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FINAL REPORT – SRDC PROJECT BSS220
UNDERSTANDING WHY POTENTIAL FIELD CCS IS NOT REALISED AT THE FACTORY

by

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ABSTRACT

Declining ccs in the Mossman–Tully region has been linked to increasing extraneous matter in mill-supply cane. This was quantified by measuring the proportion and quality of crop fractions in pre-and post-harvest subsamples. These were taken from 54 sites in 1999 and 2000, dissected into basic crop components, quantified, and analysed for five quality components. In March–July 2000, 14 sites with crops showing pre-harvest-season stalk-habit variation – erect versus lodged – were sampled three times. Pre-harvest habit had a marked effect on crop ccs. Lodged, unsound cane had a mean ccs 25% less than erect, sound cane. Relatively, average mill ccs compared poorly with pre-harvest potential ccs (75.9 and 85.1% for 1999 and 2000, respectively) and post-harvest potential ccs (83 and 87%). Mill-realised ccs was marginally above the average, weighted, whole-crop, in-field ccs, in both years, almost equalled the post-harvest ccs in 1999, and was just below in 2000. In 1999, harvesting did not reduce the in-field extraneous matter content (18.9%). In 2000, the proportion changed from 18.9 to 13.1%. An erect crop maximises quality and must be addressed by crop improvement and agronomy activities. The results severely question the efficacy of current harvesting technology, or how this is being used.

1.0 NON-TECHNICAL SUMMARY

This project addressed the relationships between pre-season crop habit and ccs, and the impact of extraneous matter content on the increasing decline in ccs levels of mill-supply cane in the region from Mossman to Tully.

1.1 Pre-harvest-season sampling

A non-erect habit increases the incidence of broken stalks, which results in increased rot and borer damage, predisposes the crop to damage from rats, and generally compromises the harvesting process. In all, quality of mill-supply cane is discounted. In this project, 14 sites were selected before the beginning of the 2000 harvest season on the basis of variable stalk habit - erect versus non-erect, the latter being <30° from the horizontal. These sites were sampled three times between March and June. Erect- and lodged-stalk subsamples were removed and subjected to full quality component analyses after classification on soundness.

Average ccs values for sound, erect stalks (109.94 g kg^{-1}), sound, lodged (101.63 g kg^{-1}), unsound, erect stalks (96.52 g kg^{-1}) and unsound, lodged stalks (83.42 g kg^{-1}) showed that crop habit and stalk soundness affected ccs. Lodging reduced ccs by 7.6%, unsoundness by 12.2%, and in combination by 24.1%. Ccs increased by 17.73 g kg^{-1} $month^{-1}$ during the sampling. This assessment was to be repeated in the 2001 pre-harvest-period. This was precluded by a generally erect crop, predicated by untimely and heavy rains in November/December 2000, which reduced tillering and crop growth, and an absence of cyclonic conditions. These data clearly reinforce the necessity for maintaining an erect-crop condition. This only can be done by a combination of crop improvement and agronomic inputs. Selection of a plant ideotype that favours crop erectness is essential. This must be reinforced by agronomic practices. Appropriate cultivar use is a simple but essential component of the production equation.

1.2 Harvest-season sampling

In 1999 and 2000, 17 and 37 random sites, respectively, were sampled. These sampled broad cultivar x crop class x soil series combinations and are considered representative of the northern coastal production environment. Subsamples of in-field and in-bin cane taken immediately before and after harvest, respectively, were dissected into basic crop fractions to quantify the impact of extraneous matter on mill-realised ccs. In-field subsamples were divided into sound and unsound mature stalks, sucker culms, and extraneous matter, defined as mature stalk tops, sucker culm leaves, and clinging trash. The in-bin subsamples were dissected into sound and unsound billets, cabbage, and leaf including dirt. A mill-realised ccs was determined for an independent mill rake from each site. All fractions were analysed for Brix, ccs, fibre, moisture and pol reading. In 1999, samples were analysed by routine methods, and scanned using near infra-red spectroscopy. Calibrations developed were used for the analysis of the pre-harvest-season samples as well as the harvest-season samples in 2000. Analysis of a random 10% of samples allowed evolutionary calibration development. These equations were applied to the 2000 harvest population before undertaking detailed analysis.

In 1999, mean values for in-field, post-harvest, and mill-realised ccs were 110.6, 117.6 and 117.4 g kg^{-1}, respectively. Potential in-field ccs (sound + unsound stalks) of 154.6 and potential post-harvest ccs (sound +unsound billets) of 141.7 g kg^{-1} were well above the mill-realised value. In-field sucker culm and extraneous matter components constituted 29.7% of the crop mass on average, this being reduced to 18.9%, on average, by harvesting. Sound and unsound stalks constituted 53 and 17%, respectively, of the in-field crop, translating to 72 and 9%, respectively, as sound and unsound billets, post harvest.

In 2000, mean values for in-field, post-harvest, and mill-realised ccs were 128.7, 127.3 and 125.4 g kg^{-1}, respectively. Although the in-field mean was about 16% higher in 2000, the latter two values were greater by half or less than this. Potential in-field ccs of 147.2 g kg^{-1}, and potential post-harvest ccs of 144.2 g kg^{-1}, were well above the mill realised ccs of 125.4 g kg^{-1}. In-field sucker culm and extraneous matter fractions constituted 13.3% of the crop mass on average, this being reduced only marginally to 13.1% by harvesting. However, the in-field data were on a different basis to the 1999 data. Clinging trash was not included in the extraneous matter component, on the suggestion of a review committee. In retrospect, this was an incorrect decision. Sound billets, sound billets from unsound stalks, and unsound billets from unsound stalks constituted 70.1, 11.1 and 5.5%, respectively, of the in-field crop, and sound and unsound billets, constituted 79.5 and 7.4%, respectively, of the post-harvest biomass.

This research showed that post-harvest and in-field extraneous matter levels were comparable. The efficacy of on-farm harvesting technology, therefore, requires considerable improvement for the ccs of mill-supply cane to approach potential in-field ccs levels. This predicates farm viability. Alternatively, development of mill pre-cleaning technologies coupled with existing harvesting technology, or revolutionary, simplified harvesting practices, and value adding to resulting fibre streams, require serious examination if extraneous matter levels are to be reduced and potential in-field ccs realised.

2.0 BACKGROUND

This information was presented in the Project Proposal and is reproduced here.

> "Declining ccs in the wet tropics has been linked to increasing extraneous matter (suckers, trash, dead stalks, and dirt) in the cane supply (Leslie and Wilson Report, SRDC, 1996), and this proposal addresses a primary recommendation of this report.
>
> Analysis of post-shredder samples from Mulgrave Mill in mid-November 1995 revealed a 4.5 units ccs differential compared with clean whole-stalk samples from a BSES Meringa trial the following week. Leaf and cabbage may account for up to 1.5 ccs units. Analysis of paired mature-stalk and sucker samples from 25 plots in the same trial, at harvest, revealed a mean ccs differential of about 7.0 ccs units. Random stool samples supplied by Mulgrave Mill personnel revealed that up to 50% of culm biomass consisted of suckers. These data suggested that suckers are affecting realised ccs adversely. The effect of components of extraneous matter on cane supply quality are not fully understood, possibly because extraneous matter is underestimated as its components are not clearly defined.

> More recently, in a heavily lodged 2R final assessment trial harvested from BSES Meringa, and containing 190 plots, data on total biomass (mature stalks + suckers) and clean-stalk ccs were complemented with objective data on sucker yield and sucker ccs. There was substantially more genetic variation for sucker yield than cane yield, and sucker yield, although more variable, was genetically determined to a high degree. Quality components are still being processed, so the impact of suckers cannot be quantified at this stage, but with suckering ranging from zero to 25 t/ha, the dilution is substantial. Clean whole-stalk ccs ranged from 9.3 to 16.6, while sucker ccs ranged from –1.5 to 7.9, on an individual plot basis. While suckering is only one of the crop components in addition to mature whole stalks that may be having an impact on overall crop quality, their impact is substantial. Wider quantification of crop sub-components composition, and their quality, is imperative to allow further development strategy development for the wet tropics industry."

Since this was written, a detailed analysis of the impact of sucker culms on crop quality, and their implication for crop improvement has been published:

Berding, N. and A.P. Hurney. 2000. Suckering: A aspect of ideotype selection and declining ccs in the wet tropics. Proc. Aust. Soc. Sugar Cane Technol. 22:153–162.

Hurney, A.P. and N. Berding. 2000. Impact of suckering and lodging on productivity of cultivars in the wet tropics. Proc. Aust. Soc. Sugar Cane Technol. 22:328–333.

3.0 OBJECTIVES

The aim of the project was to quantify and rationalize differences between in-field and mill-realised ccs in the wet tropics. This was achieved by:

1. determining the proportion of crop fractions (sound and unsound stalks, suckers, tops and trash) contained in pre-harvest (in-field) samples and the proportion of crop fractions (sound and unsound billets, cabbage and leaf) contained in post-harvest samples from erect and lodged crops;

2. determining quality components (Brix, ccs, fibre, moisture and pol. reading) of crop fractions obtained from in-field and post-harvest samples from erect and lodged crops;

3. comparing mill-realised ccs with ccs of in-field and post-harvest samples to identify factors associated with reducing ccs and substantiate findings from 1999 research;

4. quantifying the effect of lodging on the proportion and quality of crop components.

4.0 EXTENT OF ACHIEVEMENT

All objectives, with the exception of a repeat of the "erect versus lodged cane" assessment of Objective 4 in a second season were achieved in full. Sampling in 1999 and 2000 of 17 and 37 field sites, respectively, produced results that clearly addressed Objectives 1 and 3. A mill rake from each site allowed Objective 2 to be addressed. The pre-harvest-season sampling undertaken in March–June 2000 allowed Objective 4 to be fully addressed. Crop conditions in 2001 precluded the capture of a second data set, and this is explained in the "Non-technical summary" above.

5.0 METHODOLOGY

The methodology used in this project has been presented previously in earlier submitted Milestone Reports, and the reader is referred to these:

Milestone Report # 4, pp. 3–5.

Milestone Report # 5 pp. 2–3.

Milestone Report # 6 pp. 4–7.

6.0 RESULTS AND DISCUSSION

The results obtained for the pre- and post-harvest sampling in the 1999 and 2000 harvest seasons, and the pre-harvst-season sampling undertaken prior to the 2000 harvest season have been fully documented, presented, and discussed in earlier Milestone Reports, and the reader is referred to these:

Milestone Report # 4, pp. 5–8, and Table 1 (p. 13) – Table 15 (p. 29) and Fig. 1 (p. 11).

Milestone Report # 5, pp. 3–5, Table 1 (p. 7) - Table 17 (p. 31).

Milestone Report # 6, pp. 8–16, and Table 1 (p. 19) – Table 19 (p.47) and Fig. 1. (p. 48) – Fig. 14 (p.61).

These Milestone Reports presented all analyses necessary for discussion of the collected data. In addition, discussions clearly show that the outcomes fully addressed the project's objectives, with the exception of the one point discussed above.

7.0 IMPACT ASSESSMENT

Appendix 1, a manuscript accepted for the Proceedings of the ASSCT's 2002 Conference, and Appendix 2, a copy of material to be presented to the Information Meetings being conducted in northern Queensland from the 5–8 March 2002, clearly detail the impact of the findings obtained from research conducted in this project. There seems little necessity to reproduce this information here, and the reader is referred to these Appendices.

8.0 COST AND POTENTIAL BENEFIT

Table 6, Appendix 2, details an attempt at determining the potential benefit of reducing the level of extraneous material in mill-supply cane to the Australian sugar industry. The appropriate contrast is what the three industry sectors (growing, harvesting and milling) are achieving currently for the extreme situations – benefiting from the potential ccs in mature stalks, a level which may not be practically attainable, versus benefiting from what is delivered by current use of existing harvesting technology.

However, these estimates must be considered naïve, as the cost benefits to the milling sector from reduced extraneous material content cannot be determined because of non-availability of benefit costs. If the mill-supply material stream was to approach the quality of clean mature stalks, transport costs, milling train wear, and process losses all would be reduced. Sugar quality should be increased, and because the harvest-season length would be reduced, ccs would be increased because harvesting would occur closer to the maturity peak. There may well be additional benefits. However, other than listing these, the cost benefit of attaining these by reducing extraneous matter content cannot be objectively determined.

Again, from Table 6, Appendix 2, the imposition of a revolution on the Australian industry by advocating whole-crop harvesting with a simplified harvester, use of mill-supply material sorted into clean billets versus extraneous material, and processing and valuing adding to the extraneous material supply again can be described as an outcome that the data suggest requires examination. In no sense can this be costed because the expertise to perform the require analyses, and the costs and cost benefits, are lacking or are unavailable. Hopefully, these can be performed once the data are published.

9.0 FUTURE RESEARCH NEEDS

The closing of the gap between the high quality crop fraction present in clean mature stalks and the lower quality material currently being delivered as mill-supply material from current use of available harvesting technology should be viewed as a major research objective. The prudent means of achieving this will doubtless be the subject of intense debate, and a broad range of industry personnel can only conduct this. The data obtained in this project should stimulate this debate, because data of this quality for the material and quality transition from field to mill have not been available previously. Coupled with the material loss estimates available from the harvest process, these data should raise considerable concerns as to the overall cost of the use and/or efficacy of current harvest technology.

There are lessons also for crop improvement and crop production. Obviously, losses from the presence of unsound mature stalks in both years are significant. Partly, this was due to the non-erect habit of the crop. If the crop can be maintained in an erect habit through selection of an appropriate ideotype, assisted by implementation of appropriate agronomic management, considerable gains in harvest-season ccs will be attained. In addition, infestation by rats, and the subsequent losses incurred through simply mechanical damage to the stalks, and further losses incurred by fungal infection of stalks damaged by extreme stalk movement, or by rats, and perhaps borers, would be minimised, or be non-existent. Production of sucker culms can have a serious diluent effect on realised ccs, as earlier research data, as well as data from 1999 in this project have shown. Selection against suckering propensity is feasible, and selection methodology for the northern sector has been modified to effect this. The full implications of this on ratoonability and ratoon productivity are undetermined. Additional research on this aspect is essential.

10.0 PROJECT TECHNOLOGY

No technology was developed from this research, which essentially was a descriptive exercise using objective data.

11.0 TECHNICAL SUMMARY

Because of the essentially descriptive nature of this project there are no discoveries in these categories to report.

12.0 RECOMMENDATION

The attached Appendices 1 and 2 demonstrate the attempts to disseminate the results of this project to the industry. Two additional papers, one on the overall analyses of the transition from field to crop, and one on aspects of the near infra-red technology analyses developed in this project are planned in the near future.

13.0 PUBLICATIONS ARISING FROM PROJECT

Johnson, S.E. and N. Berding. 2000. Using NIS for quality analysis of in-field and post-harvest crop fractions of sugarcane. Paper presented at the 9th Conference of the Australian Near Infra-red Users Group.

This paper was awarded the Lynsey Ann Welsh Memorial Award for Innovation in NIR Spectroscopy.

Johnson, S.E. and N. Berding. 2002. Near infra-red spectroscopic quality analysis of pre- and post-harvest sugarcane. Proc. Intern. Conf. Near Infra-red Spectro. 10: In press.

Berding, N., S.E. Johnson and A.P. Hurney. 2002. What happens from field to mill? Crop fractions and ccs considerations. Proc. Aust Soc. Sugar Cane Technol. 24: Submitted.

Appendix 1.

WHAT HAPPENS FROM FIELD TO MILL? CROP-FRACTION AND CCS CONSIDERATIONS.

By

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Abstract

Sugar content (CCS) of sugarcane grown on the northeast tropical coast has plummeted in the seasons from 1995 to 2000. Increased proportions of extraneous matter and sucker-culm billets have been blamed. The research reported here quantified the proportion and quality of crop fractions pre-and post-harvest. Pre- and post-harvest sub-samples were taken from 54 sites in the 1999 and 2000 harvest seasons. These were dissected into basic crop fractions and analysed for five quality components using conventional and near infra-red spectroscopic techniques. Each sampled site produced a discrete mill rake. Potential CCS (mature stalk or billet) was high in both years. Average, weighted mill-realised CCS compared poorly with pre-harvest potential CCS (75.9 and 85.1%, for 1999 and 2000, respectively) and post-harvest potential CCS (82.9 and 87%). In 1999 and 2000, mill-realised CCS was only marginally above the average, weighted, whole-crop, pre-harvest CCS, but was almost equal to the post-harvest CCS, in 1999, and just below in 2000. In 1999, harvesting did not reduce the proportion of extraneous matter from the in-field value (18.9%). In 2000, the proportion changed from 18.9 to 13.1%. Data presented severely questions the efficacy, or use, of current harvesting technology. Implications for harvesting and crop improvement are discussed.

KEYWORDS: Potential CCS, Mill-realised CCS, Crop-fraction Analyses, Crop-fraction CCS, Harvesting Technology Efficacy.

Introduction

The general decline in the commercial cane sugar (CCS) level in the Queensland sugarcane industry, evident since introduction of mechanical harvesting in the early 1970s, accelerated markedly in the section of the industry located on the tropical northeast coast of Queensland (16° 15′ to 18° 15′ S Lat.) from 1995 to 2000. Wilson and Leslie (1997) examined actual CCS changes in the Babinda, Mulgrave, and Tully mill areas from 1960 to 1995. The decline, adjusted for gains from crop improvement, at -22, -25, and -15%, respectively, for the three areas, was substantial. Increases in extraneous matter, suckering, lodging, and a possible small increase in water content of mature stalks were considered factors responsible.

Since Wilson and Leslie (1997), a number of studies have focused on facets of this decline. Singh *et al.* (1999, 2000) determined the impact of lodging by contrasting naturally lodged crops with scaffolded (non-lodged) crops in the wet and dry tropics. Prevention of lodging increased sugar yields from 15 to 35% in August/September harvests. Stalk death reduced dry matter and sucrose accumulation, and increased rat damage accompanied lodging. The impact of crop habit on crop quality was emphasised. The influence of cultivars and levels of nitrogen fertilisation on lodging and suckering were studied by Hurney and Berding (2000). All three cultivars studied lodged, but there was variation among them. Nitrogen applications had no influence on cane yield, CCS, lodging, or suckering in the plant trials reported. Lodging reduced CCS. All cultivars studied had a high propensity for suckering. Suckering inflated biomass yield by up to 26%, and reduced CCS by 1.0 unit for each 10% increase in sucker content. Harvesting as soon as possible after lodging was advocated as a management strategy to minimise economic loss. The importance of suckering on dilution of mature stalk CCS was addressed by Berding and Hurney (2000). Selection for low suckering propensity in an ideotypic plant model for the wet tropics was advocated, and methodology to achieve this was developed. All these studies have added to knowledge of the interactions of crop fractions and crop condition on productivity and profitability. These studies addressed specific aspects of the declining CCS problem. However, an holistic assessment was required to link all these facets and their interactions with realised CCS. Studies of the composition and quality of the pre-harvest crop, and how these influence post-harvest material, were required. The only assessment of this nature was the transitional studies conducted by Crook *et al.* (1999). They sampled 42 sites pre- and post-harvest in the Mulgrave mill area in a single year. In general, the industry has minimal knowledge and appreciation of the composition and quality of the material flow from field to mill. The research reported in this paper expands our understanding of this transitional material flow, assessed over two seasons, and provides bases for strategic planning and further research.

Materials and methods

Seventeen crop sites were sampled between 27 September and 22 November, 1999, and an additional 37 sites sampled between 4 July and 19 October, 2000. Most sites were located in the Mulgrave mill area (16/17 in 1999; 24/37 in 2000), with smaller numbers being sampled from other northern mill areas (Babinda: 1/17 in 1999 and 8/37 in 2000; Mossman: 1/37; South Johnstone: 1/37; and Tableland: 3/37). The sites essentially were chosen at random.

In-field, or pre-harvest, sampling consisted of collecting all material from a minimum of 10 random 2-m row quadrats from a section of the field large enough to supply a mill rake of 25 to 30 tonnes of harvested cane. This is the minimum required to generate an individual mill analysis, which was designated mill-realised CCS. All material in each quadrat was collected in a tarpaulin and transported to the laboratory. Sampling was done immediately before harvesting. Post-harvest, or in-bin, sampling consisted of removing a minimum of 10 x 40-L bins of material at random from the tops of the bins of cane harvested from the sampled field area. At the BSES Meringa laboratory, each sub-sample was sorted into the crop fractions shown in Figure 1. There were slight variations in classification between years. In 2000, unsound stalks were partitioned into sound and unsound portions, were weighed, and were analysed separately. In 2000, clinging trash (dead leaf) was not included in the extraneous matter fraction. This variation was implemented, as in 1999 the bulk of leaf in post-harvest crop sub-samples (Figure 1) was green, and not dead. All crop fractions were weighed. Further sub-sampling reduced the weight of a crop fraction from a sub-sample if this was excessive for analytical requirements. Conversely, a crop fraction was amalgamated over sub-samples until an acceptable weight (≈ 6 kg) resulted if weight of a crop fraction within a sub-sample was insufficient for analytical requirements.

All fractions were passed through a disintegrator (Codistil Dedini, Piracicaba, Brazil), with extraneous matter sub-samples being further processed through a Jeffco cutter grinder (Jeffress Engineering, Adelaide, Australia). All disintegrated material was mixed in a rotating drum mixer for 90 s. Each sub-sample was scanned in the large cassette module (Berding and Brotherton, 1999), an at-line sample presentation device, fibre-optically coupled to a Foss-NIRSystems (Silver Spring, MD, U.S.A.) model 6500 scanning monochromator via a Foss-NIRSystems remote reflectance probe. In 1999, 527 culm samples (sound and unsound stalks and billets) and 368 non-culm samples (suckers, extraneous matter, cabbage, and leaf) were scanned (800 - 2,200 nm), subjected to routine laboratory analyses (Brix in juice, fibre, moisture, pol. reading, and CCS calculated), and calibrations developed using procedures detailed by Berding and Brotherton (1999). In 2000, quality components for all samples (1,308 culm and 299 non-culm) were predicted using near infra-red spectroscopic calibrations developed in 1999. A random 10% of these samples also were subjected to full routine laboratory analyses. These were combined with the 1999 data set to improve the calibrations, which were then applied retrospectively to the 2000 spectral data (Johnson and Berding, 2002). Data available for each site were the mean crop-fraction weights and proportions, and weighted means for the five quality components determined (Brix, CCS, fibre, moisture, and pol. reading).

Results and Discussion

The samples covered a diverse array of crop situations. In 1999, the 17 sites covered 10 soil series, nine cultivars, and seven crop classes. In 2000, the 37 sites sampled 17 soil series, 11 cultivars, and nine crop classes. The data sets are considered to reflect amply the production environment encountered within the cane growing areas of north Queensland.

Mean values for quality components, over sub-samples and sites, displayed tremendous variation, reflecting the different crop fractions analysed (Table 1). Brix ranged from 8.3 (cabbage) to 22.5° (sound mature stalk), CCS from -0.8 (extraneous matter) to 16.5 (sound mature stalks), fibre from 10.9 (sucker culm) to 33.5% (extraneous matter), moisture from 56.7 (leaf) to 81.2% (sucker culm), and pol. reading from 11.4 (extraneous matter) to 88.9°Z (sound mature stalks). Relevant comparisons between the years reveal differences. These are not unexpected (Table 1).

Pre- and post-harvest crop fractions, and their respective CCS, for 1999 and 2000, are summarised in Figures 2 and 3. These also show the material transitions that occur between pre-harvest and post-harvest crop fractions, e.g., sound billets may originate from sound stalks, unsound stalks, or sucker culms. Unsound billets arise only from unsound stalks. Cabbage may come from either sucker culms, or from mature stalk top portions included in the pre-harvest extraneous matter. Similarly, post-harvest leaf arises only from leaf in the pre-harvest extraneous matter, which originated from either mature- or sucker-culm leaves (Figure 1). The data reported here quantified crop fractions present in pre- and post-harvest sub-samples, but took no account of material losses sustained in this transition. This loss is commonly accepted as 10% of the pre-harvest mature-stalk fraction, but may range up to 25% of this fraction (Ridge and Dick, 1988). Similar data are not available for other components.

The amount of clinging trash was not determined in 2000 (Figure 1). In retrospect, this decision was a mistake. Assuming the proportion of clinging trash was the same in both years the proportions of crop fractions determined in the pre-harvest analysis, without the inclusion of clinging trash, can be readjusted for inclusion of clinging trash, and these are shown in parentheses (Figure 3). The only error this induces is in the weighted CCS values calculated for the non-culm and total crop fractions, as the CCS used for extraneous matter was determined without the inclusion of clinging trash. This difference could be substantial as CCS for extraneous matter, which included clinging trash in 1999, was -0.8 vs the CCS for extraneous matter in 2000 of 0.2, which did not include clinging trash.

The proportion of mature stalks in the 2000 crop was higher than the 1999 crop (78 vs 70%). The proportion of unsound mature stalks was marginally higher in 1999 (17 vs 15%), and was primarily due to rat damage. There was a marked differential between the CCS of sound and unsound stalks in 1999 (16.5 vs 12.3; Figure 2) and in 2000 (15.5 vs 11.3; Figure 3). In 2000, the partition of unsound stalks showed there was twice the amount of sound stalk as unsound (10 vs 5%; Figure 3) in this fraction, and the CCS of this was nearly twice that of the unsound portions (13.7 vs 6.6; Figure 3), and 88% of sound-stalk CCS (15.5; Figure 3). Biotic stalk damage is an important factor in reducing CCS below that potentially available in sound mature stalks. This reduction was six percent in 1999 and five percent in 2000.

There was a marked contrast between the potential CCS of mature stalks and the remaining in-field crop fractions - sucker culms and extraneous matter: 15.5 vs 0.2 (1999, Figure 2) and 14.7 vs 0.4 (2000, Figure 3). If all in-field material was harvested and sent to the mill, the CCS would have been 11.1 and 11.6 in 1999 and 2000, respectively. This represents a 29 and 21% reduction of mature-stalk potential CCS for those years, respectively. This difference between years can be attributed to the eight percent lower sucker culm content in 2000.

Billets constituted 81 and 87% of the in-bin material in 1999 and 2000, respectively (Figures 2 and 3). Extraneous material (cabbage + leaf) was higher in 1999 (19%) than in 2000 (13%), and can be ascribed to more sprawling and lodging in that year. The differential between CCS of sound and unsound billets was marked, with the latter being 58 and 53% of the former in 1999 and 2000, respectively. Consequently, biotic damage resulted in a reduction of sound-billet CCS by 4.6 and 4.0%, respectively, in 1999 and 2000. There also was a marked contrast between the potential CCS available in the billet fraction and the remaining crop fractions (cabbage + leaf), 14.2 vs 1.4, (1999, Figure 2), and 14.4 vs 1.7, (2000 Figure 3). This proportion (18.9 and 13.1%, respectively) of low CCS material reduced potential billet CCS by 2.4 and 1.7 units in 1999 and 2000 (Figures 2 and 3).

The crucial comparisons are between the in-field and in-bin crop fraction analyses, and the most telling of these are overall averages. The average post-harvest CCS value obtained was close to the average mill-realised CCS value in each year (Figures 2 and 3). Unfortunately, the average mill-realised CCS in 1999 and 2000 was only marginally above the average whole-crop, in-field CCS (11.7 vs 11.1; Figure 2; 12.5 vs 11.6, Figure 3). The mill-realised CCS in both years compared poorly with the potential CCS, defined as that of the in-field mature stalks or in-bin billets. In 1999, the mill-realised value was 3.7 units lower than the in-field potential CCS (11.7 vs 15.5), and 2.4 units lower than the in-bin potential CCS (11.7 vs 14.2 g kg^{-1}). In 2000, the mill-realised value was 2.2 units lower than the in-field potential CCS (12.5 vs 14.7), and 1.9 units lower than the in-bin potential (12.5 vs 14.4). This highlights the negative impact of extraneous matter on potential CCS.

Two other aspects of these data require comment. In both years sound billet CCS was below that of sound mature-stalk CCS (14.9 vs 16.5 for 1999, Figure 2; and 15.0 vs 15.5 for 2000, Figure 3). The flow of sound billets from sucker culms must be largely responsible for this. The differential between sucker culm and mature stalk CCS was marked in both years (2.0 vs 16.5, for 1999, Figure 2; and 1.3 vs 15.5, for 2000, Figure 3). Inclusion of only a small proportion of sucker culm billets in mill-supply material will have a marked dilution effect. A rule of thumb proposed by Berding and Hurney (2000) and Hurney and Berding (2000) was that 10% of sucker culm billets in mill-supply material would drop CCS by one unit. Only a small proportion of sucker culm billets present in in-bin samples can be identified with certainty. In general, these data support the earlier data (Berding and Hurney, 2000) on the impact of sucker culms on whole-crop quality, and their advocacy for inclusion of suckering propensity as an essential selection trait for the wet tropics crop improvement.

A secondary, and most likely minor effect may arise from juice loss from billets by compression during the chopping action responsible for billet production. In 1999, in-bin leaf CCS was higher than the in-field extraneous-matter fraction (1.1 vs -0.8; Figure 2). This CCS increase can arise only from juice redistributed from mature stalks and sucker culms during the chopping phase of the harvesting process. Crook *et al.* (1999) obtained a similar result where in-bin "trash", which presumably was equivalent to the in-bin leaf crop fraction defined here, had a CCS of 2.4 relative to an average in-field "trash" CCS of 0.6. This change of 0.2 is comparable to the 1.9 we observed in 1999. Retention of this significant level of "lost" culm CCS, in 1999 equaling 12% of the potential (mature stalk) CCS, may be viewed positively. Recovering this from a crop fraction with high fibre, flavonoid, and phenolic content, and their impact on milling capacity and recovery, and sugar quality, must change this purported benefit from positive to strongly negative.

What are possible implications from the preliminary results presented here?

Without any doubt these data strongly question the efficiency and rationale of current harvesting technology. These data show that an expensive process (currently AUD 6.00 - 6.50 t^{-1}) does little to enrich CCS of mill-supply material above that present in the whole crop in field, and that harvesting, on average, only marginally reduces the extraneous-matter content of mill-supply cane below that present in field. Thus, mill-realised CCS values fall well below the potential CCS available in clean mature stalks. Millers receive the first four units of CCS for all tonnes milled. However, a significant proportion of the cane received is extraneous matter. This must increase milling costs because of increased processing difficulties and increased mechanical wear. More seriously, the whole system loses because of the increased milling season required to process a material stream inflated significantly with low-CCS, high-fibre crop fractions. Milling efficiency is reduced through increased backend losses from inflated fibre throughput and increased molasses production. The economic impacts of these considerations are real, but they are difficult to quantify. More readily quantifiable losses are evident for the growers. Little manipulation of the sugar payment formula is required to see the dramatic impact the differentials we have shown between mill-realised CCS and potential CCS have on grower return. Failure to rein in these differentials, if not minimise them, constitutes one of the major threats to farm viability in the wet tropics. What possible solutions can be explored to benefit the whole system?

1. Alternative harvesting technologies:

Recent ASSCT Proceedings contain numerous papers on harvester technology research. An assessment is necessary to determine whether these evolutionary innovations are relevant to the current technology. If so, are they being applied to the production environment, and to what effect? If implementation of this evolutionary approach is failing, can this be corrected in the short term? If not, then a revolutionary approach, i.e., a significant departure from current practice, may be warranted. There are several options.

1.1 The mildest option may be that the existing harvester technology, with all its flaws, is accepted and that new technology be introduced between the harvester and the milling train. This may take the form of in-field cleaning units, as operate successfully in some overseas industries. The net effect of this would be that extraneous-matter content would be reduced markedly before the cane supply was forwarded to the mill. The cost saving effected by this pre-processing would have to cover added processing costs.

1.2 A stronger option would be to accept the output delivered by current harvesting technology at the mill, but subject this to pre-cleaning prior to milling. Capital considerations for this may be less than that required for at-field pre-cleaning. There would be control advantages offered by high-tonnage and steady-stream processing rates. Return of the extraneous matter to the field, even with or without attempted value adding, would be an added cost, and may be an environmentally sensitive issue. Again, added costs to the whole system would have to be covered by cost efficiencies accruing from processing a better quality material stream.

1.3 Redesign the harvester to deliver a high-quality material stream for milling directly from the harvester. This would be expensive. Would minimised mature-stalk loss and extraneous matter content be guaranteed? Would the new harvester operate at a non-damaging speed for the crop, and could the harvester operate cost effectively? Could such a revolution be covered by the cost efficiencies accruing from such change?

1.4 An additional option would involve a radical harvester redesign, one that would perform minimal in-field cleaning and deliver a whole crop material stream to the mill. This involves a minimalist harvest concept, one simply capable of operating at an acceptable speed to cut and elevate the total crop under wet tropical conditions. Mill pre-cleaning would be an essential component of the processing equation. A conventional milling train would process a low extraneous-matter material stream. The separated extraneous-matter stream would be subjected to value adding. Shredding and diffusion to exploit the soluble carbohydrate content as well as use of the fibre content of the extracted stream would be required. Alternatively, the total material stream could be used directly for energy conversion. Reduced harvesting costs from a less capital intensive and simpler harvesting technology, together with processing and quality benefits from the material stream separation would be required to offset the increased cost of transporting the total crop biomass.

Options such as canvassed here are beyond the domain of agriculturalists. Some are under discussion and evaluation. This paper presents an objective data set that highlights the gross deficiencies currently present in sugarcane harvesting and presentation for processing, particularly in the wet tropics. These are in addition to significant crop losses that are acknowledged, and detailed, and have long been tolerated. If these data merely stimulate discussion and action on some options detailed above, or provoke generation of alternative views, that ultimately impinge on the economics of all involved in sugarcane production in the wet tropics, then our data gathering and analysis is justified.

2. Genetics and production:

2.1 The industry needs to accept that production is the summation of the environment (weather), genetics, and management. Although the genetics component is an important part of this equation, this element is subordinate to the other variables. Our substantial data set clearly demonstrates, that on average, mature-stalk, or potential, CCS was very acceptable in the two seasons sampled. This also was clearly demonstrated by Berding and Hurney (2000). The industry, in general, exhibited a ready and sustained propensity to attack the genetic component of the production equation as the underlying weakness in this crisis of declining CCS. The crisis was weather driven, marked wet episodes in the harvest periods from 1995 to 2000 largely being responsible for record, or near record, crops. Open-canopy crop situations prevailed, and a propensity for marked sucker development in a number of cultivars was revealed. Obviously, some current cultivars were not adapted to the changed climatic conditions. Early in this period, excessive use of nitrogenous fertiliser was a catalyst for these symptoms. This crisis triggered an examination of selection criteria that resulted in a re-emphasis of ideotype selection (erect habit and low suckering propensity), adjustments to clonal assessment procedures (Berding and Hurney, 2000), and initiation of research to better understand the environmental stimuli driving sucker culm development. Data for CCS from the Tableland, over many seasons, and the northern region in the 2001 season, in general, clearly substantiate the general soundness of the genetic element of the production equation.

2.2 Selection pressure for potential CCS cannot be relaxed even though we have shown potential CCS, on average, to be very acceptable. Cane productivity in 2000 and 2001 has been at worrying levels, and care is required to ensure that management and crop improvement activities do not lose focus on sucrose production, the product of CCS and cane yield, as the primary goal, by being preoccupied with CCS.

2.3 The data presented here provide a timely warning on the importance of biotic damage as a negative effect in the production equation. This was evident in both in-field and in-bin assessments. Rat damage was dominant in the 1999 sampling and important in 2000. Management, rather than crop improvement activities must provide the primary defense against this. The re-emphasis on crop habit, hopefully will lessen crop damage from sprawling and lodging, and so minimise the CCS losses that follow from fungal and bacterial infection. In all the sampling undertaken, weevil borer was of minor consequence. Genetic resistance to this pest is readily available, and a range of resistance is available in current cultivars.

Acknowledgements

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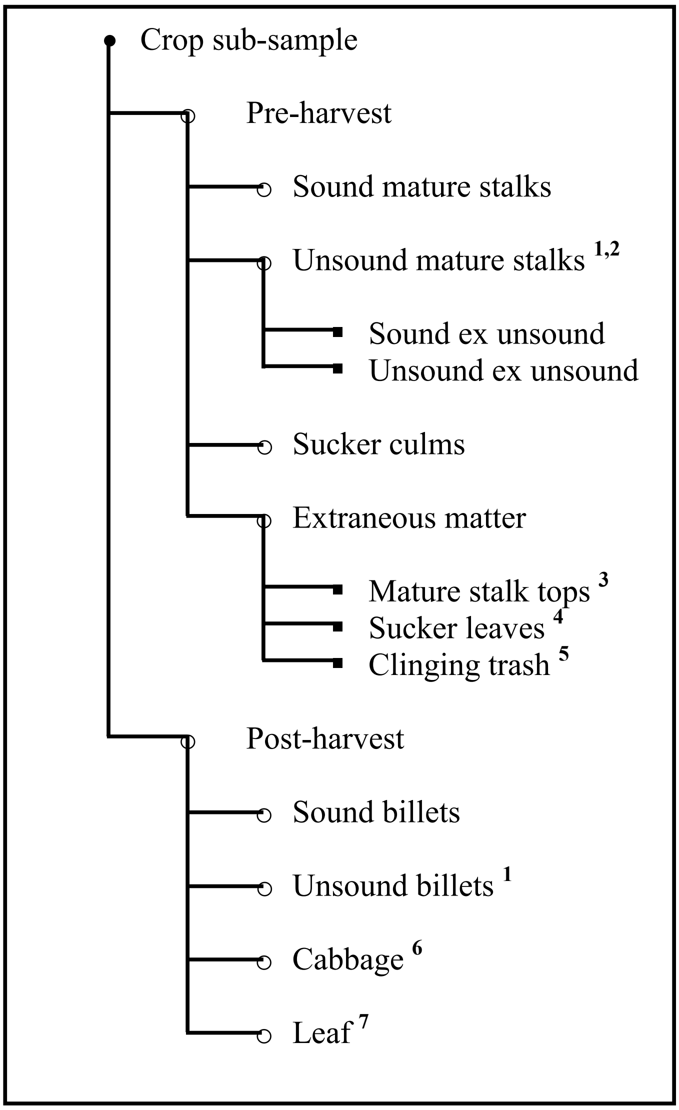
Fig. 1.— Classification strategies adopted for in-field, pre-harvest and in-bin, post-harvest sampling from 54 sites during the 1999 and 2000 harvest seasons.



[1] Classified on basis of biotic damage only, i.e., borer, rat, or rot.

[2] In 2000, unsound mature stalks were partitioned into sound and unsound portions and analysed separately.

[3] Mature stalk tops, or cabbage, was the portion of the stalk above the node subtending the last clasping leaf.

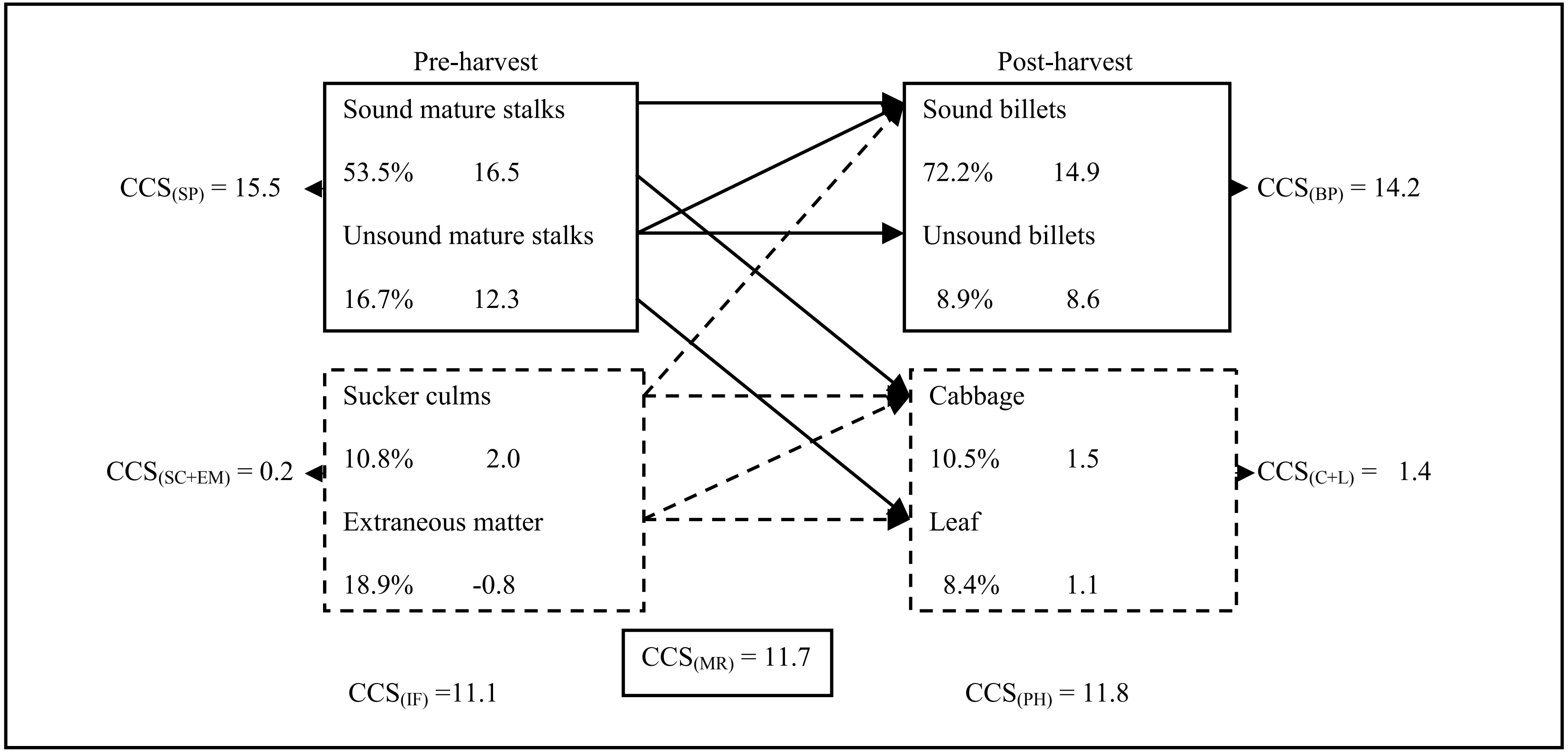
[4] The sucker culm leaf mass was severed from the culm portion at the last exposed dewlap.

[5] Clinging trash was leaf material from below the last clasping leaf that was present in the sub-sample and contained in the tarpaulin. This crop fraction was not determined, or analysed in 2000.

[6] Any billet displaying leaf furl structure on either cut surface.

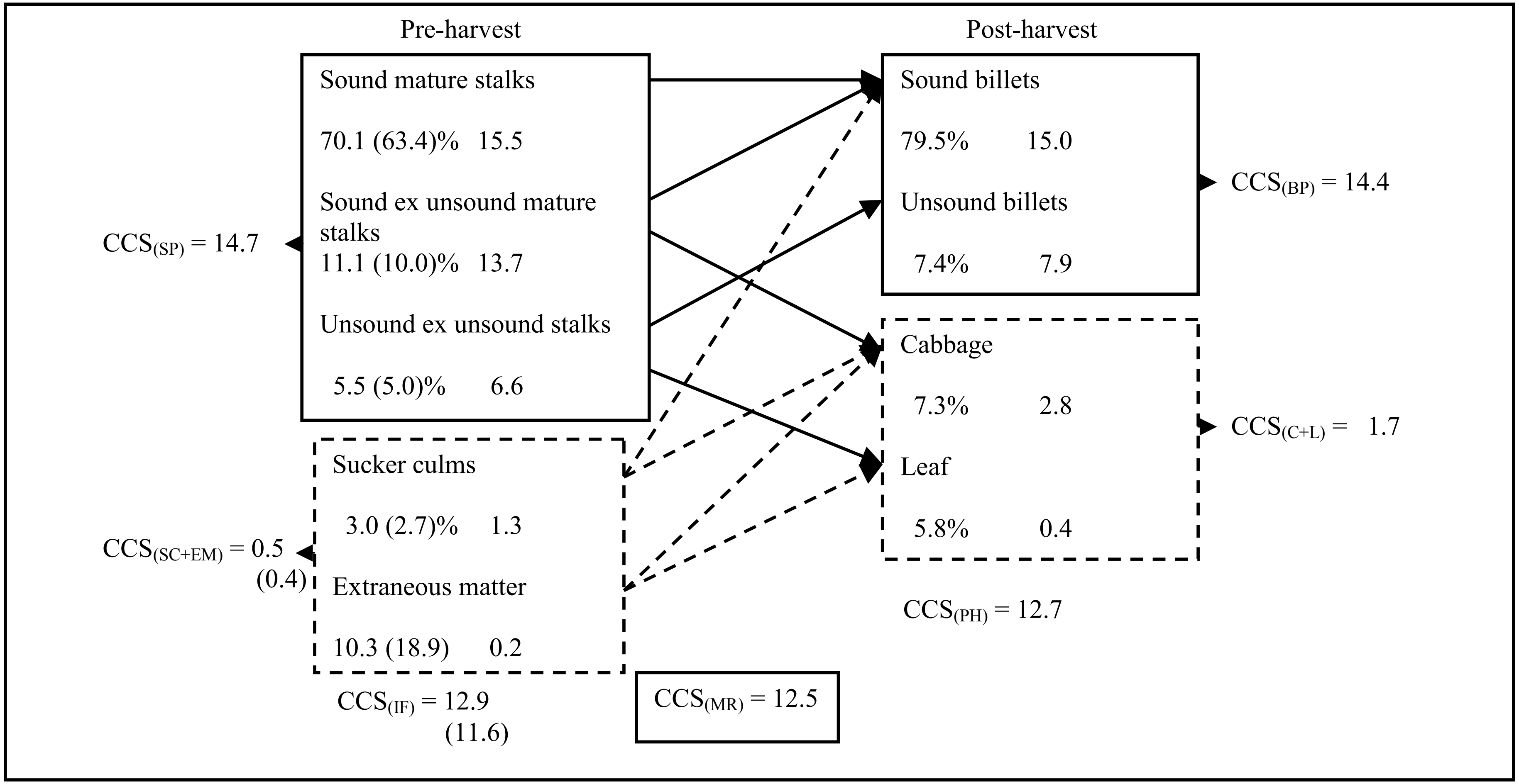
[7] Consisted of any leaf lamina material, and loose soil left after all fractions of the sub-sample were removed from the 40-L bin.

Fig. 2.— Summary of in-field, pre-harvest and in-bin, post-harvest, crop fractions and their CCS values, weighted average CCS of relevant aggregations of these fractions[1], and the average mill-realised CCS of 17 sites sampled during the 1999 harvest season.



[1] $CCS_{(BP)}$ = billet potential; $CCS_{(C+L)}$ = cabbage and leaf; $CCS_{(IF)}$ = in-field; $CCS_{(MR)}$ = mill-realised; $CCS_{(PH)}$ = post-harvest; $CCS_{(SP)}$ = mature stalk potential; $CCS_{(SC+EM)}$ = sucker culm and extraneous.

Fig. 3.— Summary of in-field, pre-harvest[1] and in-bin, post-harvest crop fractions and their CCS values, weighted average CCS of relevant aggregations of these fractions[2], and the average mill-realised CCS of 37 sites sampled during the 2000 harvest season.



[1] Values in parentheses are adjusted proportions assuming the inclusion of the same amount of clinging leaf in extraneous matter as 1999.

[2] CCS$_{(BP)}$ = billet potential; CCS$_{(C+L)}$ = cabbage and leaf; CCS$_{(IF)}$ = in-field; CCS$_{(MR)}$ = mill-realised; CCS$_{(PH)}$ = post-harvest; CCS$_{(SP)}$ = mature stalk potential; CCS$_{(SC+EM)}$ = sucker culm and extraneous.

Table 1.— Mean values for five quality components for each of four in-field and four post-harvest crop fractions sampled over 17 sites in 1999, and for each of five in-field and four post-harvest crop fractions sampled across 37 sites in 2000.

Year	Sample	Fraction[1]	No.[2]	Component				
				Brix (°)	CCS	Fibre (%)	Moisture (%)	Pol. reading (°Z)
1999	In-field	SS	180	22.5	16.5	13.9	67.0	88.9
		US	131	19.2	12.3	13.5	70.1	68.8
		SC	111	9.5	2.0	10.9	81.2	19.3
		EM	179	10.9	-0.8	33.5	58.8	11.4
	Post-harvest	SB	180	20.9	14.9	13.6	68.3	80.6
		UB	36	15.6	8.6	15.3	71.2	50.9
		C	43	8.3	1.5	13.8	79.4	16.2
		L	35	12.6	1.1	32.3	56.7	22.1
2000	In-field	SS	373	21.4	15.5	12.8	68.8	83.4
		S-US	166	19.7	13.7	11.7	71.2	73.6
		U-US	89	13.6	6.6	13.4	74.5	40.5
		SC	58	8.5	1.3	11.7	81.2	15.7
		EM	362	9.5	0.2	24.9	68.1	13.5
	Post-harvest	SB	407	20.7	15.0	12.7	69.4	80.2
		UB	70	14.4	7.9	13.2	74.0	46.3
		C	82	9.6	2.8	14.6	77.4	21.9
		L	103	13.8	0.4	39.7	50.0	18.8

[1] SS = sound mature stalk; US = unsound mature stalk; SC = sucker culm; EM = extraneous matter; SB = sound billet; UB = unsound billet; C = cabbage, L = leaf; S-US = sound fraction ex unsound mature stalk; and U-US = unsound fraction ex unsound mature stalk.

[2] Number of row quadrat (in-field) or bin (post-harvest) sub-samples analysed for each crop fraction.

Appendix 2.

SUCROSE REDISTRIBUTION FROM FIELD TO FACTORY.

Dr Nils BERDING,
Principal Scientist,
BSES Meringa.

Introduction:

In the period from 1990 to 2000, CCS in the northern region decreased markedly, from a peak of almost 14 in 1991 to a low of just below 11 in 1998. The decline rate was greater than the steady decline seen since the introduction of mechanical harvesting in the mid 1970's. Yet in the seven central years of this period (1992 – 1998), cane yield exceeded 85 tonnes per hectare. This period of generally high tonnage saw an increase in frequency of sprawled and open crops, but more importantly saw harvest periods from 1995 to 1999 characterised with marked wet episodes. The impact of these is seen vividly in the seasonal CCS plots for 1995 and 1996, contrasted with that for 1992, a year of minimal harvest-season rainfall and lost harvest days.

We have proposed that the reason for this accelerated drop in CCS from 1995 to 1999 was driven mainly by climatic change. Large crops with open canopy conditions predominated, stimulated by the passage of some five cyclones in three of these years. The occurrence of marked wet episodes in the harvest, and excessive nitrogen use early in the period, resulted in increasing extraneous matter content, particularly arising from sucker culms. Admittedly, a number of cultivars displayed a high suckering propensity, particularly when stimulated by high harvest-season moisture and residual nitrogenous fertilizer. A vital clue to support our proposal is an examination of Mossman Mill data contrasting their Tableland production region with their two coastal production regions. The genetics - the cultivars being used – differed little but the harvest-season rainfall that plagued their coastal production regions, as this did for all coastal, northern-region production, resulted in marked differences between coastal and Tableland CCS values.

The objective of my presentation today is to substantiate our hypothesis using data collected in the 1999 and 2000 harvest seasons. These highlight the high CCS levels present in mature stalks and the dilution of this that occurs through inclusion of high levels of extraneous matter. This results from ineffective use of current harvesting technology, or ineffectual harvesting technology, or a combination of both.

Data collection:

Crop quality:

Our approach was to sample at random fields being harvested during the 1999 and 2000 seasons. Most sites were located in the Mulgrave Mill area, but because of the diversity of soil series and crop classes sampled, are considered representative of the northern production environment. Seventeen sites were sampled in 1999 and 37 sites in the 2000 season. At each site, a minimum of 10 random, 2-m row sections of crop was cut from a field section located next to an operating harvester. All material from each sample was wrapped into a tarpaulin and removed to the Meringa juice laboratory for dissection into crop fractions – sound and unsound mature stalks, sucker culms, and extraneous matter, this consisting of mature stalk tops, sucker leaves, and clinging trash. The sampled field section was sent to the mill as an independent rake. A minimum of 10 x 40-L bins of material was sampled from the tops of the bins in this rake before consignment to the mill. Each of these was sorted into the crop fractions sound and unsound billets, cabbage, and leaf, any dirt in the sample being included with the latter fraction. All crop fractions were weighed and analyzed for five standard crop quality components, including CCS.

Crop habit:

In 2000, the effect of pre-season crop habit on CCS accumulation was studied by sampling 14 diverse sites in the Mulgrave Mill area on three occasion – March – April, April – May, and May – June. The sites displayed variation for stalk habit – erect or lodged. Samples of both were sorted into sound and unsound stalks, and full analyses done of physical fractions and cane quality components.

Results:

Crop quality:

Sound mature stalks constituted the major in-field crop fraction in either year, (Table 1). Unsound mature stalks, those suffering biotic damage only, i.e., from borers, rats, and rots, formed a fraction that approximated about one quarter of the sound stalks component (Table 1). The sucker culm proportion in 1999 was over three times that seen in 2000. Extraneous matter was almost 19% in each year.

Table 1. In-field crop fractions – percent of crop.

Crop fraction	1999	2000
Mature stalks – sound	53.5	63.4
Mature stalks – unsound	16.7	15.0
Sucker culms	10.8	2.7
Extraneous matter	18.9	18.9

Sound mature stalk CCS was acceptable by any measure in both years (Table 2). Stalk unsoundness was costly in both years. A reduction of 4.2 units in both years suggests management and selection pressure are necessary to reinforce and improve resistance against biotic damage. The detrimental effect of sucker culms and extraneous matter on realized CCS is clearly demonstrated by the CCS values shown by these components. This is further reinforced when weighted by the proportions of these fractions (Table 1).

Table 2. In-field crop fractions - CCS.

Crop fraction	1999	2000
Mature stalks – sound	16.5	15.5
Mature stalks – unsound	12.3	11.3
Sucker culms	2.0	1.3
Extraneous matter	–0.8	0.2

Analysis of the harvested material stream showed that the proportion that sound billets constituted was higher than the proportion contributed by sound stalks pre-harvest (Table 3). This is not surprising given that sound billets from unsound stalks, and billets from sucker culms, can add to this post-harvest fraction. Concomitantly, the proportion contributed by unsound billets decreased, but this is expected.

Table 3. In-bin crop fractions – percent of harvested material.

Crop fraction	1999	2000
Billets – sound	72.2	79.5
Billets – unsound	8.9	7.4
Cabbage	10.5	7.3
Leaf	8.4	5.8

Sound-billet CCS (Table 4) was lower than sound-stalk CCS (Table 2) in both years. The reduction of 1.6 in 1999 was three times the reduction in 2000. This agrees with the fact that the sucker culms contributed three times the crop proportion in 1999 than in 2000. The differential between extraneous matter (cabbage + leaf) and sound billet in CCS is marked (Table 4), and when weighted by the proportion of extraneous matter in harvested cane (Table 3), its impact upon in-bin CCS is emphasised.

Table 4. In-bin crop fractions – CCS.

Crop fraction	1999	2000
Billets – sound	14.9	15.0
Billets – unsound	8.6	7.9
Cabbage	1.5	2.8
Leaf	1.1	0.4

Table 5. Weighted, aggregated CCS values.

Basis	Grouping	1999	2000
In-field	Mature stalk	15.5	14.7
	Whole-crop	11.1	11.6
In-bin	Billet	14.2	14.4
	Whole bin	11.8	12.7
Mill	Realized	11.7	12.5

We can now use these basic data of composition and proportion of the main crop fractions pre- and post-harvest to develop an objective picture of declining CCS in the northern region. One can appreciate that the differential between the component of greatest desirability for milling – mature stalks – and the whole crop in the field was marked, 4.4 and 3.1 in 1999 and 2000, respectively (Table 5). This differential should be preserved if the harvesting process is effective. The differential between mature-stalk CCS and in-bin billet CCS is less, and has already been considered. The stunning contrast is that between the whole-bin and whole-crop CCS – +0.7 and +1.1, respectively. These differentials are only a fraction of those we saw between mature-stalk and whole-crop CCS. These differentials are the outcome of a sophisticated and expensive harvesting process. On average, the difference between the weighted whole-bin CCS we determined and the mill-realized CCS was small.

What do these data mean in terms of gross values for the whole crop and sectional interests? These are presented in Table 6, but I wish to highlight the assumptions made in calculating these. The average yields for the northern region have been used for the respective years – 77 and 64 tonnes cane per hectare. I have assumed 85% of the in-field crop is recovered by harvesting when using in-bin tonnages to compute values. Total gross value was computed assuming 95% of determined CCS was recovered as sugar. Value to the miller was obtained by subtracting gross value to the grower and harvester from the total value.

Table 6. Cane yield and CCS for aggregate crop groupings and total and sectional incomes ($ per hectare) for these for the 1999 and 2000 seasons.

Year	Grouping	TCH[1]	CCS	Total[3]	Grower[4]	Miller[5]	Harvester[6]
1999	Stalks	54	15.5	2,385	1,357	678	351
	Whole-crop	77	11.1	2,436	1,020	915	501
	Billets	53.1[2]	14.2	2,149	1,148	656	345
	Whole-bin	65.5[2]	11.8	2,203	992	785	426
	Mill-realized	65.5[2]	11.7	2,184	974	785	426
2000	Stalks	50.2	14.7	2,103	1,153	624	326
	Whole-crop	64	11.6	2,116	934	766	416
	Billets	47.3[2]	14.4	1,942	1,048	586	307
	Whole-bin	54.4[2]	12.7	1,969	956	660	354
	Mill-realized	54.4[2]	12.5	1938	926	658	354

[1] Based on mean yields of 77 and 64 TCH for the northern region in 1999 and 2000, respectively.

[2] Calculated on 85% of the in-field crop being delivered to the bin.

[3] $ = 0.95 * TCH * (CCS / 100) * 300.

[4] $ = TCH * [0.009 * 300 x (CCS – 4.0) + 0.578 – 6.50].

[5] $ = Total $ – [Grower $ + Harvester $].

[6] $ = TCH * 6.50.

A whole-crop consideration produced the highest value in both years, but this value was only marginally ahead of gross total value from the mature-stalk or billets grouping. One can only speculate as to net differences. A whole crop approach would be cheaper in terms of harvesting, but down-stream costs – increased transport, mill pre-cleaning, and environmental considerations – may not be off set by this and any value adding that can be effected to the extraneous matter stream. This approach would have to be balanced against resulting sugar quality. Clearly, delivering the highest CCS material possible – mature stalks only, or billets only, rewards growers. Any dilution with extraneous matter reduces these values. Millers benefit from any material grouping that includes extraneous material – whole-crop or whole-bin – but this apparent benefit, which is tonnage driven, may be discounted by increased processing costs and by sugar quality considerations. Likewise, the value for the harvesting sector also is tonnage driven.

This conflict between quality- and quantity-driven outcomes is not a revelation arising from these data. This merely requires resolution. If crop quality can be sacrificed and value maximized, then production could be simplified. If crop quality is essential to maximizing value, then presumably a whole-of-industry position is required to achieve this, and resolve these all-to-apparent conflict drivers.

Crop habit:

The CCS values obtained in this study appear low because they were determined pre-season. However, sucrose accumulation was good, with mean values of 7.3, 10.0, and 12.1 being recorded over the three samplings. The impact of crop habit and condition are clearly shown by the results in Table 7. Lodged stalks had 93% of the erect-stalk CCS. Unsoundness reduced CCS to 88% of the sound-stalk value. In combination, they reduced CCS to 75% of that found in erect, sound stalks. Their combination was greater than the estimates of lodging and unsoundness alone predicted. A loss of 25% of pre-season CCS is catastrophic. While weather can always override best practice management inputs, focusing these to maintain an erect crop is obviously wise. Elements such as selection of the most appropriate cultivar for a particular environment, use of an optimum fertilizer regime to maximize sucrose yield, and application of appropriate cultural practices to facilitate erectness must be considered.

Table 7. Pre-harvest CCS for four classifications of stalks sampled from 14 sites on three occasions (March- April, April – May, and May – June) in the Mulgrave Mill area in 2000. Values in parentheses are relative to the erect, sound class.

Stalk habit	Stalk condition	
	Sound	Unsound
Erect	11.0 (100)	9.7 (88)
Lodged	10.2 (93)	8.3 (75)

Conclusions:

I have to assume crop quality is important for grower, and therefore industry viability. What do these data allow us to conclude in this regard?

1. Mature-stalk CCS is acceptable, and this is not the reason for the observed CCS decline in the northern region.
2. Dilution of mature-stalk CCS by either sucker culms or traditional extraneous matter – non-stalk material – is responsible for the reduction of CCS.
3. Available harvesting technology must be used appropriately. This means rates of 80 rather than 180 tonnes per hour. If this is unacceptable, then the approach to harvesting, and perhaps processing the crop must undergo a revolution.
4. Harvesting must be aided by an appropriate crop presentation. Management must be focused on presentation of an erect crop at harvest. Crop improvement can assist in this, but best practice management inputs to this are vital.
5. Some cultivars have shown a high suckering propensity under the wet harvest seasons prevailing in this period. These are being phased out, and adjustments to the crop improvement program have been made.

6. Biotic stalk damage, particularly from rats and rots associated with lodging, is an important consideration, and must be addressed through management. Rat control and correct cultivar and fertilizer use are vital elements of this.
7. The two years these data sampled had the lowest cane yields since the 1990 and 1991 seasons. While the focus, if not preoccupation, in the current crisis has been CCS cane tonnage is vital to farm and industry viability. Crop management must focus on maximizing sugar yield by optimizing both cane quality and yield.

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