
	QN97-2024	105.8	100.9	107.8	104.9	14.7	13.8	14.7	14.4
	QN97-2173	99.6	94.1	108.7	100.8	15.2	14.1	16.8	15.4
	QN97-2177	104.3	96.3	103.2	101.3	15.2	14.4	15.9	15.3
	QN97-2198	106.6	105.3	98.4	103.4	16.8	16.5	15.6	16.3
	QN97-23	127.1	107.1	105.3	113.2	15.2	13.2	13.6	14.1
	QN97-315	100.8	101.1	98.7	100.2	15.2	14.6	14.9	14.9
	QN97-44	85.4	106.8	101.3	97.8	12.5	14.8	14.2	13.8
	QN97-633	100.7	114.3	95.5	103.5	12.5	12.1	11.8	12.1
	QN97-670	100.4	96.4	106.2	101.0	12.9	11.3	13.9	12.7
	Mean	106.1	101.8	102.4	103.5	14.5	13.4	14.0	14.0
1 Ratoon	Q208	104.8	111.4	109.1	108.4	18.0	18.6	18.8	18.5
	QN89-2208	101.6	103.5	101.5	102.2	18.2	16.7	16.7	17.2
	QN92-1234	136.8	128.0	113.6	126.2	21.6	21.1	18.4	20.4
	QN95-1700	107.2	120.5	109.9	112.5	18.2	20.5	19.0	19.2
	QN95-289	134.3	112.3	122.2	122.9	22.3	18.4	20.4	20.4
	QN97-1105	115.0	104.2	99.8	106.3	18.4	16.4	15.7	16.8
	QN97-1111	109.4	100.5	105.9	105.3	18.2	16.0	17.7	17.3
	QN97-1229	103.3	104.3	96.8	101.5	17.0	17.5	16.0	16.8
	QN97-1535	95.7	92.5	108.3	98.8	15.8	15.3	16.1	15.8
	QN97-1866	88.2	86.1	79.5	84.6	14.4	12.2	11.9	12.8
	QN97-1889	105.3	93.2	87.3	95.3	16.9	14.8	13.7	15.1
	QN97-2024	104.2	109.3	120.2	111.2	17.6	18.3	19.7	18.5
	QN97-2173	93.7	96.8	108.3	99.6	15.3	16.1	18.2	16.6
	QN97-2177	101.6	83.8	112.5	99.3	16.9	14.4	18.5	16.6
	QN97-2198	93.6	108.2	91.7	97.8	15.9	18.8	15.4	16.7
	QN97-23	104.0	109.7	96.1	103.3	17.3	18.5	16.0	17.3
	QN97-315	90.7	91.0	96.0	92.6	15.9	15.9	16.8	16.2
	QN97-44	107.2	119.5	101.8	109.5	16.7	19.3	16.6	17.5
	QN97-633	101.6	118.0	110.1	109.9	17.1	20.0	18.0	18.4
	QN97-670	106.0	99.3	101.6	102.3	17.7	15.7	16.2	16.5
	Mean	105.2	104.6	103.6	104.5	17.5	17.2	17.0	17.2

$LSD^{(0.05)}$ Plant crop: Cult. TSH 2.5

$LSD^{(0.05)}$ 1st ratoon: Cult. TCH 13.1; Cult. TSH 2.1; Cult. x Row config. TCH 18.0; Cult. x Row config. TSH 3.2

APPENDIX 6

Baseline project evaluation for BSS296
‘Evaluation of genotypes for controlled traffic farming systems’

Please indicate your current position:

□ **Plant breeder/Researcher working on breeding issues**
□ **Technician/Variety officer/Farm manager**
□ **Agronomist**
□ **Extension**

Please indicate by marking the appropriate box whether you: 1. Strongly agree; 2. Agree; 3. Neither agree nor disagree; 4. Disagree; 5. Strongly disagree; # there is insufficient evidence to comment.

Statement	1	2	3	4	5	#
Current varieties, selected on 1.5 m row spacings, will be suitable for wider row spacings (1.8 – 1.9 m)						
The plant-breeding program needs to conduct some selection trials on wider row spacings (1.8 -1.9 m) in order to adequately select varieties for farming systems using these configurations						
The current breeding program is inadvertently selecting varieties for declining/poor soil conditions						
Varietal performance on wider row spacings will depend on whether single rows or dual rows are grown						
Varieties selected on the 1.5 m conventional farming system will be suitable for the new farming system (controlled traffic, minimum tillage, fallow legume crops)						
The plant-breeding program needs to wait until the majority of farmers are using one specific system before making any changes						
Varieties with an erect growth habit will be required for dual-row configurations						
Varieties with a sprawling habit will be required for single rows on wide row spacings						
The breeding program should remain on 1.5 m row spacings even if the majority of farmers are using a different system as it will allow more clones to be assessed (per unit area)						
There is likely to be a significant variety by row spacing interaction*						
There is likely to be a significant variety by row format (single or dual row) interaction*						
Clones that perform well on wider row spacings aren’t making it through the breeding program						
Excessive early tillering is detrimental to the crop						
Poor tillering varieties are also poor ratooning varieties						
Varieties have different growth pathways to final yield (early vigorous growth, slow steady growth, ect.)						
Productivity will be reduced if single rows are planted wider than 1.65 m						
All varieties produce heavier stalks when stalk numbers are low						

Dual row cane usually has lower CCS than standard 1.5 m singles						

If you would like to elaborate on any of the answers above or feel there are other issues not covered in the survey please indicate these below:

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* the interaction effect will be significant if the ranking of varieties on one row spacing/format is vastly different to the ranking on another row spacing/format (see below)

1.5 m singles	**TCH**	**Rank**
Variety A	100	1
Variety B	95	2
Variety C	82	3
Variety D	77	4

1.8 m singles	**TCH**	**Rank**
Variety A	84	3
Variety B	76	4
Variety C	120	1
Variety D	100	2

APPENDIX 7

Project evaluation for BSS296
'Evaluation of genotypes for a controlled traffic farming system'

Please indicate your current position:

□ **Plant breeder/Researcher working on breeding issues**
□ **Technician/Variety officer/Farm manager**
□ **Agronomist**
□ **Extension**

Please indicate by marking the appropriate box whether you: 1. Strongly agree; 2. Agree; 3. Neither agree nor disagree; 4. Disagree; 5. Strongly disagree

Statement	1	2	3	4	5
Project outputs					
I am aware of the outputs of BSS296 – Evaluation of genotypes for a controlled traffic farming system					
There are large differences among genotypes (varieties/clones) but only a small difference as to how the genotypes perform over different row configurations					
Currently, there are varieties available that perform well on wide-row configurations					
Genotypes that perform well on wide-row configurations will make it through the breeding program					
If a variety performs well at a site it will do so on narrow and wide-row configurations					
Varietal performance on wide-row configurations will depend on whether single or dual-row configurations are used					
Project outcomes					
No specific changes are required to the breeding program in order to select varieties for wide-row configurations					
An increasing number of Final Assessment Trials should be conducted on wide-row configurations as industry adoption of these configurations increases					
The plant-breeding program needs to conduct selection trials on wider row spacing's (1.8 -1.9 m) in order to adequately select varieties for farming systems using these configurations					
BSES farms should be managed according to best practise, which includes wide-row configurations, regardless of project outputs					
BSES farms should be managed using a 1.5 m single-row configuration as it allows a greater number of clones to be assessed per unit area than a wide row configuration					
Crop development					
Varieties have different growth pathways to final yield					
Productivity will be reduced if single-row configurations are planted wider than 1.65 m					
Dual-row configurations have large stalk populations (stalks/m^2)					
Low stalk populations are often compensated for by increased stalk weight					

If you would like to elaborate on any of the answers above or feel there are other issues not covered in the survey please indicate these below: