PERFORMANCE OF SUGARCANE VARIETIES WITH CONTRASTING GROWTH HABIT IN DIFFERENT ROW SPACINGS AND CONFIGURATIONS

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Abstract

CONTROLLED traffic (matching wheel and row spacing) is being widely adopted in the Australian sugar industry to minimise the adverse effect of soil compaction caused by heavy machinery such as cane harvesters and haul-outs. In this study, the performance of current cane varieties with contrasting growth habits in differing row spacings and planting arrangements designed to achieve controlled traffic outcomes is reported. The study was conducted on an irrigated site in the Farnsfield district of the Isis mill area. Cane varieties Q138, Q188$^{\Phi}$, Q205$^{\Phi}$ and Q222$^{\Phi}$ were planted with whole stick, conventional mouldboard opener planters in 1.5 m and 1.8 m single rows and in dual rows on 1.8 m or 2.0 m centres, as well as by billet planting in a 1.8 m wide throat system. Shoot counts and biomass samples were collected at intervals during the growing season. There were no significant differences in cane yields, ccs or sugar yields between row spacings at harvest, and nor was there any significant interaction between varieties and row spacings for any parameter. This was despite there being significantly fewer harvested stalks in 1.8 m single rows (8.2/m^2) and 1.8 m wide throat (9.3/m^2) than in standard 1.5 m single rows (10.2/m^2) or the 1.8 m (10.6/m^2) and 2.0 m (10.3/m^2) dual row spacings. Much heavier individual stalk weights recorded in the 1.8 m single and wide throat billet plantings were able to compensate for lower stalk numbers. Results confirm the relative insensitivity of cane yields to crop row spacing and suggest considerable flexibility in developing row spacings to suit controlled traffic farming systems. There were significant differences between varieties in cane yields, ccs and sugar yields. Cane yields for Q205$^{\Phi}$ and Q222$^{\Phi}$ (124 t/ha and 121 t/ha) were significantly higher than Q188$^{\Phi}$ (115 t/ha) and Q138 (112 t/ha). However, in terms of sugar yield, these cane yield differences were modified to some extent by variation in ccs, with Q222$^{\Phi}$ and Q188$^{\Phi}$ (13.8% and 13.5%, respectively) having higher CCS than Q205$^{\Phi}$ (12.9%) and Q138 (11.1%). The combined effects resulted in the highest sugar yields in Q222$^{\Phi}$ (16.8 t/ha), with Q205$^{\Phi}$ and Q188$^{\Phi}$ (15.8 and 15.5 t/ha, respectively) out yielding Q138 (12.7 t/ha). Varieties used different strategies to achieve final cane yields, with high final stalk numbers in Q138 (10.5/m^2) and low stalk numbers in Q188$^{\Phi}$ (9.0/m^2) compensated for by differences in individual stalk weights.

Introduction

There have been a number of recent reports highlighting the negative impacts of compaction on productivity and sustainability of sugarcane cropping systems. These effects include reduced infiltration of rainfall and irrigation (Bell *et al*., 2001; Braunack *et al*., 2003a), and poorer soil structure and an increase in soil strength and resistance to root penetration (Braunack *et al*., 2003a; McGarry and Bristow, 2004). In addition to reducing water use efficiency in sugarcane cropping systems, compaction has increased the costs associated with land preparation between crop cycles (Braunack *et al*., 2003b) and also reduced cane yields by at least 15% (M.J. Bell and N.V. Halpin, unpublished data).

Measurements of soil properties in the cane row have shown that soil structure and organic matter levels at the end of a crop cycle are indicative of a healthy soil (McGarry and Bristow, 2001; Braunack *et al*., 2003a). There are also suggestions of the development of beneficial biology that can be disrupted by tillage (Bell *et al*., 2003; G. Stirling, unpublished data), which in the current system is a necessary management response to alleviate compaction between cane cycles. Therefore there are real opportunities to develop farming systems that can capitalise on the benefits of healthy soils and microbial communities in the cane rows by adopting controlled traffic (matched wheel and row spacings) and thus minimising the compacted area. Controlled traffic farming systems have already been adopted extensively in the grains and cotton industries.

The harvesting and haul-out operation represents by far the largest capital input into the sugarcane production system. Standard wheel spacing on harvester and haul-out equipment ranges between 1.8 (wheeled harvester) and 1.9 m (tracked harvester) and given the existing capital investment it is preferable if this equipment can continue to be utilised. However, the traditional row spacing in the sugarcane farming system is 1.5 m and if this is retained it is not possible to implement controlled traffic. If future sugar farming systems are to capture the benefits of controlled traffic, crop row spacings must increase to at least 1.8 m–2.0 m to match the wheel spacings of the current harvesting equipment. However there are concerns at the ability of the sugarcane crop to achieve high yields in what are perceived to be excessively wide row spacings–especially in the plant crop.

Research has shown that the sugarcane crop has the ability to produce similar yields from a variety of crop row spacings and planting densities due to the ability to compensate for varying stalk numbers by increasing or decreasing the weight of individual stalks (Garside *et al*., 2002; Bell and Garside, 2005). The extent to which this can occur in differing production environments and row arrangements, and with different sugarcane varieties, has yet to be determined.

Garside *et al*. (2005) found that plant cane yields of Q138 grown at Bingera were 15% greater with dual or triple rows on 1.8 m beds or dual rows on 2.1 m beds, compared to single rows planted on 1.8 m or the standard 1.5 m spacings. However, subsequent studies at Gordonvale (Garside *et al*., 2006) showed significant interactions between sugarcane variety and yields in different row spacings from 1.5 m singles to 2.3 m duals.

Some varieties performed similarly in all row spacings including 1.8 m single rows (eg. Q201$^{(b}$), while others performed poorly in 1.8 m single rows (eg. Q200$^{(b}$ and Q218$^{(b}$) or in some dual row arrangements (e.g. Q187$^{(b}$ in 1.8 m dual rows). The reasons for these interactions were not able to be determined conclusively, but included the ability to develop heavier stalks at low stalk populations and the propensity to sprawl or lodge in different arrangements at different times of the growing season.

This experiment was designed to investigate the performance of four current commercial cane varieties grown in the Farnsfield district in the Isis mill area under a series of planting configurations designed to facilitate controlled traffic cropping systems. This paper reports results from the plant cane crop.

Materials and methods

Site description and treatment details

The experiment was conducted in a commercial cane field at Farnsfield in the Isis mill area on a Yellow Dermosol soil (Isbell, 1996). The site had been sown to soybeans (cv. A6785) in the fallow, with grain harvested in autumn 2005. The block was prepared using conventional tillage (ripping and rotary hoeing) and sown to cane during the 27–30 September 2005. Recommended applications of insecticide (Lorsban 500EC ® at 1.5 L/ha) and fungicide (Sportak® at 20ml/100L) were made at planting. Plots were irrigated immediately after planting to ensure good crop establishment, and then at regular intervals during the growing season to avoid water stress.

Varieties were chosen on the basis of differences in growth characteristics (especially varying tillering ability) as well as importance within the local mill area (A. Linedale and B. Quinn, pers. comm.). The following varieties were chosen for the study:

Q138—Strong early stool development and has performed well in dual rows.

Q188$^{\phi}$—Slower stool development but strong erect cane.

Q205$^{\phi}$—Strong early stool development with extensive plantings in the district.

Q222$^{\phi}$—Moderate early stool development but very promising new variety.

There were five row spacing treatments. These included the current standard row spacing in the Isis mill area of 1.5 m single rows, which was planted with a whole stick planter with conventional mouldboard openers. The other row spacings were designed to harness the benefits of controlled traffic. These consisted of 1.8 m narrow single rows (planted with the whole stick planter), 1.8 m wide single rows (planted with a conventional billet planter using boards that had been widened to produce a 37.5 cm furrow width), and dual rows either 50 cm apart on 1.8 m centres or 80 cm apart on 2.0 m centres. Both dual row plantings were planted with a whole stick planter with narrow mouldboards and twin chopper boxes. The variation in planters and planting method (whole stick versus billet planting) resulted in different planting rates, and these are shown in Table 1 using data from Q138 as an example.

The experiment was established as a split plot design with row spacings as main plots and varieties as sub plots, with three replicates. Main plots (row spacings) were 10.8 m–12 m wide, and consisted of 6 row (inter row spacings of 1.8 m and 2.0 m) to 8 row (1.5 m single rows) plots of length 120 m. These plots were split into 28 m long subplots of the different varieties, with 2 m gaps between varieties.

Fertiliser applications were made to ensure nutrients were not limiting. The trial received basal nutrients (42 kg N/ha, 27 kg P/ha, 51 kg K/ha, 23 kg S/ha, 9 kg Zn/ha and 7 kg Cu/ha) as a pre-planting broadcast application that was incorporated during tillage operations. Side dressing was undertaken 2 months after planting, with two bands supplying 100 kg N/ha, 10 kg P/ha and 72 kg K/ha applied into the outside of each planting bed. Bands were therefore 75 cm apart in the 1.5 m and 1.8 m single row treatments, but 100 cm (1.8 m dual rows) and 130 cm (2.0 m dual rows) apart in the dual row treatments.

All treatments were hilled up using various combinations of tined implements. Weed control was achieved by post plant applications of a mixture of Atrazine® (3 kg/ha), Stomp Xtra® (3 L/ha) and Sprayseed® (1.6 L/ha), followed by an in-crop directed spray of

Sprayseed® (1.6 L/ha) and Velpar K4® (3 kg/ha) shortly after fertiliser application. Sugarcane smut was detected on a single stool of Q205$^{\Phi}$ in June 2006 but there was no evidence of any effects on crop yield.

Table 1—Planting rates (eyes/m^2) in each of the row spacing configurations. Values in brackets indicate standard errors of means (n = 9).

Row spacing (m)	Planting arrangement	Planting rate (eyes/m^2)
1.5	Single row (whole stick)	5.23 (± 0.7)
1.8	Single row (whole stick)	4.88 (± 0.4)
1.8	Single row (billet)	9.88 (± 1.1)
1.8	Dual row (whole stick)	8.77 (± 1.1)
2.0	Dual row (whole stick)	6.61 (± 0.7)

Plant cane management and plant sampling

Shoot counts were recorded at regular intervals during crop establishment, with destructive samples taken to determine crop biomass on 6 January and 4 April 2006—ca. 3 months and 6 months after planting. Shoot counts were repeatedly taken during the season in a fixed subplot consisting of 5 m length in the centre two beds in each plot, with each 'bed' consisting of either a single or a dual row depending on treatment (i.e. a total sample area, including the associated inter row space, of 15–20 m^2). These sections were also used for the final harvest quadrats, allowing a good estimate of the time course of shoot dynamics for the different varieties and row spacings without confounding effects of within plot variability.

The 3 month and 6 month destructive samples were taken from randomly chosen 1 m lengths of the centre 4 beds in each plot, so sample areas (including the associated inter row space) varied from 6–8 m^2, depending on row spacing. Fresh and dry weights were determined from these samples.

At final harvest in late August 2006 the marked 5 m quadrats used for shoot counts during the season were cut by hand from each plot and total stalk number and fresh weight were recorded. Suckers were not included. A subsample representing 10–15% of the total plot biomass was split into millable stalk and trash (dead leaf and tops), with tops separated from millable cane at the 5th visible dewlap from the top of the stalk. The proportions of millable cane and trash were used to calculate trash and cane yields from the whole biomass sample, while sub samples of the cane and trash were mulched and dried at 80° C to determine moisture content. Juice samples for ccs determination were extracted from a further subsample of the millable stalks using a portable three-roller small mill.

Statistical analysis

Standard analysis of variance techniques were used to determine the impact of treatment on shoot numbers throughout the season and plant biomass and yield in the mid-season and final harvests.

Results and discussion

Shoot dynamics

There were significant variety x row space interactions for shoot numbers in the first 3.5 months. However, shoot counts taken with the first biomass sampling in early January and subsequent shoot counts in February and later, showed no statistically significant interactions. The early shoot data collected 40 days after planting (DAP) (Table 2) and the planting rates in Table 1 suggested that emergence was >80% in all planting arrangements. Data also showed that Q188$^{\phi}$ was very slow to emerge, especially compared to Q138 and Q205$^{\phi}$, with shoot numbers 45–50% lower in Q188$^{\phi}$ some 40 DAP. This differential between Q138 and Q188$^{\phi}$ was maintained over the next 70 days (Table 2), but the advantage for Q205$^{\phi}$ reduced with time to 27% at 74 DAP and to only 18% at 101 DAP. The variety Q222 $^{\phi}$ seemed to be intermediate between Q188$^{\phi}$ and Q205$^{\phi}$.

Table 2—Interactions between sugarcane variety and crop row spacing in the early establishment phase of the crop at Farnsfield.

Row spacing	Variety	11 Nov (40 dap)	15 Dec (74 dap)	11 Jan (101 dap)
		(shoots/m^2)		
1.5 m single	Q138	4.2	16.3	18.9
1.8 m single	Q138	3.9	11.3	13.9
1.8 m billet	Q138	8.3	17.9	15.3
1.8 m dual	Q138	6.3	20.8	24.5
2.0 m dual	Q138	5.6	18.1	20.0
1.5 m single	Q188$^{\phi}$	3.5	11.4	12.5
1.8 m single	Q188$^{\phi}$	2.3	7.7	8.2
1.8 m billet	Q188$^{\phi}$	6.0	12.7	10.5
1.8 m dual	Q188$^{\phi}$	4.1	14.6	15.1
2.0 m dual	Q188$^{\phi}$	3.5	12.7	14.7
1.5 m single	Q205$^{\phi}$	4.8	15.1	15.1
1.8 m single	Q205$^{\phi}$	3.8	10.8	10.3
1.8 m billet	Q205$^{\phi}$	9.1	15.7	12.7
1.8 m dual	Q205$^{\phi}$	6.0	17.5	17.4
2.0 m dual	Q205$^{\phi}$	5.2	15.8	16.3
1.5 m single	Q222$^{\phi}$	4.5	14.5	14.2
1.8 m single	Q222$^{\phi}$	3.6	10.3	9.4
1.8 m billet	Q222$^{\phi}$	7.3	11.6	9.7
1.8 m dual	Q222$^{\phi}$	4.7	16.1	15.2
2.0 m dual	Q222$^{\phi}$	4.7	15.3	15.3
Lsd (var x row space: $P < 0.05$)		*1.0*	*2.2*	*1.8*

As the relative ranking of varieties in terms of shoot density changed with crop age, so did the differences between row spacings and planting methods. The 1.8 m wide throat billet planted treatment recorded significantly higher shoot populations than all others 40 DAP, and this was not unexpected due to the larger number of eyes planted (Table 1). However, this early advantage was rapidly eroded so that by 75 DAP the 1.8 m and 2.0 m dual rows had significantly more shoots and the 1.5 m single row had the same shoot numbers–despite the lower planting rates (Table 1). This trend for limited shoot addition in the 1.8 m wide throat billet planted treatment continued so that by 100 DAP it had significantly fewer total shoots per m^2 than all treatments except the 1.8 m single row treatment for all varieties. This result clearly suggests that strong inter-plant competition within a densely planted cane row will limit subsequent shoot addition post-establishment, thus representing a clear waste of 2–3 t/ha of additional planting material *cf.* 1.5 m single rows planted with the whole stick planter.

The performance of the dual row plantings compared to the 1.5 m standard was fairly consistent up to the sampling in January (101 DAP), with the 1.8 m dual rows establishing *ca.* 20% more shoots and the 2.0 m duals establishing *ca.* 10% more shoots. This advantage, especially in the 1.8 m duals, varied between varieties. In the strong tillering Q138, the advantage in 1.8 m dual rows *cf.* 1.5 m rows ranged from 50% (40 DAP) to 28–30% in samplings up to 100 DAP, while the advantage was minimal in Q222$^{\Phi}$ (only 5–10% at any sample date). The performance of Q188$^{\Phi}$ and Q205$^{\Phi}$ was intermediate, with only moderate advantages (15–30% more shoots) in the 1.8 m dual rows.

In all samplings after the first 100 DAP there were no significant interactions between variety and row spacing with respect to shoot populations. Data are therefore represented graphically to show the main and subplot effects of row spacing and variety in Figure 1 (a, b), respectively.

The means for the earlier sample dates are also included to provide a seasonal pattern of shoot dynamics. There were clear differences in the pattern of shoot accumulation and loss in response to row spacing and variety. For row spacing, differences in shoot numbers in response to planting rate dominated the earlier sample dates (as per Table 2), but then effects of interplant competition started to impact on shoot numbers. For example, peak shoot numbers in the 1.8 m wide throat billet planted treatment ($14.5/m^2$) were achieved by the 15 Dec (74 DAP), after which shoot numbers declined rapidly to *ca.* $9.5/m^2$ by April (6.5 months after planting) and maintained those numbers until final harvest a further 4.5 months later. In contrast, shoot numbers in all the whole stick planted treatments reached maximum shoot numbers a month later (i.e. 3.5 months after planting) and lost shoots over a longer time period than the billet planted treatment. The extent of shoot loss varied markedly between treatments and was positively correlated ($r = 0.97$) to the maximum shoot number shown in Figure 1a. The greatest shoot loss (41% of total shoots) was in the 1.8 m dual rows and the smallest loss (22% of total shoots) was in the 1.8 m single rows. Despite this differential shoot loss there were still significant differences in the number of stalks at final harvest (Figure 1a), with the greatest numbers in the dual row and 1.5 m single row arrangements and the lowest in the 1.8 m single row.

The different varieties also exhibited marked differences in shoot addition and loss, with Q188$^{\Phi}$ always having the fewest stalks and while Q138 always had the most (Figure 1b). Interestingly, Q205$^{\Phi}$ and Q222 $^{\Phi}$ reached maximum shoot number a little earlier (74 DAP) than the other two varieties, with a fairly constant rate of loss through until 6.5 months after planting. In contrast, Q138 and Q188$^{\Phi}$ reached maximum shoot numbers at 3.5 months after planting but then experienced a relatively more rapid loss of shoots through to April. The extent of shoot loss was again positively correlated ($r = 0.89$) to maximum shoot number, with Q138 losing 43% of total shoots and Q188$^{\Phi}$ and Q222 $^{\Phi}$ only losing 27% of total shoots. There were still significant differences between varieties at final harvest, with shoot number in Q138>Q205$^{\Phi}$ and Q222$^{\Phi}$ > Q188$^{\Phi}$ (Figure 1b).

Biomass accumulation

Crop biomass was determined from the destructive samplings in January and April and the final harvest in August. At none of these stages were there any statistically significant interactions between variety and row spacing/planting method. However, there were significant differences between row spacings in January and April (Figure 2a) and between varieties at all sampling dates (Figure 2b), although the latter were very small later in the growing season (i.e. <5%).

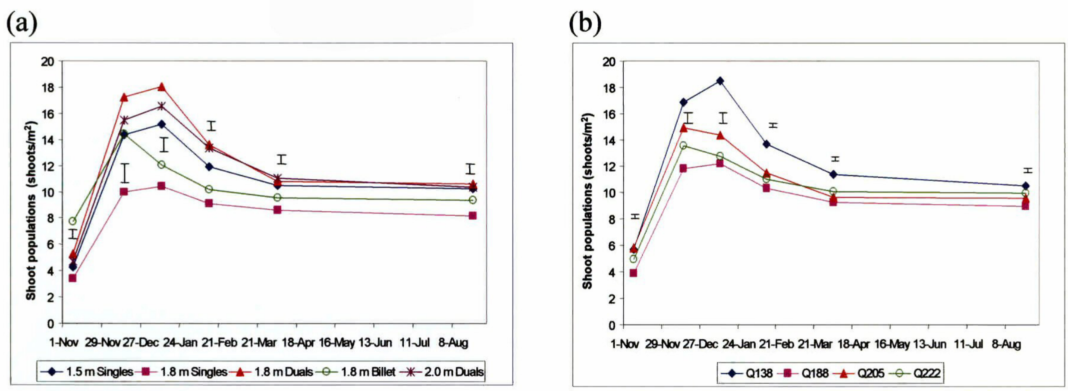

Fig. 1—Seasonal pattern of shoot addition and subsequent loss in irrigated sugarcane grown at Bundaberg. Data are shown for (a) the effects of crop row spacing/planting method averaged over four varieties, and (b) the effects of sugarcane variety, averaged over all row spacings/planting methods. Vertical bars indicate LSD values (P<0.05).

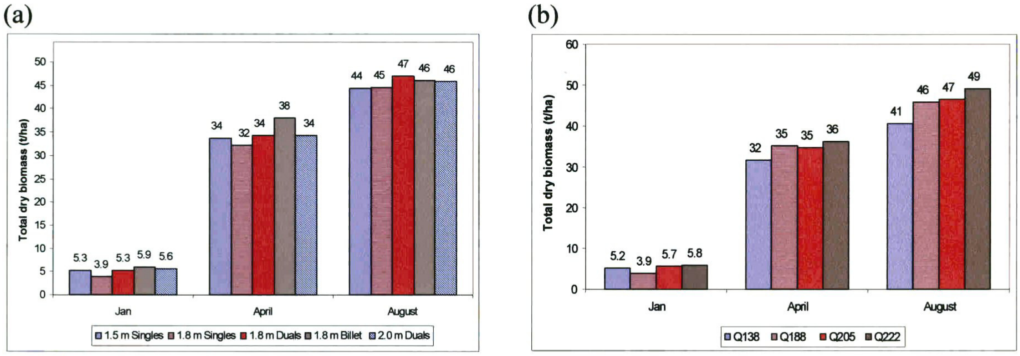

Fig. 2—Seasonal pattern of dry matter accumulation in irrigated sugarcane grown at Bundaberg. Data are shown for (a) the effects of crop row spacing/planting method averaged over four varieties, and (b) the effects of sugarcane variety, averaged over all row spacings/planting methods. LSD values (P<0.05) for comparing row spacings were 0.7 and 3.9 t/ha in January and April, with no significant differences in August, while the LSD values for varietal comparisons were 0.5, 2.8 and 2.1 t/ha for the January, April and August sample dates.

The 1.8 m single row (wide throat billet and whole stick planted) and dual row treatments provide an interesting contrast relative to the standard 1.5 m single row arrangement (Figure 2a). The billet planted treatment produced the greatest biomass at both 3.5 and 6.5 months after planting (11% greater than the 1.5 m single row standard), but these differences had disappeared by final harvest. Conversely, the 1.8 m single row whole stick treatment produced much less biomass at 3.5 months (26% less than the 1.5 m single row), but this deficit reduced to *ca*. 5% in the samples in April and August. The 1.8 m dual row treatment performed similarly to the 1.5 m standard throughout the season, despite the significant increases in shoot/stalk numbers recorded in that treatment (Figure 1a). There were clearly differences in the weight of individual stalks contributing to the differences between shoot number and biomass responses to row spacing, and these are discussed later.

The varietal differences were also strongly influenced by the weight of individual stalks (Figure 2b). Despite Q138 having significantly greater shoot numbers throughout the season (Figure 1b), the only time this variety tended to produce more biomass was in the sampling at 3.5 months, and then only relative to the slow establishing Q188$^{\Phi}$. In all subsequent sample dates, Q138 produced the lowest biomass of all varieties, indicating that individual shoots were of low mass in that variety.

Sugar yield and yield components

Yield and yield component information is provided in Table 3. As there were no significant variety x row space/planting method interactions only the main and subplot effects are shown. In terms of row spacing/planting method, there were no significant impacts on cane yields, ccs or sugar yields and this finding was consistent with results of total biomass (Figure 2a).

Table 3—Effects of row spacing/planting method and variety on cane yield fresh weight, CCS and sugar yields in the plant crop.

	Cane yield	CCS	Sugar yield
	(t/ha)	(%)	(t/ha)
	Row spacing/plant method		
1.5 m single	118	12.7	15.0
1.8 m single	116	12.7	15.0
1.8 m billet	120	13.3	15.9
1.8 m dual	117	13.0	15.2
2.0 m dual	118	12.6	14.8
Lsd (0.05)	*ns*	*ns*	*ns*
	Variety		
Q138	112	11.1	12.7
Q188$^{\Phi}$	115	13.5	15.5
Q205$^{\Phi}$	124	12.9	15.8
Q222$^{\Phi}$	121	13.8	16.8
Lsd (0.05)	*6.6*	*0.7*	*1.0*

Effects of varieties were significant for all yield parameters, with effects on ccs having a greater relative impact on final sugar yield than differences in cane yield. Both Q205$^{\Phi}$ and Q222$^{\Phi}$ had significantly greater cane yields than Q138 and Q188$^{\Phi}$, but differences averaged less than 10 t/ha. Varietal differences in CCS were more than 2.5 units, with Q138 the lowest and Q188$^{\Phi}$ and Q222$^{\Phi}$ the highest. The resulting sugar yields varied by more than 30%, with Q138 < Q188$^{\phi}$ and Q205$^{\phi}$ < Q222$^{\phi}$. However, the practicality of any conclusions about varieties has been eliminated by the establishment of sugarcane smut, with all four varieties likely to disappear from the farming system in the near future due to their susceptibility to this disease.

The ability of row spacings with low shoot/stalk numbers to produce similar cane yields to those with higher shoot/stalk numbers suggests there must have been considerable compensation in individual stalk weight. There was a highly significant variety x row spacing interaction in individual stalk weights and data are shown in Figure 3. These results clearly show that all varieties significantly increased individual stalk weights to compensate for the lower shoot/stalk numbers in the 1.8 m single row (whole stick planted) treatments. All varieties except Q138 were also able to achieve heavier stalks in the 1.8 m wide throat billet planted treatment, although in the case of Q138, and to a lesser extent Q222$^{\phi}$, the stalks were not as heavy as in the 1.8 m whole stick planted treatment. There were no significant differences in stalk weights between the 1.5 m standard and either dual row treatment.

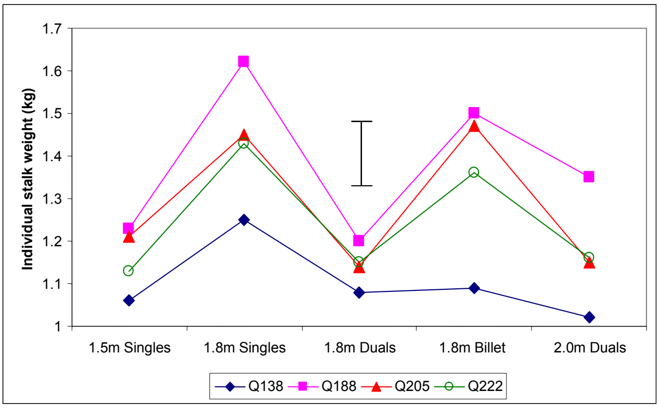

Fig. 3—Variation in fresh weight of individual millable stalks with row spacing/planting method and variety. Vertical bars indicate LSD values (P<0.05).

General discussion and conclusions

Results of this study have again confirmed the considerable flexibility exhibited by sugarcane in terms of performance under different planting arrangements and row configurations (Garside *et al*., 2002; Bell *et al*., 2004; Bell and Garside, 2005). Cane yields of all four varieties, which were shown to differ significantly in terms of growth habit/tillering ability (Figure 1b and Table 2), were unaffected by moving to row spacings consistent with controlled traffic farming systems (i.e. 1.8–2.0 m inter row spacings). This was despite 1.8 m singles having significantly fewer final stalks than the 1.5 m standard, and the dual row treatments having significantly more stalks than either 1.8 m single row treatment (Figure 1a). The flexibility in response to row spacing was associated with the ability of varieties to vary individual stalk weight in response to changes in stalk populations (Figure 3). Stalk weights varied by as much as 35% in Q188$^{\phi}$ and 23–28% in the other varieties. It was unclear how much of this compensatory ability was due to differential lodging (time or extent), as exact details of when each treatment lodged were not kept. However, at the time of final harvest the 1.8 m single row treatments (especially the whole stick planted treatment) had much less severe lodging (or in the case of Q188$^{\phi}$, no lodging) than the 1.5 m or dual row treatments. It is also unknown whether this compensation would have been able to make up for lower shoot numbers if water availability in the stalk filling period (and hence dry matter accumulation) had been limited.

The ability of 1.8 m single rows to achieve yields similar to those of the 1.5 m standard treatment in all varieties suggests that similar yields under controlled traffic layouts may be possible without the need for dual row planting. While the similar performance of cane grown in either 1.5 m or 1.8 m single rows was consistent with the findings of Garside *et al*. (2006) from a trial at Gordonvale, it contrasted with the results of Garside *et al*. (2005) from Bundaberg, where plant crop yields in 1.8 m single row spacings with variety Q138 were 10–20% lower than standard 1.5 m plantings. A review by Ridge and Hurney (1994) also concluded that yield would be reduced by row spacings wider than 1.65 m. The inconsistency of some of these reports, while sometimes for just a single cane variety, can probably be related to variation in two key factors—(i) the quality of planting material to allow good establishment at relatively low planting rates in whole stick plantings; and (ii) the crop growth rate during the stalk filling period to allow plantings with lower shoot populations to compensate by growing bigger stalks.

The relatively poor performance of the 1.8 m single row treatments in the Garside *et al*. (2005) study can be explained in terms of the impact of both these factors. Early shoot counts taken at *ca*. 40 DAP in that study (directly comparable to our data in Table 2), only showed shoot numbers of 1.3–1.5 shoots/m^2 in the 1.5 m and 1.8 m single row whole stick planted treatments, compared to shoot numbers of 5.5–6 shoots/m^2 in the 1.5 m billet planted standard. These low early shoot numbers were *ca*. half those recorded at a similar stage in our study (Table 2) and suggest that the quality of planting material may have been suboptimal. Combined with that, the Garside *et al*. (2005) study was conducted under dry seasonal conditions with very limited irrigation capacity, so the ability of crops to compensate for lower stalk densities by growing larger stalks would have been compromised. This was also reflected in their data, with individual stalk weight only increasing by 13% between the 1.5 m billet planted treatment and the 1.8 m single row treatment (compared to increases of 25–30% in Figure 3). In other words, unlike our study reported here, initial establishment was poor and the later ability to compensate for fewer stalks by producing heavier stalks was restricted by a lack of available water.

The similarity in response between our study and the results from Garside *et al*. (2006) at Gordonvale can probably be related to the comparable moisture availabilities in both studies during stalk filling. This ability to continue to accumulate biomass to fill stalks during the latter half of the growing season resulted in individual stalk weights able to compensate for differences in stalk numbers in both these studies.

Finally, the lack of significant variety x row spacing interactions affecting cane or sugar yields contrasts with the findings of Garside *et al*. (2006). In that study, at least part of this interaction was attributed to differences between varieties in the accumulation of dry matter late in the growing season. The variety Q200$^{⚐}$ accumulated less than half the biomass of the other three varieties in the last 5 months of the growing season and there was evidence that this variety was more mature than others in the study (lower stalk water contents causing higher CCS).

The authors suggested this attribute of early maturity may have been the reason that this variety performed poorly in the 1.8 m single rows, as it was not able to effectively utilise the resources in wider rows later in the growing season. In our study there were no significant differences in the amount of dry matter accumulated between April and the final harvest in August between varieties or row spacings (average of 11.0 t/ha) and there were no differences in sucrose % dry matter (average of 47.7%) that would indicate CCS differences between varieties were due to differences in crop maturity.

The immediate relevance of these results for the Bundaberg/Childers districts has been reduced as none of these varieties will continue to be planted in the region due to the appearance of sugarcane smut. However, this trial will be extended into the 1st ratoon crop to assess the impacts of further stool development (and possibly harvester damage) on productivity of the different row spacings.

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REFERENCES

Bell, M.J. and Garside, A.L (2005). Shoot and stalk dynamics and the yield of sugarcane crops in tropical and subtropical Queensland, Australia. Field Crops Res., 92: 231–248.

Bell, M.J., Garside, A.L., Halpin, N.V. and Berthelsen, J.E. (2004). Interactions between stalk number and stalk weight and the implications for cane yield. Proc. Aust. Soc. Sugar Cane Technol., 26: (CD-ROM).

Bell, M.J., Halpin, N.V., Garside, A.L., Stirling, G.R., Moody, P.J. and Robotham, B.G. (2003). Evaluating combinations of fallow management, controlled traffic and tillage options in prototype sugarcane farming systems at Bundaberg. Proc. Aust. Soc. Sugar Cane Technol., 25: (CD-ROM).

Bell, M.J., Halpin, N.V., Orange, D.N. and Haines, M. (2001). Effect of compaction and trash blanketing on rainfall infiltration in sugarcane soils. Proc. Aust. Soc. Sugar Cane Technol., 23: 161–167.

Braunack, M.J., Garside, A.L. and Bell, M.J. (2003a). The effect of rotational breaks from continuous sugarcane on soil physical properties. Proc. Aust. Soc. Sugar Cane Technol., 25: (CD-ROM).

Braunack, M.V., McGarry, D. and Halpin, N.V. (2003b). The economic advantages of reduced tillage planting of sugarcane in Australia. Proc. 16th ISTRO Conf., Soil Management for Sustainability, 13–18 July, 2003, Univ. of Qld., Brisbane. (CD-ROM).

Garside, A.L., Bell, M.J., Berthelsen, J.E. and Halpin, N.V. (2002). Effect of fumigation, density and row spacing on the growth and yield of sugarcane in two diverse environments. Proc. Aust. Soc. Sugar Cane Technol., 24: 135–144.

Garside, A.L., Berthelsen, J.E., Robotham, B.G. and Berding, N. (2006). Row spacing effects on the growth and yield of several sugarcane varieties in north Queensland. Proc. Aust. Sugar Cane Technol., 28: 298–309.

Garside, A.L., Robotham, B.G., Chappell, W. and Berthelsen, J.E. (2005). Row spacing and tillage effects on the growth and yield of sugarcane. Proc. Aust. Soc. Sugar Cane Technol., 26: (CD-ROM).

Isbell, R.F. (1996). Australian Soil Classification. CSIRO Publishing, Melbourne.

McGarry, D. and Bristow, K.L. (2001). Sugarcane production and soil physical decline. Proc. Int. Soc. Sugar Cane Technol., 24: 3–7.

McGarry, D. and Bristow, K.L. (2004). Soil physical decline with sugarcane production. Proc. 16th ISTRO Conf., Soil Management for Sustainability, 13–18 July, 2003, Univ. of Qld., Brisbane. (CD-ROM).

Ridge, D.R. and Hurney, A.P. (1994). A review of row spacing research in the Australian sugar industry. Proc. Aust. Soc. Sugar Cane Technol., 16: 63–69.