BUREAU OF SUGAR EXPERIMENT STATIONS

QUEENSLAND, AUSTRALIA

FINAL REPORT - BS169S

GxE INTERACTIONS ON RATOONING OF GENOTYPES UNDER TRASH BLANKETS UNDER COOL/WET CONDITIONS

by

T A Bull

SD00006

Principal Investigator: **Dr Terry Bull**
BSES
Private Bag 4
Bundaberg Q 4670
Phone: 07 4132 5200
Fax: 07 4132 5253

This project was financed by the Sugar Research and Development Corporation during the financial years 1996/1997 to 1999/2000. The Research Organisation is not a partner, employee or agent of SRDC and has no authority to legally bind SRDC, in any publication of substantive details or results of this Project.

BSES Publication **June 2000**
SRDC Final Report SD00006

CONTENTS

LIST OF TABLES

Page No.

LIST OF FIGURES

SUMMARY

This project was established to investigate the magnitude of the genotype by environment interaction effect for ratooning under a trash blanketing under cool/wet conditions. A population of 50 genotypes was deemed necessary for this study but was not manageable in a fully replicated agronomic trial. Hence, it was necessary to assess a population of 50 genotypes and select a representative sub-population of 25. Accordingly fifty genotypes (40 unselected genotypes and 10 cultivars) were planted in the field at Bundaberg BSES station at fortnightly intervals from February to August 1997. Measurements of shoot emergence, stalk elongation and leaf appearance from each planting date were used to calculate base temperatures and thermal times for each parameter for each genotype. Plots of base temperature against thermal time were used to display the range of variation present in the population and to select a sub-population of 25 genotypes (21 genotypes and 4 cultivars) that represented this range. Population means and standard deviations for the selected 25 genotypes were not significantly different from those for the original 50 genotypes.

Germination response to temperature for each of the 25 selected genotypes was measured by germinating single eye cuttings in controlled temperature cabinets at 35, 30, 25 and 20°C. The base temperature for germination for each genotype was computed to ascertain whether this parameter might provide a easy way of screening genotypes for potential to ratoon under cool, wet conditions.

The selected 25 genotypes were planted into a trial in a grower's field at Wallaville in September 1997. The site was selected because it had a history of winter frosting to generate cool ratooning conditions, irrigation was available to generate wet conditions for ratooning and the dark cracking clay soil was likely to maintain cool, wet conditions for ratooning in winter. The trial was laid out as split-split plots in a complete randomised block design with four replications. Two times of ratooning (July and December) were the main plots and four treatments (two irrigation levels +/- trash) were the split plots. A further split encompassed the 25 genotypes, to give a trial with 800 plots and an area of 6 ha. After ratooning in June 1998 soil temperature and moisture probes were installed in two plots of each of the four treatments, ie cool-wet plus trash, cool-wet minus trash, cool-dry plus trash, cool-dry minus trash. The probes were reinstalled in the other half of the trial after the November 1998 ratooning to monitor the warm soil treatments.

Unfortunately climatic conditions did not favour this trial. No frosts occurred at the site in the winter of 1998, reducing anticipated low soil temperature effects, and heavy rains in July/August and in December prevented adequate differentiation of moist and dry ratooning conditions.

Measurements of the treatments ratooned in winter showed that the presence of the trash blanket reduced soil temperatures by 0 to 3°C (average 1.3°C) up until canopy closure but that soil moisture tended to remain higher under trash throughout the growth period. The presence of the trash blanket and lower soil temperatures delayed shoot emergence and reduced initial shoot numbers. However, there was a subsequent larger loss of tillers from the trash free plots so that there was no difference in stalk numbers by canopy closure and at harvest. The treatments had no significant effect on stalk height.

The winter-ratooned crop was harvested at 12 months of age. Stalk counts, stalk weights and CCS levels were measured to provide estimates of cane yield (TCH) and sugar yield (TSH). Analysis of variance showed a highly significant effect of genotype for all yield parameters but no significant trash treatment effect or genotype by treatment interaction effect.

Measurements of the treatments ratooned in summer showed that the presence of the trash blanket reduced soil temperatures by 0 to 3.8°C (average 0..3°C) and increased soil moisture by 0 to 9% (average 2.4%) over the growth period. The presence of the trash blanket and lower soil temperatures delayed shoot emergence and reduced initial shoot numbers but there was no difference in stalk numbers by harvest. The treatments had no significant effect on stalk height.

The summer-ratooned crop was harvested at 12 months of age. Stalk counts, stalk weights and CCS levels were measured to provide estimates of cane yield (TCH) and sugar yield (TSH). Analysis of variance showed a highly significant effect of genotype for all yield parameters, no significant trash treatment effect and a significant genotype by treatment interaction effect for cane and sugar yield. Most of the interaction effect was associated with five genotypes that performed better in the absence of trash and a single genotype that preformed better in the presence of the trash blanket. A combined analysis covering both ratooning dates failed to show a significant genotype by trash treatment interaction. Although both ratoon crops were 12 months old at harvest the crop ratooned in July was significantly larger than the crop ratooned in December.

Attempts to relate ratoon performance to base temperatures for germination or to performance in the plant crop were not successful. No useful predictor of ratoon performance, under any of the conditions studied was detected.

Given that it had not been possible to generate the full range of treatments originally planned due to unexpected climatic variations, the proposal to continue with observations in second ratoons was deleted and the project terminated when SRDC called for submissions to trim budget expenditures.

1.0 BACKGROUND

Green cane harvesting and trash blanketing (GCTB) was introduced to Australia in 1976 (Ridge *et al.* 1979) as an environmental protection measure. The trash blanket conserves soil structure, moisture and nutrients and the lack of cane fires avoids the smoke and ash nuisance for nearby communities. Continued community attention to environmental and sustainability issues is likely to maintain pressure on the sugar industry for the adoption of at least green cane harvesting and possibly also the use of trash blanketing.

GCTB has been widely adopted by the sugar industry, particularly in northern Queensland (McMahon and Ham 1996). Unfortunately adoption of GCTB in southern regions has been severely restricted due to problems associated with ratooning through a trash blanket when soil conditions are cool and wet (Kingston 1997).

Experimental and anecdotal evidence suggests that trash blanketing under cool, wet soil conditions may reduce ratoon yields by up to 25%. Whilst green cane harvesting continues to be adopted in many areas the use of trash blanketing is less popular and alternate uses are being sought for the trash. It has been postulated that poor ratooning under these conditions may be associated with a combination of poorly aerated conditions due to excessive soil moisture, reduced shoot germination and emergence due to prolonged periods of low soil temperatures and an inability of current commercial varieties to tolerate these conditions. Improved agronomic practices, including mounding, may help to reduce soil water levels but trash management practices, other than removal, are unlikely to be appreciably beneficial. To date there has been little reported work to assess whether there is any potential to develop varieties better able to tolerate these conditions and ratoon successfully.

This project seeks to ascertain whether or not there is any genotype by environment interaction for the capacity to ratoon under a trash blanket when soil conditions are wet and cool.

2.0 OBJECTIVES

The objectives of this project were to:

- determine the magnitude and nature of clone x environment (with/without trash blanket) interactions under cool/wet conditions of the sugarcane growing districts of central and southern Queensland and New South Wales.
- characterise the environmental constraints and/or benefits for ratooning under trash blankets.
- identify growth parameters that can be used to identify genotypes specifically adapted to cool wet conditions under trash blanket cropping systems.
- develop strategies/solutions for overcoming limitations to adoption of trash blanketing under cool/wet conditions.

3.0 METHODOLOGY

3.1 Genotype population

The assessment of genotype by environment (G x E) interactions should involve a population size of at least 50 genotypes (McRae, *pers comm*). However, it is difficult to manage a population of this size in a replicated agronomic trial encompassing trash management practices, soil moisture regimes and soil temperature regimes. Consequently, a means is required to evaluate a population of 50 genotypes for the range of variability in characters expected to be related to the capacity to ratoon under cool, wet conditions so that a representative and manageable sub-population, of say 25 genotypes, can be selected.

A population of 51 genotypes including seven commercial cultivars and 43 clones from stage 3 of the breeding program was selected for this study (Table 1). The physiological growth parameters displayed by a plant crop that are most likely to relate to ratooning capability are shoot emergence, shoot elongation and leaf emergence. Previous experiments (Liu *et al*. 1998) have shown that the base temperatures and thermal periods (degree-days) for these parameters vary between genotypes. Accordingly they were selected to assess the variability present in this base population and to provide a basis for selecting a sub-population of genotypes that represented the full range of variability.

Table 1. Genotypes and cultivars selected at random as the base population

No.	Genotype	No.	Genotype	No.	Genotype
1	87S 9315	18	87S 8124	35	87S 9021
2	87S 8110	19	87S 9234	36	87S 9010
3	87S 9262	20	Q138	37	87S 9264
4	87S 9079	21	87S 9355	38	85S 7325
5	85S 7341	22	87S 9063	39	87S 8075
6	87S 8368	23	87S 8015	40	87S 9078
7	87S 9086	24	87S 9212	41	87S 8105
8	87S 8292	25	Q124	42	87S 8428
9	87S 8067	26	Q125	43	Q151
10	Q141	27	87S 8005	44	87S 8349
11	87S 9047	28	Q155	45	87S 8379
12	87S 8039	29	87S 9132	46	87S 8114
13	87S 9403	30	87S 8337	47	85S 7329
14	87S 8214	31	87S 8384	48	87S 8162
15	Q170	32	87S 8407	49	87S 8432
16	87S 9050	33	CP51-21	50	87S 8239
17	87S 8066	34	87S 9105	51	87S 9019

The 51 genotypes were planted in the field at the BSES Station at Bundaberg across five planting dates; 18 October 1996, 7 January 1997, 3 March 1997, 15 April 1997 and 6 June 1997. Three replicates were planted as single rows in a randomised block design. Plots were 5 m long and separated by a 2 m gap. Shoot emergence was observed 2-3 times a week and achievement of 1 shoot per linear meter was defined as completion of the emergence stage. In addition, stalk elongation and leaf appearance was measured at fortnightly intervals on six random stalks per clone between 19 February 1997 and 1 August 1997. Plots were irrigated regularly to maintain non-stressed conditions and temperatures were recorded by an automatic weather station 100 meters from experiment site.

Thermal parameters for the three processes (shoot emergence, stalk elongation and leaf appearance) were determined from the following function, derived by Liu *et al*. (1998):

$$\frac{\sum_{1}^{D}\theta_g}{X} = \theta_T + T_b\frac{D}{X}$$

where Θ_g is calculated as:

a) if $T_b \leq T_{min}$

$$\theta_g = \frac{T_{\min} + T_{\max}}{2}$$

b) if $T_{min} < T_b < T_{max}$

$$\theta_g = \frac{T_{\min} + T_{\max}}{2} + \frac{(T_b - T_{\min})^2}{2(T_{\max} - T_{\min})}$$

c) if $T_b > T_{max}$

$$\theta_g = T_b$$

where T_b and Θ_T are the base temperature (°C) and thermal time (degree days, °Cd), respectively; X is the measured stalk elongation (cm) and number of new leaves produced during each period from day 1 to day D. It is assumed that the number of days when temperatures were above optimum temperature was small.

Selection of the representative sub-population was firstly based on shoot emergence. The base temperatures for shoot emergence were sorted and classified into 0.5°C classes, then Θ_T values were sorted within each class. The thermal parameters for shoot emergence, stalk elongation and leaf appearance in the sun-population were checked to ensure the ranges of variability were similar to those for the original population (Table 2).

Table 2. Thermal parameters for shoot emergence, stalk elongation and leaf appearance for the 50 genotypes and 25 selected genotypes

	No. of genotypes	Base temperature (°C)	Thermal time (°Cdays)
Shoot emergence			
Source population	51	13.39±0.45	147.80±25.25
Selections	25	13.32±0.50	150.37±28.82
Stalk elongation			
Source population	51	17.31±1.34	3.54±1.04
Selections	25	17.21±1.44	3.53±1.13
Leaf appearance			
Source population	51	16.37±1.59	54.10±17.04
Selections	25	16.27±1.78	55.16±18.88

There is no significant difference (P>0.05) between the 50 source genotypes and 25 selected genotypes for the designated thermal. The 25 selected genotypes are listed Table 3.

Table 3. Sub-population of 25 genotypes selected to represent the original population of 50 genotypes

No.	Genotype	No.	Genotype	No.	Genotype
1	87S 9315	10	87S 8066	18	87S 9105
2	87S 9262	11	87S 8124	19	87S 9021
3	85S 7341	12	87S 9234	20	87S 9010
4	87S 8368	13	87S 9063	21	87S 9078
5	87S 9047	14	Q124	22	87S 8105
6	87S 8039	15	Q155	23	87S 8379
7	87S 9403	16	87S 8384	24	87S 8239
8	Q170	17	CP51-21	25	87S 9019
9	87S 9050				

3.2 Sub-population genotype ranking

The selected sub-population was further evaluated by measuring germination and shoot elongation under controlled temperature conditions.

Ten single eye setts from each genotype were planted into trays of vermiculite and placed in controlled temperature cabinets set at 35, 30, 25 and 20°C. Three replicate trays were planted at each temperature (ie a total of 120 setts per genotype). The number of shoots emerging (> 10mm high) was monitored daily. Despite selection of apparently sound setts not all eyes germinated in some genotypes and germination percentages were expressed against the final number of eyes that germinated in each replicate.

The average germination patterns for all 25 genotypes are shown for each temperature in Figure 1. The curves were used to derive the time taken to achieve 50% germination (G_{50}) at each temperature so that an overall temperature response curve could be obtained (Figure 2). In order to estimate the base temperature for germination (T_b) the raw data was transformed to obtain a linear relation against temperature. No transformation was perfectly suited to all data but a plot of $1/(G_{50})^{0.5}$ gave a near linear response for most genotypes (Figure 3). This relation was used to compute T_b for each genotype, where T_b was defined as the temperature for germination such that G_{50} was more than 100 days. The computed values for T_b for each genotype are summarised in Table 4 where genotypes have been ranked from low to high base temperature.

Base temperatures estimated by using controlled constant temperature regimes are usually lower than those determined using germination under the variable conditions found in the field. However, the estimated values might provide some estimate of the likely potential for individual genotypes to tolerate low soil temperatures under field conditions. Ranking of the plant crop and ratooning performance of the genotypes will be compared with the T_b ranking to ascertain whether T_b can be used to screen clones for expected ratooning under trash blanket and cool, moist soil conditions.

Figure 1. Average effect of temperature on germination (all clones)

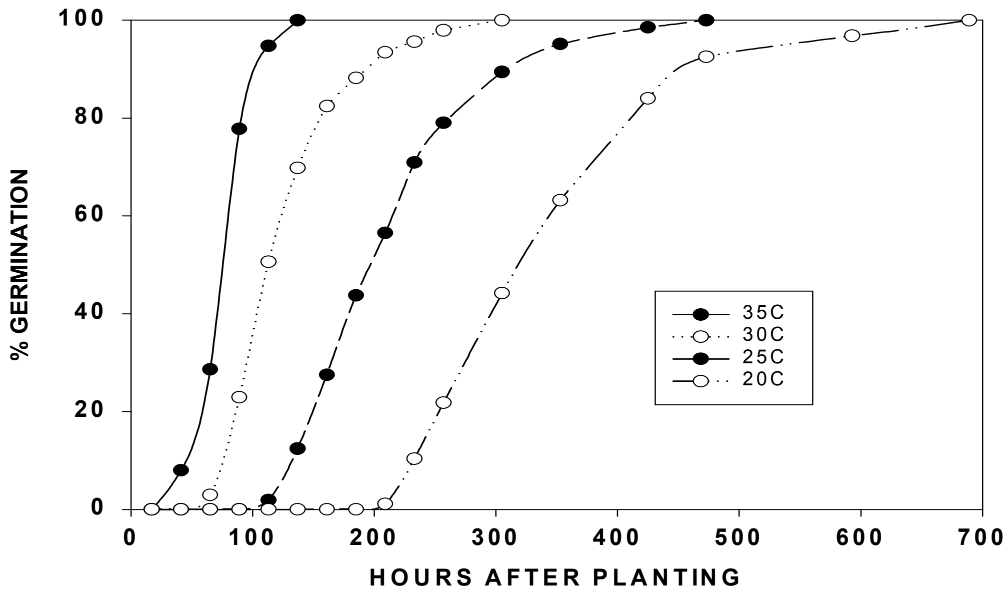


Figure 2. Average effect of temperature on time to 50% germination (all clones)

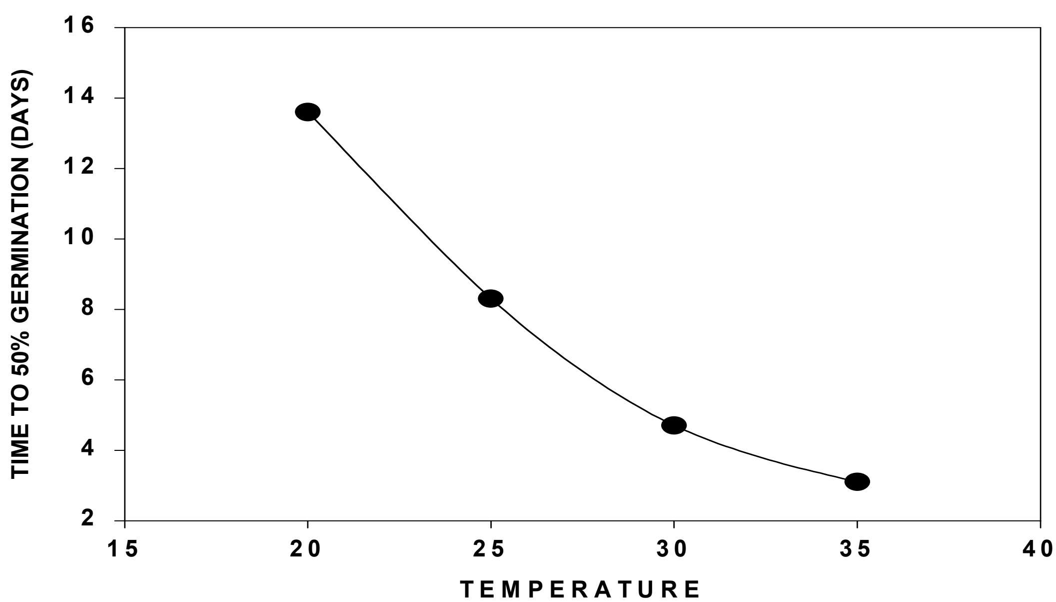


Figure 3. Regression of $1/G_{50}^{0.5}$ against temperature

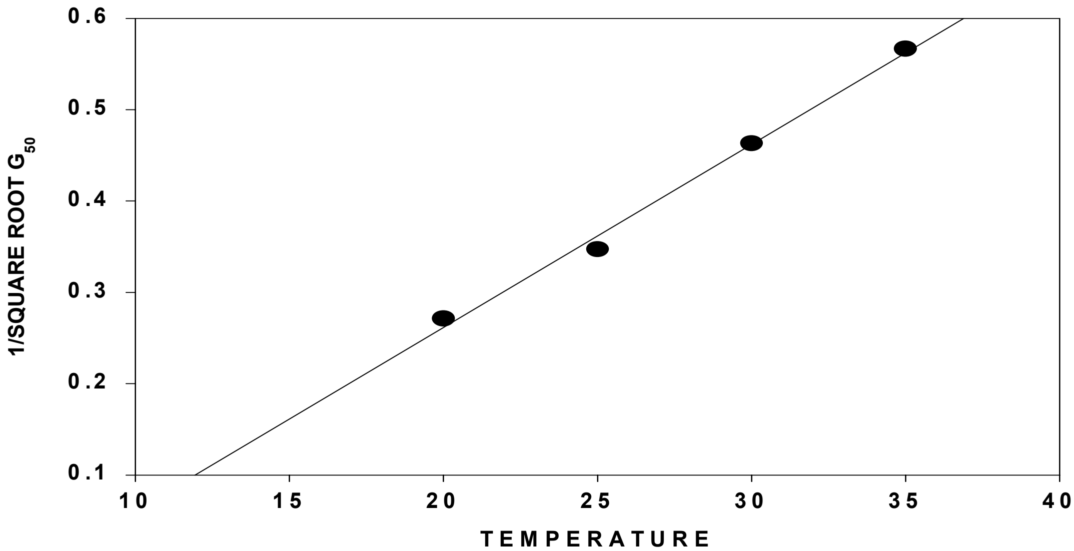


Table 4. Estimated base temperatures (T_b) for each genotype

Genotype No.	T_b	Genotype No.	T_b
6	8.3	12	11.2
23	8.7	2	11.3
14	8.9	5	11.3
17	9.6	13	11.5
24	9.8	10	11.8
8	10.0	25	11.9
21	10.0	16	12.3
22	10.1	15	12.3
11	10.1	9	12.4
20	10.4	18	12.5
4	10.8	19	12.8
1	10.9	7	13.7
3	11.0		

3.3 Trial site requirements

This trial was designed so that ratooning could be compared in the presence or absence of a green cane trash blanket under cool and wet, cool and dry, warm and wet and warm and dry soil conditions. Original planning called for these soil conditions to be generated by geographical separation of two trial sites. However, the logistical and quarantine difficulties of developing and managing two populations of the same genotypes caused estimated project costs to be excessive. A cheaper, compromise plan based on generating the range of soil conditions at a single site by seasonally displacing the planting times was developed.

To achieve this range of soil conditions a site near Wallaville (near Bundaberg) was selected according to the following criteria:

- Grower cooperative and willing to manage the site
- Area adequate for the trial design (ca. 6ha)
- Location in an district where low soil temperatures and frosts occurred in winter
- Soil heavy, water retaining clay to maintain moist soil conditions
- Irrigation available to provide wet soil conditions

The initial trial design called for crops to be planted at this site in winter (June) and summer (December) and ratooned 12 months later under cool and warm soil conditions respectively. In each case supplementary irrigation was to be used to generate the necessary wet and dry soil conditions. However, further thought suggested that although the two plant crops would be chronologically of similar age at the time of harvest the late planted (December) crop would be smaller and less physiologically mature than the early planted crop.

In order to provide more similar physiologically aged crops for ratooning the trial was rescheduled to be all planted in August with half the area ratooned in June and the other half in November. The ratoon crops would then be harvested when each was 12 months old.

3.4 Field trial design and layout

The selected sub-population of 25 genotypes was planted in August 1997 at Wallaville. The site was slightly sloped in a lightly undulating terrain and the soil was a black, self-mulching, cracking clay (Black Earth or Aquic vertosol). The grower's standard fertiliser schedule of 250 kg/ha DAP at planting plus a side dressing of 650 kg/ha of 150S was adopted for the trial site. Two sprayings with Atrazine were required to control weeds. The trial was laid out as split plots in a randomised complete block design. The two harvest times (June and November) were the main plots with plus and minus irrigation as sub plots. A further split encompassed the plus and minus trash blanket treatments and the 25 genotypes provided the final split. Treatments were replicated four times and each plot was 3 rows wide and 15 m long. Plots were separated by a 1 m gap.

Half of the plant crop was harvested green by a harvesting contractor in June 1998 and the second half was harvested by the same contractor in November 1998. At each harvest those plots designated as minus trash the trash was raked up by hand and removed. Temperature and soil moisture probes were inserted into 2 plots from each irrigation and trash blanket treatment and outputs continuously recorded on a data logger (Campbell Scientific Inc CR10X).

Stalk heights were monitored in the ratoon crop at regular intervals for 10 marked stalks in 2 replicate plots from each soil moisture and trash blanket combination. Stalk numbers were counted in 10 m long quadrats in the centre row of each plot at regular intervals. Final plot yields for the ratoons were estimated from stalk numbers and stalk weights measured in two samples of 20 contiguous stalks taken from the centre row of each plot. A sub sample of 6 stalks was taken from each plot for CCS estimations using the small mill at Bundaberg SES.

4.0 RESULTS and DISCUSSION

4.1 Plant crop performance

Evaluation of the plant crop, prior to the imposition of any treatments, was undertaken at the first harvest (3 July 1998) to ascertain if there is any link with ratooning capacity under the various treatments.

Performance data for each genotype have been summarised in Table 5. In this table genotypes have been ranked from 1 to 25 (high to low) for each of the above criteria. A combined vigour ranking, based on the product of individual rankings for stalk height and tonnes cane per ha, has been included to provide a possible estimate of relative clonal vigour.

It was not possible to secure similar measurements for the November harvest of the plant crop since the grower, under pressure to supply the mill, made a unilateral decision to harvest the field without informing BSES of his intentions.

4.2 Cool season ratoon crop

The cool season ratoons were established from the half of the trial harvested in July 1998. Half of the ratoon area was irrigated to provide cool, moist soil and trash conditions and the remainder of the plots was left unirrigated to provide cool, dry soil conditions. Unfortunately subsequent heavy rainfall minimised this planned treatment effect.

Records of average soil temperature and soil moisture in trash blanketed and trash free plots for the first 140 days after ratooning are summarised in Figures 4 and 5. Over this period soil temperatures under the trash blanket ranged from 0.8°C warmer to 1.9°C cooler than those in trash free plots and, on average, were 0.5°C cooler across the full period. By about 40 days after ratooning soil temperatures had risen to 18°C so no extended period of cold soil temperature was encountered. During this time soil moisture levels under trash blanketed plots were from 0.9% lower to 8.5% higher than under trash free plots and, on average, were 5% higher. The impact of irrigation was evident, as was the slow but progressive decline in soil moisture content with increasing crop growth. Soil moisture levels tended to decline faster in the trash free plots between irrigations, suggesting less stressful conditions in the trash blanketed plots.

Measurements of stalk height (Fig 6) showed little consistent impact of irrigation treatment or trash blanketing treatment during the first 100 days of growth. However, stalk numbers were consistently lower in trash blanketed plots for the first 70 days after ratooning. Subsequently, by about 160 days after ratooning, this effect was lost and stalk numbers showed no significant treatment effect at the final harvest.

The cool weather ratoon was harvested at 12 months of age on 7 July 1999. Mean squares from the analysis of variance for key yield parameters are summarised in Table 6.

Although the genotype effect was highly significant for all yield parameters, no significant effect of irrigation, trash blanket or genotype x trash blanketing interaction was detected for any parameter.

Table 5. Genotype performance for key growth parameters in the plant crop (1997/98)

Rank	Clone No.	TCH	Clone No.	Wt per stalk	Clone No.	Stalks per ha	Clone No.	Stalk Ht (cm)	Clone No.	CCS	Vigour Class*
1	12	81.2	12	1.330	10	95,417	3	206.9	15	8.9	12
2	15	68.5	11	1.055	6	93,750	11	194.0	6	8.1	3
3	8	67.4	3	1.036	13	90,333	12	191.7	11	7.6	8
4	14	66.3	8	1.007	15	86,667	1	181.2	18	7.3	15
5	17	63.9	21	0.908	7	81,250	8	180.4	2	7.0	1
6	3	63.6	17	0.900	1	78,750	2	176.4	12	6.9	11
7	1	63.5	20	0.893	14	76,833	16	175.3	3	6.9	17
8	16	62.3	5	0.868	4	76,167	15	174.6	1	6.7	14
9	21	59.9	14	0.853	2	75,500	17	174.0	17	6.7	16
10	10	59.7	16	0.853	22	74,000	14	173.1	14	6.2	21
11	11	59.7	23	0.800	16	73,583	21	170.6	5	6.1	2
12	6	57.1	1	0.787	18	71,583	20	169.1	21	5.4	6
13	20	56.5	15	0.775	9	71,417	6	168.9	7	5.4	20
14	5	55.9	2	0.735	24	71,000	5	162.9	23	4.9	5
15	2	55.4	9	0.708	17	70,917	4	159.5	20	4.7	23
16	7	52.4	24	0.681	19	69,833	24	155.8	10	4.7	24

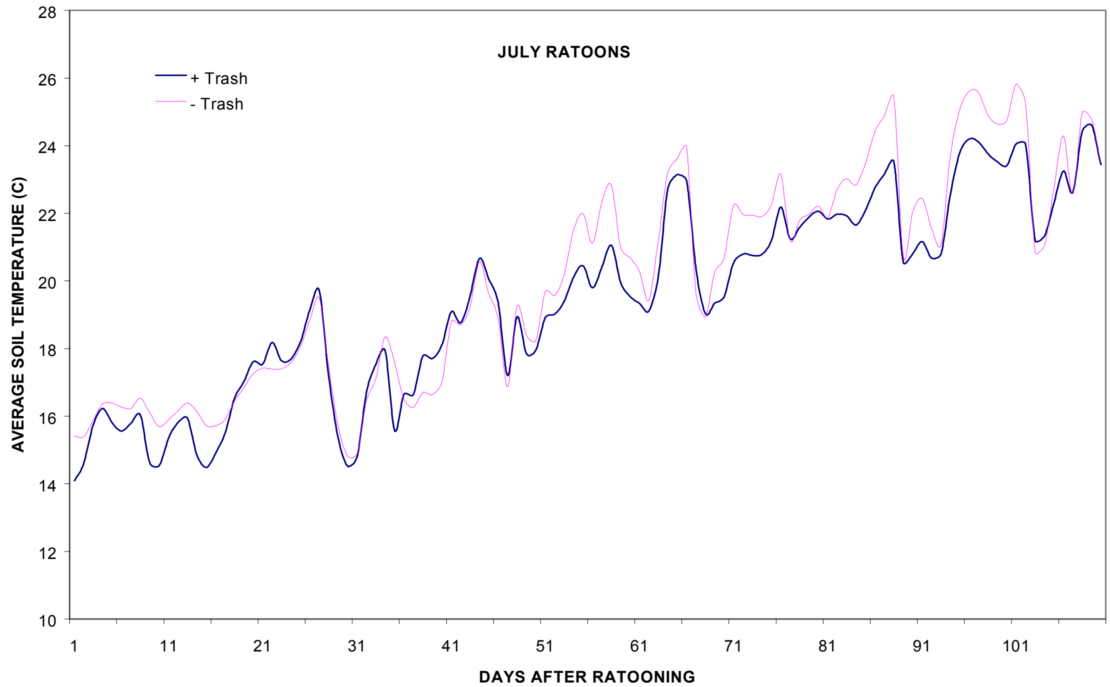
Rank	Clone No.	TCH	Clone No.	Wt per stalk	Clone No.	Stalks per ha	Clone No.	Stalk Ht (cm)	Clone No.	CCS	Vigour Class*
17	23	52.0	19	0.678	8	68,417	19	151.3	24	4.1	4
18	9	50.8	22	0.658	25	66,167	23	144.0	4	4.1	7
19	13	48.4	18	0.650	21	65,583	25	137.9	16	3.9	10
20	24	48.1	25	0.649	20	64,833	22	136.1	8	3.8	22
21	22	48.1	7	0.639	5	64,583	18	135.3	22	3.8	19
22	4	47.2	10	0.606	23	64,583	7	135.1	25	3.2	9
23	19	47.2	6	0.605	12	61,750	9	134.5	9	3.1	18
24	18	46.9	4	0.594	3	60,583	10	131.5	19	2.8	13
25	25	42.4	13	0.526	11	57,000	13	124.8	13	1.9	25

* Vigour Class – genotypes ranked according to the product of TCH and Stalk height rankings

Table 6. Mean squares from the analysis of variance of yield components for the July ratooning of 25 genotypes (1998/99)

Source	df	Stalk No. per ha		Cane yield t/ha		CCS		Sugar yield t/ha	
Replication	3	88,330,000		125.8		0.356		1.13	
Irrigation	1	38,830,000		1086.1		1.168		9.32	
Error a	3	351,200,000		1968.1		1.676		26.46	
Treatment	1	36,200,000		4.8		6.224		9.58	
Irrig x Treatment	1	15,520,000		91.7		0.154		1.26	
Error b	6	2,280,000,000		10978.9		2.075		187.38	
Genotype	24	2,319,000,000	***	4113.3	***	19.185	***	122.13	***
Geno x Irrig	24	512,300,000		1200.7		1.054		25.57	
Geno x Treatment	24	388,900,000		1067.1		0.745		18.19	
Geno x Irrig x Treat	24	359,700,000		547.6		0.780		10.44	
Error c	288	397,300,000		1025.3		1.094		20.69	
TOTAL	399								

Figure 4. Soil temperatures in trash blanketed and trash free plots ratooned in July
Figure 5. Soil moisture levels in trash blanketed and trash free plots ratooned in July



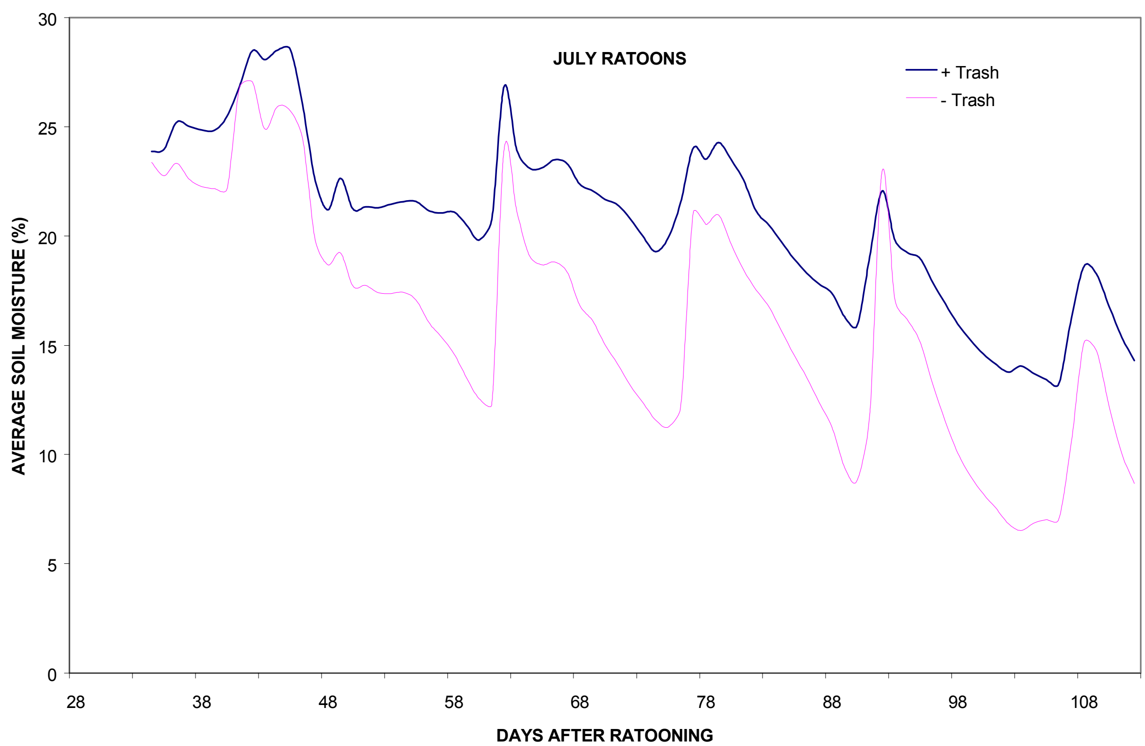


Figure 6. Impact of +/- irrigation and +/- trash blanket treatments on stalk height for plots ratooned in July

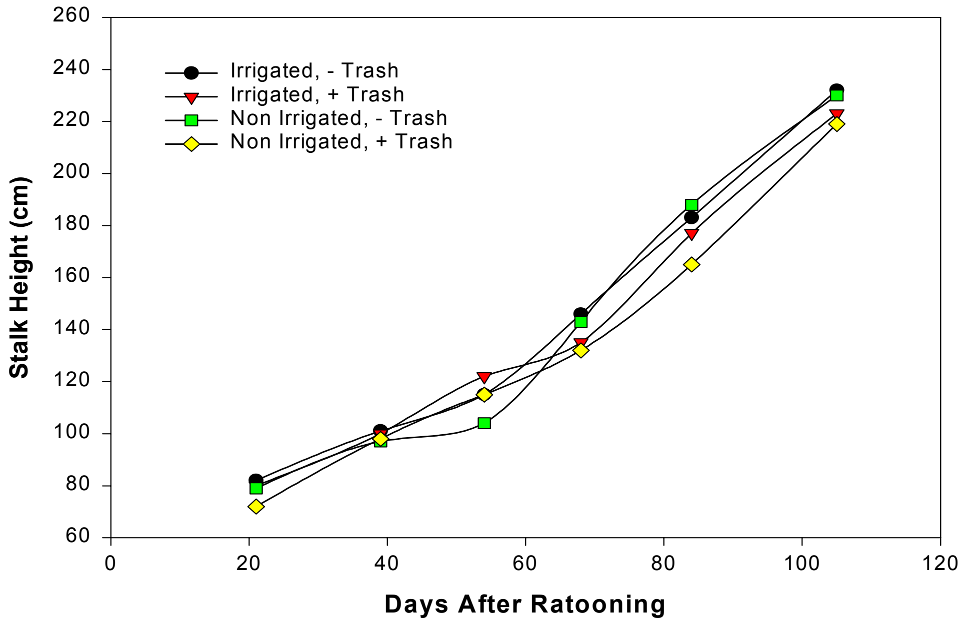
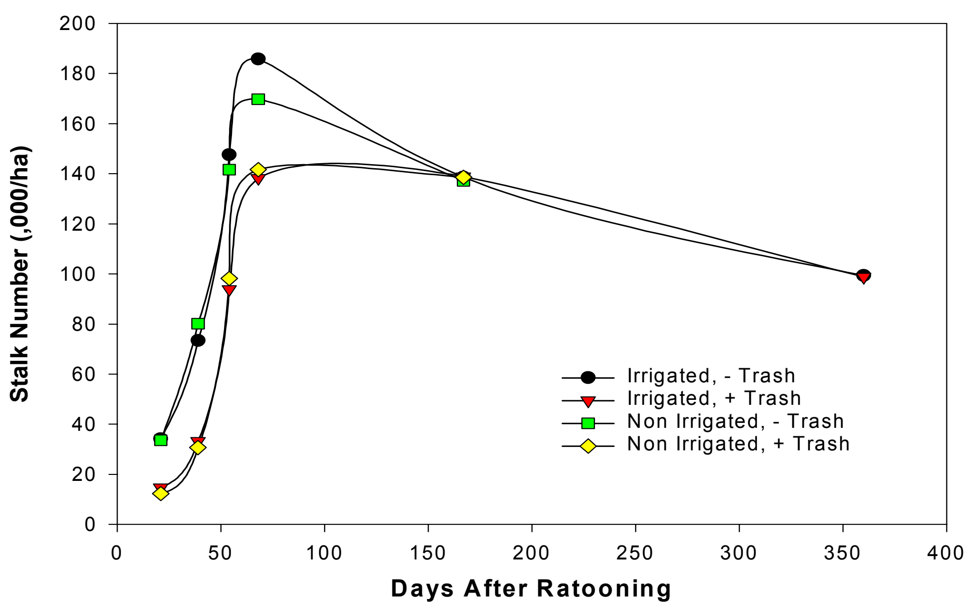


Figure 7. Impact of +/- irrigation and +/- trash blanket treatments on stalk numbers in plots ratooned in July



Actual performance of the individual genotypes for key yield parameters has been summarised in Table 7. A comparison of plant and ratoon crop performance of the genotypes shows that although genotypes appeared to display a similar distribution of cane yield (TCH) about the mean (Fig 8) the correlation for deviation from the mean for plant and ratoon crops was not strong (Fig 9).

The ranking of vigour calculated for the plant crop (Table 5) seems to bear little relation to the performance of the ratoon crop shown in Table 7. Similarly there is no correlation between the base temperatures for germination of individual genotypes (Table 4) and their ratoon crop yields (Fig 10). Hence, it seems unlikely that evaluation of germination parameters or of yield parameters for the plant crop will provide a reliable estimate of likely genotype ratooning capabilities under cool soil conditions.

Table 7. Genotypes ranked for individual yield parameters

Rank	Clone No.	Wt/Stalk	Clone No.	Stalk No. per ha	Clone No.	Cane yield t/ha	Clone No.	CCS	Clone No.	Sugar yield t/ha
1	12	2.083	10	122658	12	170	15	14.9	12	24.0
2	3	1.732	13	122389	3	156	17	14.8	3	21.7
3	14	1.626	25	116212	8	150	5	14.7	17	20.6
4	11	1.621	6	114018	14	146	9	14.3	15	20.6
5	8	1.575	22	113347	22	143	4	14.3	14	20.5
6	20	1.560	7	106184	20	142	12	14.1	8	18.8
7	15	1.443	16	103991	17	139	14	14.1	5	17.8
8	17	1.407	18	103722	15	138	3	14.0	10	17.7
9	9	1.349	21	102603	10	136	6	13.4	19	17.2
10	21	1.296	4	101663	21	132	19	13.3	21	17.2
11	5	1.284	19	100946	16	132	25	13.1	20	17.1
12	1	1.267	23	98529	18	130	18	13.0	18	17.0
13	19	1.266	17	98440	19	129	21	13.0	25	16.6
14	16	1.262	8	95396	13	129	10	12.9	9	16.6
15	22	1.262	24	95351	7	126	1	12.7	22	16.3
16	24	1.252	15	95216	25	126	2	12.7	16	15.8
17	18	1.243	5	95082	11	123	11	12.6	4	15.6
18	2	1.224	20	90964	5	121	23	12.6	11	15.5
19	7	1.176	1	89397	24	119	8	12.4	13	15.2
20	10	1.100	3	89397	9	115	20	12.1	7	14.7
21	25	1.079	14	89084	1	115	16	12.0	6	14.6
22	4	1.073	2	88323	4	109	13	11.8	1	14.4
23	23	1.066	9	85681	2	109	7	11.7	2	13.7
24	13	1.055	12	81429	6	108	22	11.5	23	13.2
25	6	0.950	11	76236	23	105	24	11.0	24	13.1

Figure 8. Comparison of cane yields in plant and ratoon crops, showing distribution about mean yields for each crop

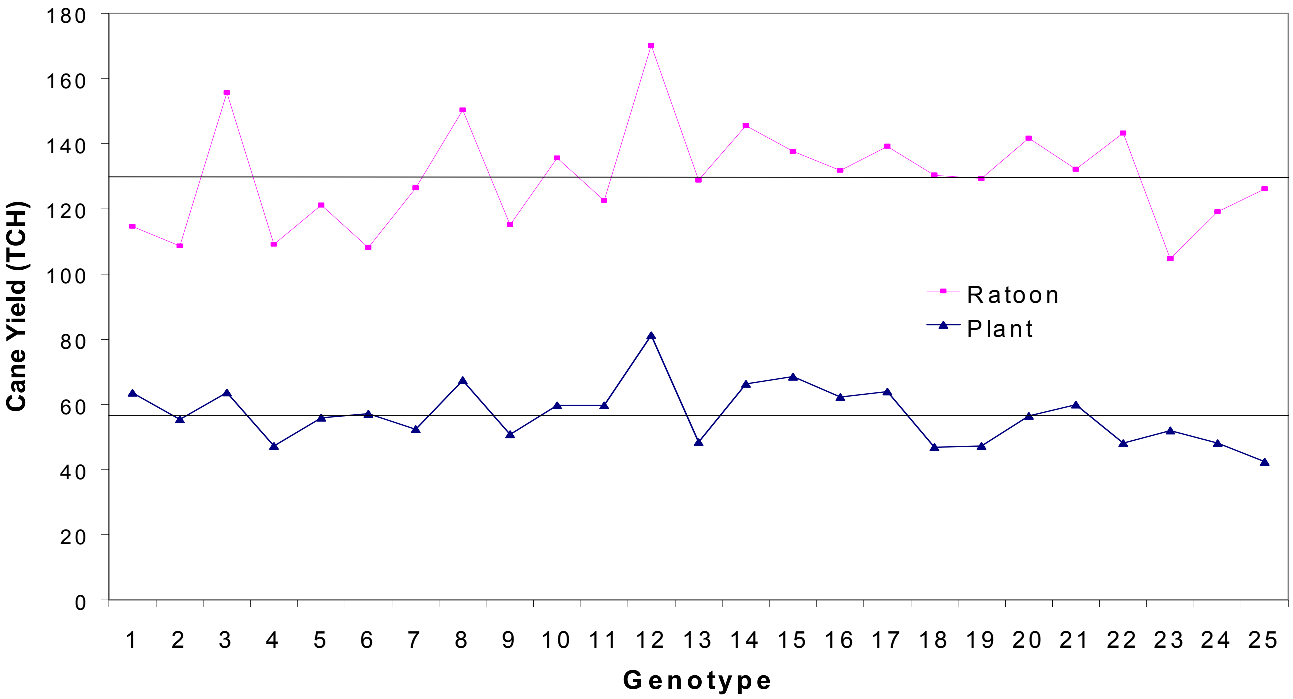


Figure 9. Regression of deviations from mean cane yields for plant crop against ratoon crop for individual genotypes

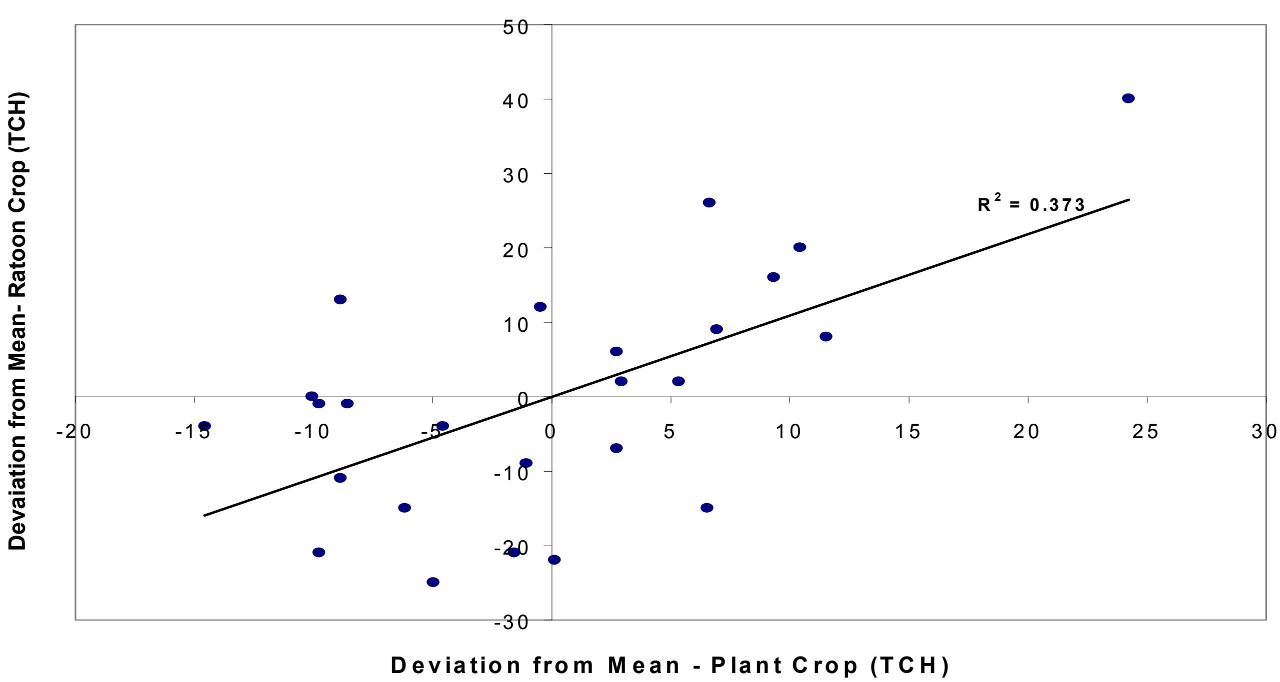
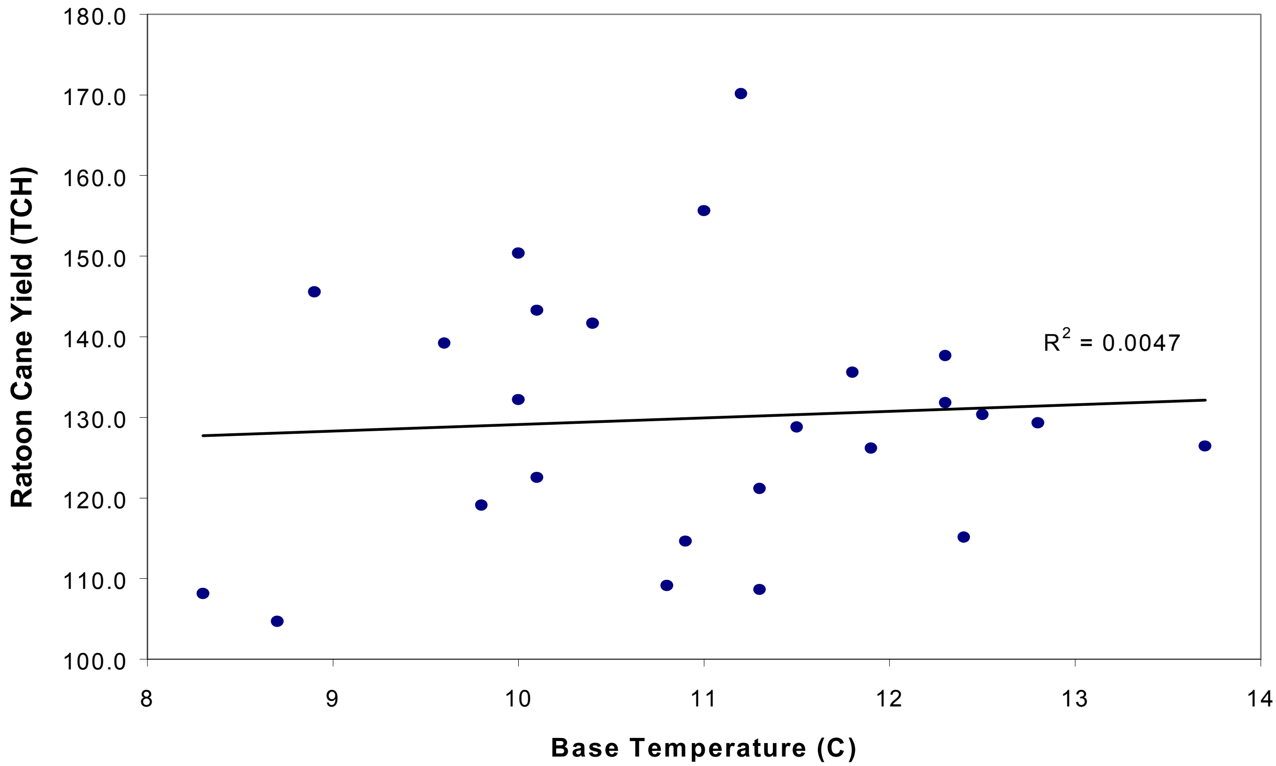


Figure 10. Correlation between estimated base temperature and ratoon cane yield



4.3 Warm season ratoon crop

The warm season ratoons were established from the half of the trial harvested in November 1998. Half of the ratoon area was irrigated to provide warm, moist soil and trash conditions and the remainder of the plots was left unirrigated to provide warm dry soil conditions. Subsequent heavy rainfall mitigated this planned soil moisture treatment effect and limited treatments to warm soil conditions plus and minus a trash blanket.

Records of average soil temperature and soil moisture in trash blanketed and trash free plots for the first 250 days after ratooning are summarised in Figures 11 and 12. Over this period soil temperatures under the trash blanket ranged from 0.4°C warmer to 3.8°C cooler than those in trash free plots and, on average, were 0.3°C cooler across the full period. The soil temperatures over the 60-day period after ratooning averaged 25.9°C, about 6°C higher than the soil temperatures for the July ratooning. During this time soil moisture levels under trash blanketed plots were from 0.7% lower to 9.4% higher than under trash free plots and, on average, were 2.4% higher. The impact of irrigation/rainfall events on soil moisture was evident. Unfortunately wild animals (foxes and/or pigs) damaged both the temperature and soil moisture probes so recording was disrupted for a period between 25-85 days after ratooning.

Figure 11. Soil temperatures in trash blanketed and trash free plots ratooned in December

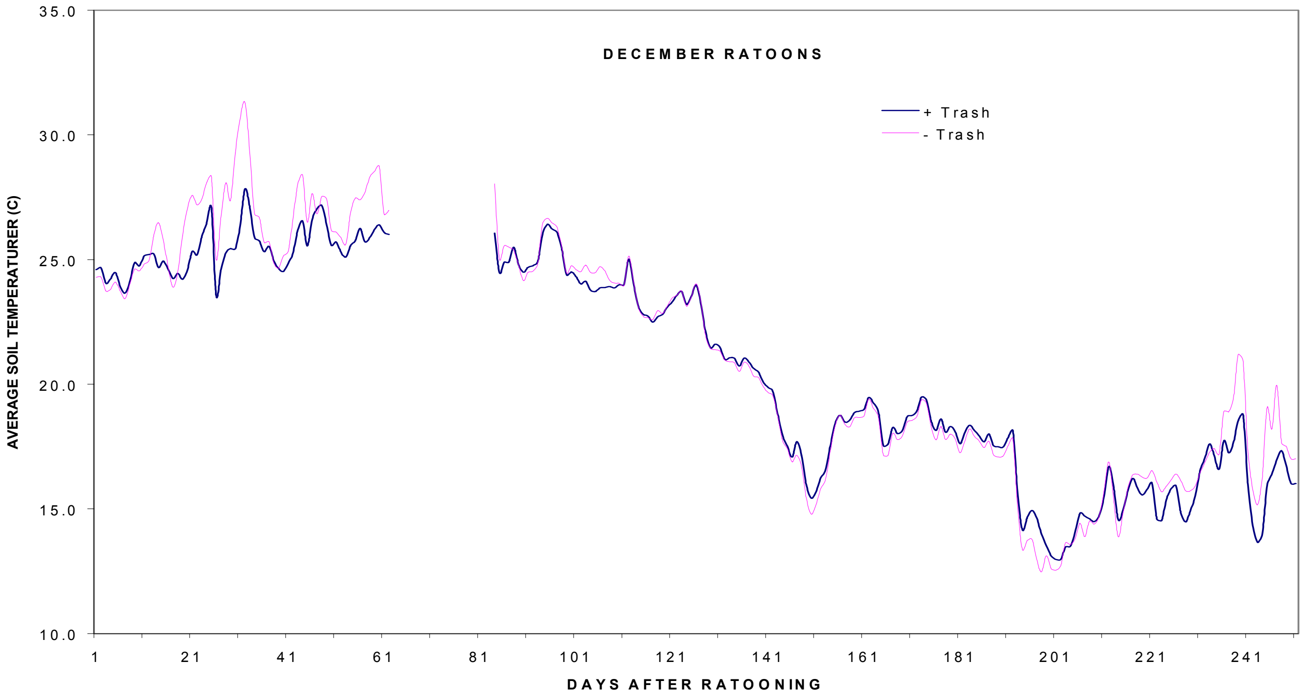


Figure 12. Soil moisture levels in trash blanketed and trash free plots ratooned in December

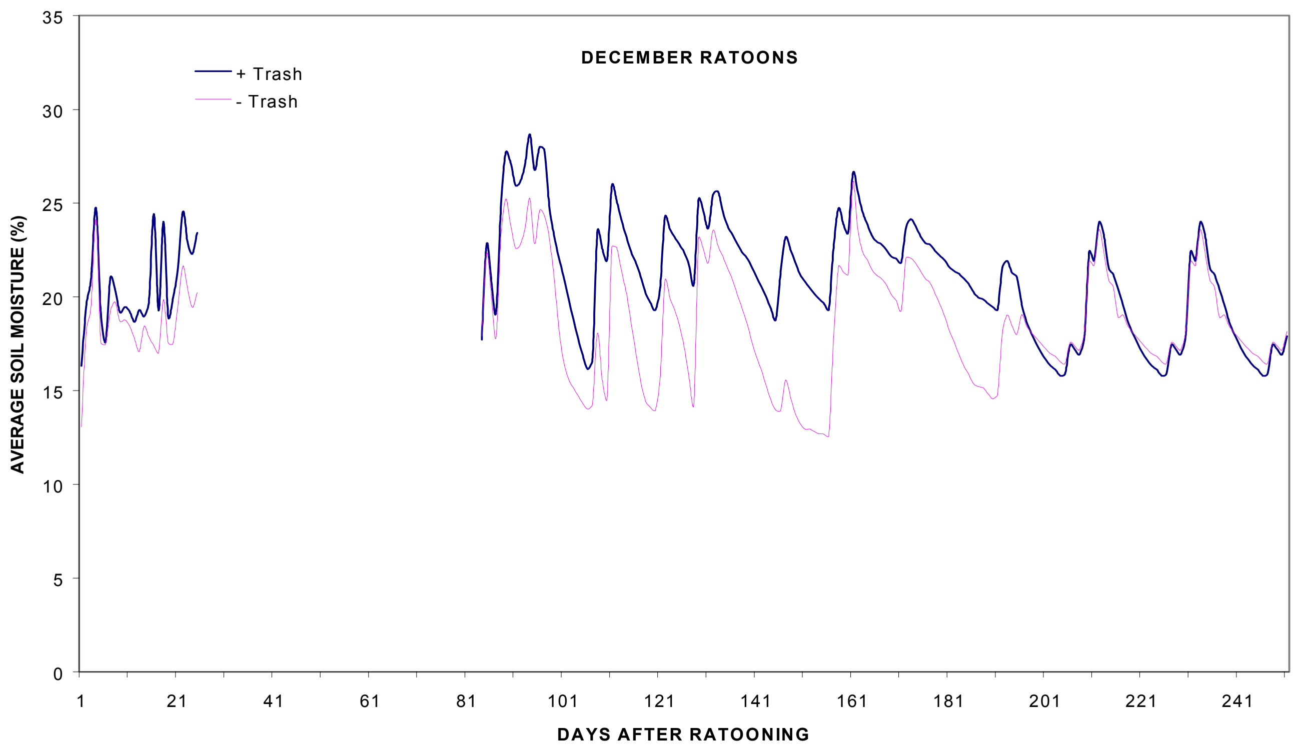


Figure 13. Effect of irrigation and trash treatments on stalk heights

for December ratoons

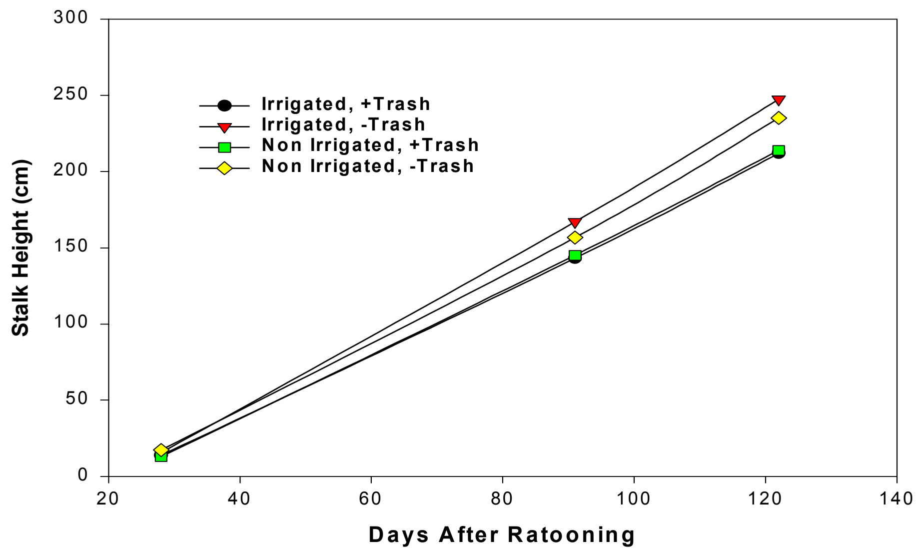
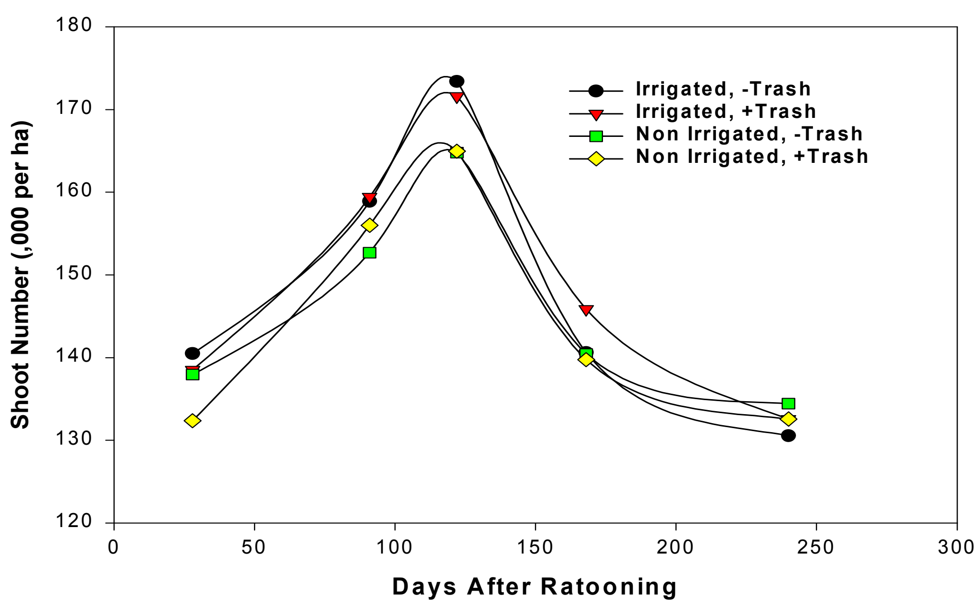


Figure 14. Effect of irrigation and trash treatments on shoot numbers for December ratoons



Measurements of stalk height (Fig 13) showed little consistent impact of irrigation treatment or trash blanketing treatment during the first 120 days of growth. However, towards the end of this period there was a trend for stalk heights to be larger in the trash free treatments. Stalk numbers were initially somewhat higher in the irrigated treatment but this effect was lost after canopy closure. There appeared to be little consistent effect of trash blanketing on stalk numbers at any stage of growth.

The warm weather ratoon was harvested at 12 months of age on 30 November 1999. Mean squares from the analysis of variance for key yield parameters are summarised in Table 8. The genotype effect was highly significant for all yield parameters, as already noted in the July ratoons. However, in warm season ratoons there was a strongly significant genotype by trash treatment interaction effect for both cane and sugar yield. Irrigation effects on CCS and irrigation by trash blanket interaction effect on stalk numbers were also significant but difficult to interpret.

Table 8. Mean squares from the analysis of variance of yield components for the December ratooning of 25 genotypes (1998/99)

Source	df	Stalk No. per ha		Cane yield t/ha		CCS		Sugar yield t/ha	
Replication	3	1,345,000,000		379.26		1.924		12.40	
Irrigation	1	130,000,000		27.04		19.572	*	6.25	
Error a	3	1,433,000,000		2142.05		1.119		52.13	
Treatment	1	28,440,000		1198.70		0.055		22.75	
Irrig x Treatment	1	3,054,000,000	*	517.82		0.002		8.66	
Error b	6	420,400,000		1507.28		1.308		35.98	
Genotype	24	2,291,000,000	***	1024.08	***	9.556	***	25.20	***
Geno x Irrig	24	188,800,000		191.10		0.444		4.15	
Geno x Treatment	24	117,400,000		452.99	***	0.412		9.60	**
Geno x Irrig x Treat	24	198,300,000		170.55		0.255		3.84	
Error c	288	130,400,000		198.57		0.481		4.32	
TOTAL	399								

Actual performance and ranking of the individual genotypes for key yield parameters has been summarised in Table 9. Comparison of the genotype rankings for the July and December ratoons shows that there is very little consistency for any yield parameter (Fig 15). Indeed there is a tendency for a negative correlation between the two ratoon crops for stalk weight, CCS and sugar yield rankings.

The meaning of the genotype by trash treatment interaction was assessed by estimating the difference in yield (TCH) observed in the presence and absence of trash in the December ratoons (Table 10). Results show that only one genotype (No. 3) yielded significantly heavier under the trash blanket but five genotypes (Nos. 9, 22, 8, 7 and 17) yielded significantly heavier in the trash free treatment. Comparison of the base temperatures recorded for emergence in these genotypes (Table 4) shows no discernible relation between T_b and the yield performance +/- trash blanket. These results suggest that it may be possible to screen genotypes for their capacity to perform well under a trash blanket but the likely selection rate might be quite low.

Table 9. Genotypes ranked for individual yield parameters (December ratoons)

Rank	Clone No.	Wt/Stalk	Clone No.	Stalk No. per ha	Clone No.	Cane yield t/ha	Clone No.	Sugar content CCS	Clone No.	Sugar yield t/ha
1	18	0.628	11	63667	18	52.6	16	13.00	18	7.5
2	13	0.668	12	66542	17	59.2	21	13.13	21	8.0
3	23	0.681	20	71333	5	59.3	24	13.28	5	8.6
4	4	0.690	3	74000	21	60.7	20	13.29	16	8.8
5	6	0.709	5	74958	23	62.7	22	13.41	23	8.8
6	10	0.755	17	79875	4	64.3	7	13.57	11	9.1
7	21	0.759	21	80208	11	65.3	13	13.82	20	9.3
8	17	0.763	1	81125	3	65.9	10	13.86	3	9.3
9	22	0.767	24	81208	16	67.9	11	13.95	22	9.4
10	7	0.768	16	83750	1	68.1	6	14.02	17	9.5
11	25	0.795	2	83792	2	69.1	23	14.03	7	9.7
12	9	0.800	18	83917	20	69.8	3	14.05	2	9.9
13	19	0.807	8	84458	22	70.3	12	14.15	4	10.0
14	5	0.808	14	86583	9	70.9	18	14.33	10	10.2
15	16	0.834	9	87833	7	71.9	2	14.34	1	10.3
16	15	0.838	25	91500	25	72.9	8	14.43	24	10.4
17	2	0.841	22	91875	10	73.4	5	14.59	9	10.5
18	1	0.851	23	92750	6	75.2	19	14.62	6	10.6
19	3	0.896	4	93750	19	77.0	25	14.62	13	10.6
20	8	0.958	7	93917	13	77.2	9	14.81	25	10.7
21	24	0.970	15	94708	24	77.3	14	15.06	19	11.3
22	14	0.980	19	95583	15	79.1	1	15.08	8	11.6
23	20	0.992	10	100083	8	80.3	15	15.22	12	12.0
24	11	1.058	6	106542	14	83.2	4	15.59	15	12.1
25	12	1.294	13	116375	12	84.7	17	16.01	14	12.5

Figure 15. Comparison of genotype ranking for key yield parameters in the July and December ratoon crops

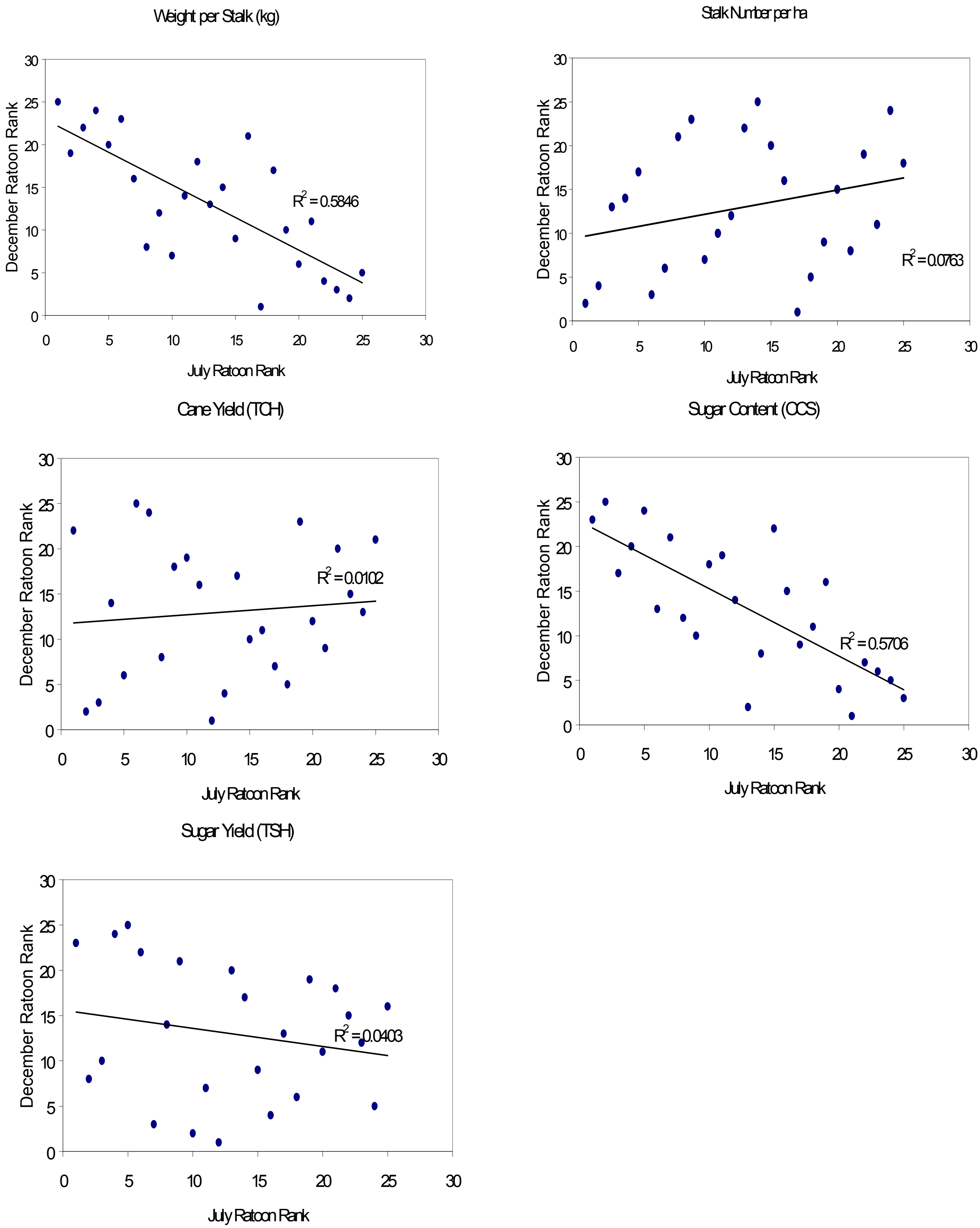


Table 10. Comparison of the yield differentials between + and - trash treatments (yield under -trash minus yield +trash) for the 25 genotypes (December ratooning)

Genotype	Yield differential (t/ha)	Genotype	Yield differential (t/ha)
3	-14.0	12	5.2
21	-12.4	18	5.7
14	-11.6	10	6.6
20	-10.6	23	6.9
13	-10.2	4	8.3
5	-7.8	25	11.0
2	-2.9	11	11.2
19	-0.9	17	14.4
15	0.3	7	15.6
6	0.5	8	17.0
24	1.9	22	17.9
1	3.2	9	26.1
16	5.1		
lsd@5%	13.9		

4.4 Combined analysis

Results from the two ratooning dates were combined and subject to an analysis of variance, which is summarised in Table 11. In this analysis the irrigation treatments have been ignored because they were confounded by prevailing rainfall patterns.

Only the main effects for ratooning date and genotype and their interaction term were significant for each yield parameter in this analysis. Detail of the analysis of variance for cane yield is summarised in Table 12 and relevant yields are summarised in Table 13. These demonstrate the magnitude of the impact of ratooning date on yield, the lesser impact of genotype and indicate that the responses detected for genotype numbers 3, 7, 8, 9, 17 and 22 in the December harvest are less apparent as overall trends.

This combined analysis shows that the overall genotype by trash blanket interaction effect is non-significant and suggests that inferences from the significant interaction effect detected in the December ratoons should be treated with caution.

Table 11. Mean squares from the combined analysis of variance of yield components

Source	df	Stalk No.		Cane yield		CCS		Sugar yield	
Replicate	3	882,400		297		1.51		6.90	
Ratooning	1	31,940,00 0	***	709,372	***	277.73	***	9,737.80	***
Error (a)	3	551,100		208		0.77		6.64	
Trash	1	233		678		3.72		1.40	
Trash x Ratoon	1	64,410		526		2.56		30.93	
Error (b)	6	1,007,000		6,081		2.41		97.58	
Genotype	24	4,133,000	***	3,306	***	24.62	***	93.93	***
Geno x Ratoon	24	477,100	*	1,831	***	4.12	***	53.40	***
Geno x Trash	24	224,200		772		0.46		14.56	
Geno x Trash x Ratoon	24	282,100		748		0.70		13.23	
Residual	688	292,000		662		0.80		13.48	
Total	799								

Table 12. Combined analysis of variance for cane yield (t/ha) across ratooning dates

Source	df	SS	MS	F	P
Replicate	3	891	297	1.43	0.3882
Ratooning	1	709,372	709,372	3410.74	0.0000
Error (a)	3	624	208		
Trash Treatment	1	678	678	0.11	0.7499
Trash x Ratooning	1	526	526	0.09	0.7786
Error (b)	6	36,485	6,081		
Genotype	24	79,341	3,306	4.99	0.0000
Genotype x Ratoon	24	43,956	1,831	2.77	0.0000
Genotype x Trash	24	18,521	772	1.17	0.2662
Geno x Trash x Ratoon	24	17,961	748	1.13	0.3031
Residual	688	455,607	662		
Total	799	1,363,961			

Table 13. Mean cane yields across ratoon dates, trash blanket treatments and genotypes

Genotype	July ratoons		December ratoons		Treatment means		Ratoon means		Genotype means
	+Trash	-Trash	+Trash	-Trash	+Trash	-Trash	July	December	
1	112.6	116.7	66.6	69.7	89.6	93.2	114.6	68.1	91.4
2	110.3	106.9	70.6	67.7	90.4	87.3	108.6	69.1	88.9
3	164.5	146.8	72.9	58.9	118.7	102.8	155.6	65.9	110.8
4	111.6	106.6	60.1	68.4	85.9	87.5	109.1	64.3	86.7
5	123.2	119.1	63.2	55.4	93.2	87.3	121.2	59.3	90.3
6	117.6	98.7	74.9	75.4	96.3	87.0	108.1	75.2	91.7
7	132.8	120.1	64.1	79.7	98.4	99.9	126.4	71.9	99.2
8	159.5	141.3	71.8	88.8	115.6	115.0	150.4	80.3	115.3
9	126.7	103.6	57.9	84.0	92.3	93.8	115.1	70.9	93.0
10	151.6	119.5	70.1	76.7	110.9	98.1	135.6	73.4	104.5
11	113.9	131.2	59.7	70.9	86.8	101.0	122.5	65.3	93.9
12	159.9	180.4	82.1	87.3	121.0	133.9	170.2	84.7	127.4
13	129.6	128.0	82.3	72.1	106.0	100.0	128.8	77.2	103.0
14	149.6	141.6	89.0	77.4	119.3	109.5	145.6	83.2	114.4
15	135.6	139.8	78.9	79.2	107.2	109.5	137.7	79.1	108.4
16	125.6	138.0	65.3	70.4	95.5	104.2	131.8	67.9	99.8
17	131.1	147.3	52.0	66.4	91.5	106.9	139.2	59.2	99.2
18	116.1	144.6	49.8	55.4	82.9	100.0	130.4	52.6	91.5
19	124.3	134.3	77.4	76.6	100.9	105.4	129.3	77.0	103.2
20	135.5	147.9	75.1	64.6	105.3	106.2	141.7	69.8	105.8
21	129.0	135.3	66.9	54.4	98.0	94.9	132.2	60.7	96.4
22	129.5	157.1	61.3	79.2	95.4	118.1	143.3	70.3	106.8
23	98.1	111.3	59.2	66.1	78.7	88.7	104.7	62.7	83.7
24	128.1	110.1	76.3	78.2	102.2	94.1	119.1	77.3	98.2
25	128.3	124.0	67.4	78.4	97.9	101.2	126.2	72.9	99.6
Means	**129.8**	**130.0**	**68.6**	**72.1**	**101.0**	**99.2**	**129.9**	**70.3**	
lsd main	-				13.5		3.2		12.6
lsd interaction	25.3				17.9		17.9		-

4.5 Summary and conclusions

This trial addressed the project objectives but the expected environmental conditions did not eventuate so that not all objectives could be addressed in detail. In essence, the trial showed:

- A highly significant genotype by ratooning date interaction effect on final yields. Higher yields were obtained from the crop ratooned in July and grown through to the following July than from the crop ratooned in late November and grown through to the following November. In other words, the crop ratooned at 14°C was not seriously disadvantaged by low temperatures and significantly outyielded the crop ratooned at 25°C later in the season. Despite both crops being 12 months old at harvest the difference in conditions (radiation and temperature) during the growing season far-outweighed soil temperature effects at germination.

- The genotype by trash blanketing interaction was insignificant overall and in the crop ratooned in the cool season. A positive interaction was evident in the warm season ratooned crop with five genotypes yielding more under trash free conditions and one variety yielding more under trash blanket conditions.

- Trash blanketing delayed shoot emergence initially at high and low soil temperatures but the effect was lost by about 150 days after ratooning. There was no significant effect of the presence or absence of trash on final stalk numbers or crop yield.

- Trash blanketing had little or no impact on the rate of shoot elongation. Stalk heights were similar in trash blanketed and trash free plots under both cool or warm soil conditions.

The outcomes from this project did not fully achieve the original objectives because the expected constraint to ratooning under trash blankets in cool/wet conditions was not encountered. Consequently it was not feasible to characterise the environmental constraints involved, assess growth parameters to identify adapted genotypes or to develop strategies for overcoming limitations to adoption of trash blanketing.

Based on the conditions encountered in this trial, it can be concluded that whilst trash blanketing at soil temperatures down to 14°C delays shoot emergence the ultimate effect on final crop yield is non-significant.

5.0 DIFFICULTIES ENCOUNTERED

Several difficulties were encountered during the implementation of this project, which impacted on the level of achievement of objectives. The primary problem arose from an atypical weather pattern that saw winter temperatures warmer than expected, thus somewhat restricting the planned generation of cool, moist soil conditions. In addition, the increased incidence of rain greatly reduced the capacity to differentially generate moist and dry soil conditions at ratooning.

Soon after the plant crop of the trial was established the grower decided to replace his winch irrigation system with a centre pivot system. The winch system was ideally suited to this project and the trial was designed to allow the generation of differential soil moisture conditions at ratooning using the winch irrigator. However, installation of the centre pivot system completely negated the trial design and further precluded the generation of differential soil moisture conditions.

Budgetary restrictions prevented the trial being continued beyond the first ratoons. Given the constraints encountered it is unlikely that second ratoons would have provided any different results from those reported for the first ratoons.

6.0 APPLICATION TO INDUSTRY

The results from this project suggest that many of the reservations about the value of green cane trash blanketing under cool, moist soil conditions might be based on perceptions rather than facts. Although trash blanketing delays germination under these conditions it may not have any detrimental effects on subsequent crop production in areas where soil temperatures do not drop below 14°C for extended periods. Such a finding is of immediate application in the Southern and Central regions of the industry.

7.0 PROJECT TECHNOLOGY

No significantly new technology was employed or developed during this project.

8.0 TECHNICAL SUMMARY

No significantly new discoveries in methodology or equipment design were developed during this project.

9.0 RECOMMENDATIONS FOR FURTHER RESEARCH

This project did not detect a reliable significant genotype by trash blanketing interaction. However, this may not mean that such an interaction does not exist. Inference from the results of the summer ratoons suggests that some genotypes may perform differently under the trash blanket. Hence, it will be worth screening a much larger population of unselected genotypes in a simple +/- trash trial in northern New South Wales to ascertain if genetic capacity to ratoon under cool, wet trash exists.

In addition, attention should be focussed on trash management practices that avoid the nuisance of cane fires, maintain soil fertility and structure and provide an alternate source of income.

10.0 PUBLICATIONS

No publications are yet associated with this project.

11.0 REFERENCES

Kingston, G. 1997. Australian Sugarcane. Vol 1. No 2: 3-6.

Liu, D L, Kingston, G and Bull, T A. 1998. Agricultural and Forest Meteorol. 90: 119-139

McMahon, G G and Ham, G J. 1996. Proc. Aust. Soc. Sugar Cane Technol. 18: 131-136.

Ridge, D R, Hurney, A P and Chandler, K J. 1979. Aust. Soc. Sugar Cane Technol. 1: 89-93.

12.0 ACKNOWLEDGMENTS

The financial support provided for this project by the Sugar Research and Development Corporation and by BSES gratefully acknowledged.

In addition the dedication and hard work of our technical staff, particularly Danny Leary and Bernie Leary is acknowledged and appreciated.