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Review of current & future investments in high density planting for the Sugar Research & Development Corporation

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Review
of
Current & Future Investments
in
High Density Planting

for the

Sugar Research & Development Corporation

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1. SUMMARY

Project Background
1. The BSES is presently confronting the issue of how to facilitate the adoption of HDP as a commercially productive system. Relevant preliminary project proposals have been submitted for SRDC funding. This consultancy assesses these proposals in the light of identified uncertainties and views developed on the best strategy for implementation.

2. A review of international literature established a general positive yield response for close rows over 1.4-1.8m single row which are clearly a suboptimal compromise for yields of biomass and millable cane. No change in CCS is associated with the close row response.

3. This knowledge has been available since the 1960’s in the USA, Australia and South Africa. However the industry has been unable to successfully exploit the potential for higher yields due to its failure to mechanize close row, husbandry and harvesting operations.

Exclusion of Dual Row Responses from this Report
4. This report focuses on assessing the potential industry benefits from the adoption of close row systems. Dual rows have been specifically excluded. Trial responses (TCH) for dual rows, relative to 1.5m single rows (29 trials) ranged from -35% to +24% about an arithmetic mean of 10.9% and this is below the average difference required for statistical significance. Cane growers should operate on the assumption of a 10% response. The net benefit after costs at this response level will be marginal.

Evaluation of Trial Data
5. Stalk count, TCH, CCS and TSH data were provided for 27 replicated experiments or strip trials. Various sets of response data were examined to determine the effects of ratooning, and latitude. Observations were also made on time of planting, crop age, prior crop/fallow history, N fertiliser, and irrigation treatment and for plant and first ratoon cane.

6. A detailed examination of these data demonstrated consistent responses to 0.5m rows relative to 1.5m rows for a wide range of varieties/clones, locations, latitudes, planting times, crop ages, water and fertiliser regimes.

7. A number of uncertainties are highlighted:
   □ the responses which occurred in plant cane and extended into 1R without reduction, have not been adequately demonstrated beyond 1R cane for 3R and 4R cane;
   □ examination of the effect of latitude for northern vs southern latitudes showed no lessening of the response, which might result from “catch up” by 1.5m single rows, associated with warmer winter environments. Nevertheless the data represent very restricted experience in the sense of latitude vs year sampling – more experience is desirable for plant and ratoon performance;
   □ whilst the response data showed no obvious effect of planting time or harvested crop age, the trials comprised a high proportion of late harvested, spring and early summer planted crops. It would be opportune to extend experience with autumn plantings, greater crop ages and earlier times of ratooning;
   □ well documented negative responses due to water stress and other factors have not, as yet been encountered and measured in BSES trials;
   □ there is some evidence that part of the close row response may be associated with 1.5m comparisons that have been slower attaining canopy closure than should be achievable for 1.5m cane. This concern would be allayed by close row responses relative to high yielding 1.5m controls.
8. The present evidence therefore has sufficient uncertainty in the range of conditions experienced to make it premature to move directly into commercialisation on the assumption that the magnitude and frequency of responses of the 27 trials conducted to date, will be easily translatable.

9. An intermediary phase of site replicated strip trials (SRST's) is consequently included in the recommendations below, to cover the areas of expressed uncertainty and allow a suitable period for the commercialisation of associated prototype machinery.

10. The high density response seems to be dominantly phenotypic. Data presently available do not establish the existence or scale of genotypic interaction with row spacing across cane classes and across soil and climatic conditions.

**Industry Benefits**

11. A survey of milling groups and Queensland Sugar Corporation was conducted to assess attitudes to expansion in the event of significant crop increases through the wide spread adoption of close row systems.

- The QSC forecasts raw sugar production increasing to 6.8million tonnes by 2007, up from ca 5.5 million in 1999. The estimates, based on an industry survey, reflect the anticipated impact of vertical expansion and productivity gains. No allowance is made for the gains from close row planting. QSC is evaluating a $50-100m investment in additional storage. HDP systems may influence its investment decision.

- CSR and Mackay Sugar will require investment capital to accommodate additional cane. Both groups expressed an unwillingness to invest capital under the present cane payment system, which does not deliver an acceptable return on investment.

- Bundaberg Sugar has ca 900,000 tonne of spare capacity across its mills. 67% of this is in the Bundaberg region where it grows 500,000 tc/yr on its own farms. It therefore represents a potential conduit for implementing HDP systems. Bundaberg Sugar raised doubts however, over HDP yield claims and switching costs.

- Sugar North is not capital-limited and will invest if HDP commercialisation eventuates.

- Both Proserpine and ISIS Mills have spare capacity, resulting from capital expansion, continuous operation and season length extension. Additional cane is required – there is a keen interest in dual and close rows.

- Maryborough Mill is similarly budgeting additional throughput based on limited capital expansion, continuous operation and season length extension. The impact of close rows will require major CAPEX, which is estimated at $300K/tec/hr, with secondhand equipment. A sugar price of $340-350/tonne is required to deliver a hurdle rate of 10%.

- Rocky Point Sugar Mill is land-locked and dependent on dual row and close row systems to deliver the 400,000 tc/yr, vital to its survival.

- NSW Sugar Milling Coop pointed to specific regional issues associated with a 2-year cropping cycle. Capital expansion is not a limiting factor.

12. The total harvester fleet in Australia is 1200 machines. Austoft has 80% market share and average sales of new harvesters of $32m pa (80 machines per year at $400K each). Austoft suggested that sales may escalate 20% with the gradual adoption of close row systems ie an incremental $6.4m turnover. Industry sources suggest that Austoft would recoup its $2-3m in development costs via gross marginal contribution on year1 sales.

13. Calculations for incremental gross marginal contribution were performed to determine the benefit to growers over a range of close row yield responses and sugar prices. A 25-30 % yield response over standard rows is required to cover additional input costs and provide an acceptable return to growers. Yield responses of 40-60% provide an above average return.

14. Estimates of return on capital for expansion of milling capacity demonstrate that acceptable returns can be achieved, only if miller and grower benefits are combined. The financials are based on capital investment of $400,000/tec/hr at $335/tonne sugar.
2. RECOMMENDATIONS

Strategic Direction – Recommendations for the Implementation Phase

Each of the PPP’s were evaluated to determine their respective contributions to the key objectives of:
- addressing the outstanding areas of uncertainty identified above;
- developing and implementing the best strategy to facilitate industry adoption.

The summary recommendations for the PPP’s follow, in rank order from lowest to highest priority:

1. **P035e “NQ Productivity-HDP an opportunity for improving N Qld profitability”**
   In the early stages of this review, BSES agreed that P035e was peripheral to its mainstream HDP objectives and consequently should be deleted for funding considerations.

2. **P022de “HDP- Breeding and selection for close rows”**
   Initiating a breeding program is premature at this stage, given that the potential of available commercial varieties has not been thoroughly determined. Furthermore, clonal experiments have failed to demonstrate the reproducible influences of genotype in responsiveness to close rows.

3. **P039e “HDP-Effective furrow irrigation of high density planted sugarcane”**
   Adoption of HDP systems in areas such as the Burdekin is contingent upon the successful development of furrow irrigation capable of servicing close rows at wider centres.
   It is most likely that suitable systems can be adapted from close row practices in other industries using narrow cropping. A travel grant is recommended to support an industry review by a suitably experienced individual.

4. **P066e “HDP-Economical insecticide rates for control of cane grubs in high density plantings”**
   Direct application of present lineal row metre rates of suSCon to close row systems results in an illegal per hectare application rate, under present regulations. Furthermore the cost impost would be unacceptable to growers.
   Extensive trialing is required for a spectrum of pesticides and target species. There are also application issues to be factored into precision planter design.
   The project is important and should proceed with minor modifications; the inherently long lead time (3years+) for collecting efficacy data for regulatory purposes is a significant consideration.

5. **P0356e & P061c-Establishing a regional unit to support large scale testing of HDP & Facilitating adoption of high density farming systems for sugarcane”**
   The two proposals in concert are the crux of BSES’s implementation strategy and as such assume the highest priority for funding. A number of significant modifications are required:
   - Commercial scale non-replicated trials should be replaced with mechanically harvested SRST’s to test the outstanding areas of uncertainty ie autumn planting, crop age, time to ratooning, water stress, suckering and lodging, close row response over high yielding controls and issues associated with 2 year crop cycles relevant to Harwood.
   - The SRST’s should test commercial varieties of cane across a number of regions.
   - The development of successful mechanization systems is crucial to industry adoption.
This 3 - 5 year SRST program will see the transition of current prototype harvesting and planting equipment to full commercial design and manufacture.

- There is considerable concern over the linkage between BSES's present prototype harvester design and the commercial version ultimately developed for the marketplace.
- Discussions with Austoft revealed a different attitude to commercialisation. Austoft's optimal outcome is a flexible harvester design, capable of harvesting single, dual and close rows. This approach reduces business risk and also deals with market concerns regarding the transition phase from single to close rows, which may force growers to operate parallel systems for up to 5 years.
- BSES's research however, raises concerns over Austoft's present harvester design, in relation to field losses of CCS which, are likely to be exacerbated at the higher pour rates encountered in close row harvesting.
- SRDC is positioned to play a vital role in resolving this crucial issue. P036e includes a capital allowance of $944K for prototype machinery for field trials. It is essential that Austoft involvement in commercial design escalates to ensure the most efficient use of capital.

This might be best facilitated through a formal agreement between SRDC, Austoft and other relevant parties to commercialise close row harvester design.

BSES has an essential role in ensuring that the crop/machine interaction is recognised and factored into Austoft's design. It also represents a golden opportunity to deal with fundamental issues of harvester design and performance, which presently account for significant, measurable costs to the industry.

6. These recommendations take a positive line in maintaining the developmental momentum of high density technology. The review has however, identified a number of areas where further research, parallel to the proposed development phase should be conducted in the interests of sound commercial husbandry.

The areas include:

- thorough analysis of BSES's existing data;
- full characterisation of the density*rectangularity response surface for cane;
- specific experimentation on planting rates;
- at least one experiment using fumigation to measure the close row response at ceiling crop growth rates.
3. INTRODUCTION

3.1 Project Background, Objectives & Methodology

The BSES is actively promoting high density planting to growers and is presently confronting the issue of how to facilitate the adoption of HDP as a commercially productive system. To this end, a number of preliminary project proposals have been submitted for SRDC funding.

SRDC has commissioned this consultancy to review BSES’s work in HDP to assess the likelihood of industry adoption, threats to successful adoption, ensuring benefits to industry in the event of successful adoption and the relevance of the submitted proposals, in the light of these findings.

3.2 Supporting Reviews – Literature & Analytical, J.K. Leslie

Whilst this consultancy report is deliberately brief, it does not mean to understate the complexity of the experimental and analytical data which underpin the conclusions and recommendations, contained herein.

Two supporting reviews have been written by J. K. Leslie. The first is a comprehensive literature review on high density planting studies from 1965 to the present, with particular focus on examining the responses in physiological terms of plant competition influenced by density/rectangularity interactions. This interaction appears to have been largely ignored in the interpretation of close row responses in both research and extension phases. The review also describes and acknowledges the collaborative work on crop modelling performed with R. Muchow and B. A. Keating from CSIRO.

The second work by J.K. Leslie, details his assessments of data provided by BSES Bundaberg which have in general confirmed the potential benefit of high density planting. In the case of clonal experiments, his analyses oppose the conclusions posited by BSES, that they evidence useful genetic variation in responsiveness to high density culture.

The full reviews have been transmitted to the SRDC.

Similarly, the financial analyses contained herein, represent summaries of selected scenarios, considered germane to the primary objectives of the consultancy.

3.3 Louisiana’s Experiences

The general theory of plant competition is that both density (plants per square metre) and rectangularity (ratio of interrow distance to intrarow distance between plants) exert separate effects on plant growth. A schematic representation of this interaction is shown in Appendix1 (Figure1). In trials with sugar cane these effects are mostly confounded. Interpretations are complicated by the difficulty of associating stalks with individual plants.

Irvine and Benda (1980) is a definitive paper which examines the effects of plant density at equidistant plant spacing (rectangularity = square = 1:1). These and other results indicate that substantial changes in tonnes of cane per hectare (TCH) may occur with shifts from wide rows to narrow rows and that those changes result from interacting influences of plant density and plant rectangularity.

The literature on close row trials in Louisiana, describes a range of hand and mechanically harvested experiments which demonstrated:
- positive plant cane yield responses to changes in density and/or rectangularity which did not always persist for 1R/2R yields;

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1 Data from HDP trials was made freely available by BSES during our review in Bundaberg (Dec 98).
3 Equidistant rectangularity = square = 1:1
Recent conversation (Dec 1998) with C.A. Richards from the American Sugar Cane League of USA, Louisiana confirmed that the theory of density and rectangularity effects on biomass production remains sound for sugar cane. They have not however been able to make high density work and Louisiana’s industry remains on 6 foot bedded rows. The following reasons were cited for commercial failure:

- Louisiana has a combination of problems due to high watertables, shallow root systems and predisposition to root lodging and stool exposure to frost damage. These difficulties are exacerbated in close rows.
- Harvesting is often in wet conditions, resulting in extreme stool damage at high density.
- High density cane established “on-the-flat” lodges more than cane on traditional beds.
- Recent commercialisation of a new variety has generated 20-30% higher yields, without the need for radical changes in mechanization systems.

There is little interest in Louisiana to commercialise high density systems due to this range of obstacles and the prohibitive need for total redesign of planters, harvesters and haulout machinery to retain the benefits into ratoons.

### 3.4 General Observations and Questions

- J.K. Leslie’s review, extends to published results of trials in Queensland, South Africa and India. In all countries, responses were seen to spatial changes that reduced rectangularity and at the same time increased density. There is little evidence that smaller or nil responses are effected by density changes within constant interrow spacings.
- Cane planted in conventional 1.4m-1.8m rows at 8-10 stalks/m² is suboptimal for biomass accumulation and for yields of millable cane.
- Of relevance to Queensland, early or severe water stress may reduce yields of better grown, high density cane. Also, vigorously well grown cane may generate negative effects on high density crops due to shading, increased stalk deaths and lodging.
- Commercialisation may impose additional suboptimal states eg
  - row spacing limitations to accommodate tillage and harvesting operations which minimise damage to stands and stools;
  - surface topographies which are dictated by drainage and irrigation needs;
  - production of stalks that are robust and well rooted.
- Historical experiments have been so constrained by traditional husbandry and mechanization that several basic questions about HDP systems remain unanswered:
  - What are the effects of crop age and its possible interaction with latitude and length of growing season - also related to this is the influence of planting time?
  - How does planting rate and establishment control the responses of individual plants or stools to their spatial deployment in terms of tillering and mature stalk development in both plant and ratoon cane?
  - What are the population * geometry response surfaces for cane and how are they expressed in asymmetric arrays such as dual and triple rows?
  - What are the responses to all these variables in at least 1R to 3R cane?
  - Given that suckering and lodging are major features and problems in current crops, what is their incidence in relation to plant spacing?
  - What is the evidence for species (phenotypic) reaction to these factors as well as for important genotypic (varietal) variation in response?
  - How does one recognise when the spatial response is greater than it should be and an artefact due to unconscious introduction of other growth controlling factors?
4. EVALUATION OF BSES TRIAL DATA

4.1 Focus of this Report – Close Rows

Despite the present wide scale trialing of dual rows, the focus of this investigation has been limited to assessing the potential benefits from industry adoption of close rows.

The following observations support this decision:

- Dual row responses in TCH relative to 1.5m singles ranged (29 trials) from -35% to +24%; the arithmetic mean was +10.9% and this is below the average difference required for statistical significance.
- Responses to dual rows are quantitatively consistent with the probable effects of plant density and rectangularity on millable stalk numbers and cane yields. The responses persist at least to 1R.
- Dual row options appear to have been pursued for practical reasons with little understanding of the separate effects of density and geometry. Systems based on the use of existing machinery – particularly harvesters and haulout bins – have led to experimenting with wider (1.8 - 2.1m) centre spacing.
- Under these conditions, increases achieved in plant density have probably been offset by increasing rectangularity.
- Cane growers should budget for a 10% level of response and recognize the inherent variability of dual rows in deciding whether to adopt dual rows.
- The eSYS Development economic assessment determined that economic benefits over conventional rows were extremely marginal.

4.2 Evaluation of BSES's HDP Trials

Stalk count, TCH, CCS and TSH data were provided for 27 replicated experiments or strip trials. Various sets of response data were examined to determine the effects of ratooning, and latitude. Observations were also made on time of planting, crop age, prior crop/fallow history, N fertiliser and irrigation treatment.

4.2.1 Ratoon Effects

Means across variety/clones are shown in Table 4.1 for millable stalk number per m² and for cane yield (TCH hand harvested). Cane yields for location 2 (2R) and 6 (1R) are machine harvested with prototype equipment.

Since planting rates within trials were constant per metre of row length, potential plant densities for constant germination rates would, for 0.5m rows, be three times those for 1.5m rows i.e. 200% increase.

These data show:

- stalk numbers for 1.5m rows, at the commercial norm for plant cane i.e 8-10/m²;
- stalk numbers for 1R similar to plant cane or slightly greater;
- stalk numbers approximately 40-70% higher for 0.5m rows;
- similar effects across P, 1R and 2R;
- cane yields 30-60% higher for 0.5m rows for P and 1R;

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4 This compares with responses ranging from +1 to 96%, mean +47.1%, for 0.5m singles relative to 1.5m rows in the same set of trials.
5 The incremental benefit for a 20% dual row response over single rows is $330/ha at $335/tonne at 13.5 CCS, Southern Region Crop; this benefit reduces to $93/ha for a 10% response, reflecting that the majority of additional grower input costs are fixed (Appendix 5).
on average 0.5m rows produced 61.3% more millable stalks per hectare, individual stalk weights were 14% lower and cane yields were 49.6% higher *ie the dominant component of yield increase is stalk number. This is consistent with the cane density literature;

* CCS levels (not shown), follow the same pattern in this set of nine, as in all 27 experiments and those reported in the literature *ie they are occasionally significantly different (higher or lower), but are mostly similar within experimental errors*.

<table>
<thead>
<tr>
<th>Location</th>
<th>Class</th>
<th>Month of Planting/ Ratooning</th>
<th>Age at Harvest (mths)</th>
<th>% Response ((0.5m-1.5m) / 1.5m x 100)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>% (StalkN/ m²)</td>
</tr>
<tr>
<td>1</td>
<td>Bundaberg</td>
<td>12/94</td>
<td>7</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1R</td>
</tr>
<tr>
<td>2</td>
<td>Bundaberg</td>
<td>6/95</td>
<td>14</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1R</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2R*</td>
</tr>
<tr>
<td>3</td>
<td>Mackay</td>
<td>9/96</td>
<td>13</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1R</td>
</tr>
<tr>
<td>4</td>
<td>Mackay</td>
<td>9/96</td>
<td>13</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1R</td>
</tr>
<tr>
<td>5</td>
<td>Harwood</td>
<td>11/96</td>
<td>12</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1R</td>
</tr>
<tr>
<td>6</td>
<td>Bundaberg</td>
<td>10/96</td>
<td>12</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1R*</td>
</tr>
<tr>
<td>7a</td>
<td>Bundaberg</td>
<td>10/96</td>
<td>12</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1R</td>
</tr>
<tr>
<td>7b</td>
<td>Bundaberg</td>
<td>NA</td>
<td>NA</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1R</td>
</tr>
</tbody>
</table>

Arithmetic Means | P | 69.9% | (8.5) | 49.9%

1R | 54.6% | (9.5) | 49.8%

Source: Analysis of BSES data by JKL.

1 12 month fallow, supplementary irrigation
2 9 month fallow, Vapam treated, trickle irrigated
3 9 month fallow
4 9 month fallow, rainfed
5 Fallow from soybeans, rainfed
6 12 month fallow, irrigated
7a 12 month fallow, irrigated high N
7b 12 month fallow, rainfed low N
* Mechanically harvested

Early tiller counts for locations 1&2, P cane display the same pattern as that recorded in the literature viz that tiller densities at narrow rows are high relative to wide rows and the differences are offset, but not completely, by higher tiller mortality in the progression to millable stalks.

Behaviour of cane in narrow rows is consistent with a response to increased plant density and reduced rectangularity which could not be achieved by changing either alone.

* Unfortunately CCS were derived using a constant fibre figure for each trial. The literature indicates that % fibre tends to increase, as stalks become thinner at higher densities.
The effects persisted undiminished into 1R cane and 2R for the only trial so far extended to that class. Ratoon ages ranged from 12-14 months – a median selection within the maximum commercial range of 7-17 months. Since the Queensland industry has extended to 3R – 5R in different districts in recent times it is important to know whether 0.5m rows will allow similar extension, for sound economic reasons.

Obviously, there is inadequate experience beyond first ratoon crops.

4.3 Latitude Effects

The latitudinal effect on P cane was examined through data from 11 locations from Meringa to Harwood. Seven of these were 1998 harvests, the other four were 1997 harvests (Table 4.2).

<table>
<thead>
<tr>
<th>Location (Latitude)</th>
<th>Month of Planting</th>
<th>Age at Harvest (months)</th>
<th>% Response ((0.5m-1.5m) / 1.5m x 100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meri (17° 09&quot;)</td>
<td>7/97</td>
<td>12</td>
<td>N/A</td>
</tr>
<tr>
<td>Tully (17° 56&quot;)</td>
<td>8/97</td>
<td>12</td>
<td>N/A</td>
</tr>
<tr>
<td>Ingham (18° 39&quot;)</td>
<td>8/97</td>
<td>12</td>
<td>N/A</td>
</tr>
<tr>
<td>Ayr (19° 34&quot;)</td>
<td>6/97</td>
<td>15</td>
<td>N/A</td>
</tr>
<tr>
<td>Mackay (21° 09&quot;)</td>
<td>9/96</td>
<td>12</td>
<td>150 (6.2)</td>
</tr>
<tr>
<td>Mackay</td>
<td>9/96</td>
<td>13</td>
<td>71 (9.5)</td>
</tr>
<tr>
<td>Mackay</td>
<td>9/96</td>
<td>13</td>
<td>63 (8.8)</td>
</tr>
<tr>
<td>Nambour (26° 38&quot;)</td>
<td>10/97</td>
<td>12</td>
<td>98 (7.2)</td>
</tr>
<tr>
<td>Rocky Point (27° 43&quot;)</td>
<td>11/97</td>
<td>12</td>
<td>42 (9.7)</td>
</tr>
<tr>
<td>Condong (28° 19&quot;)</td>
<td>11/97</td>
<td>12</td>
<td>N/A</td>
</tr>
<tr>
<td>Harwood (29° 26&quot;)</td>
<td>11/96</td>
<td>12</td>
<td>68 (7.7)</td>
</tr>
</tbody>
</table>

Source: Analysis of BSES data by JKL

Stalk data had not been compiled for several locations. The range in cane yield increases was from 1% (Condong) to 75% (Mackay). The Ingham trial (9% increase) was probably affected by excessive wetness and the Condong trial was “a very poor establishment”.

Stalk numbers per square metre were consistent with cane yield for the limited data. For the Mackay north trials, planting dates ranged from June to September and ages at harvest from 12-15 months. Mackay trials were planted on 9 month fallows. Prehistories were not available for trials further north.

These data represent very restricted experience in the sense of “latitude vs year” sampling of narrow row response and much more experience is desirable for both plant and ratoon performance.

Nevertheless the data do not reveal any obvious trends to lower responsiveness at narrow rows at northern of southern latitudes, which could result from “catch up” by 1.5m rows associated with warmer winter environments.

4.4 Other Agronomic Influences

4.4.1 Planting Time & Crop Age

Main commercial planting times are April-May and August-September. Plant crop ages at harvest vary from 9-20 months and ratoons from 7-17 months.
Of the 27 trials, months of plantings (number of trials) were:
April (1), June (1), July (1), August (5), September (6), October (6), November (4),
December (3).
Plant crop ages ranged from 7-15 months (most 11-13 months).
The response data show no obvious effect of planting time or age within these ranges.

*It would be opportune to accumulate experience with autumn plantings, greater crop ages
and earlier times of ratooning.*

4.4.2 Soil Fertility
A common criticism of experimental design in BSES’s work is directed to the confounding
of mineral nutrition in the narrow row/dual row comparisons. BSES trials have maintained
constant lineal row fertiliser application rates, increasing the rate per hectare and hence
potentially leading to an over estimation of the narrow row response.
Whilst the criticism is valid, confounding can still occur (leading to an underestimate of the
HD effect) at a constant application rate per hectare eg phosphate fertilisers can give this
effect in other crop species due to a requirement for close placement of fertiliser.
The greater biomass of narrow row cane probably necessitates higher than standard N
rates.

*The review of BSES trial data showed large and similar close row responses at all N
rates.*

4.4.3 Weather Extremes
The literature contains well documented cases of the negative effect of water stress⁷ and of
stalk deaths from shading⁸ on close row yields.
There are several undocumented references to high density cane being more susceptible to
lodging.

*BSES’s work shows a virtual absence of such negative effects, which will no doubt be
encountered under commercial conditions.*

4.5 Variety/Clone
Recent BSES trials have incorporated a substantial number of different genotypes - either
released varieties or experimental clones.
There is no doubt that there have been significant differences recorded between genotypes
in the magnitude of their stalk number and cane yield responses to higher density.

4.5.1 Commercial Varieties
22 commercial varieties constituted 5% or more of 1997 district tonnages in one or more of
four Queensland districts and NSW. Of these, 13 have not been in any high density trials
and with the exception of Q124, most have been in only one or two trials.
There has been no deliberate repetition of varietal comparisons in time or location to
determine the consistency of relative Variety vs Density effects across environments.

*Until this is done there is in fact no definitive evidence that varietal differences can be
exploited to enhance the benefit accruing from high density planting.*

4.5.2 Experimental Clones

Two BSES experiments have compared a number of clones across plant and 1R from the same plantings.

The 26 Clone Experiment

A trial with 26 clones at Hi/Hi and Lo/Lo nitrogen and water levels provided an environmental comparison. Relevant correlations for % yield-response of 0.5m and dual rows relative to 1.5m rows in plant cane led to the following conclusions:

- Relationships between clonal responses of Hi/Hi and Lo/Lo environments are very weak.
- There are stronger relationships between responses to 0.5m and dual rows within the two environments for plant cane but these do not continue into 1R.
- The clonal rankings of 0.5m responses in plant and 1R are not related.

The main implication of this perplexing finding is that if clonal variations in % response are distributed randomly, they provide no basis for postulating useful genetic variability and certainly no basis for a breeding program.

The 78 Clone Experiment

- Figure 2 (Appendix 2) demonstrates that the clonal variation in % response to 0.5m rows was not correlated between P and 1R harvests \( r^2 = 0.0009 \)\(^9\).
- In contrast, Figure 3 (Appendix 3), derived from the same data by Dr T.A. Bull, shows an apparent coincidence of P and 1R response level frequencies.
- Closer scrutiny revealed that this coincidence is invalid as evidence for stability in genetic variation, since the same response levels for P and 1R are not based on the responses of the same groups of clones.

Thus it can be concluded, that the only two experiments so far conducted which could provide evidence for clonal variation in narrow row responsiveness, to justify a breeding program have failed to do so.

4.6 Sampling – A potential source of Error

One possible cause of small plot errors is the practice of measuring stalk number and stalk weight on separate areas /row sections. Due to the stalk density * stalk weight relationship this could be a cause of extremely high and low TCH estimates for individual treatments.

There are certainly many unrealistically high treatment yields amongst the data. It may be more vulnerable as a method in plant density experiments, and one, which is very susceptible to operator bias in selection of the stalks/row sections, actually sampled. In the absence of bias, this sampling system may increase the range of values but should not alter treatment or aggregate trial means.

It seems unlikely to have been a problem in all experiments since mechanical plot harvesting and whole stalk sampling have obtained similar yields with similar errors. It may be significant that the greatest differences between the two methods occurred in the 78 clone 1R harvest.

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\(^9\) Based on analysis of BSES data by J K Leslie

Page 7
4.7 Summary

General conclusions are that:

- the responses to 0.5m rows in plant cane reflect higher population densities of millable stalks at lower rectangularity than occur at 1.5m singles;
- these responses are consistent, and are not precluded by higher tiller mortalities and/or reduced size of millable stalks across a range of planting times, crop ages, latitudes and seasonal/moisture supply conditions;
- it is probable that 1.5m single rows at 8-10 millable stalks per square metre and stalk rectangularities of 18:1 to 25:1 are sub-optimal throughout that range, and that 0.5m narrow rows at 12-16 millable stalks per square metre for rectangularities of 3:1 to 5:1 are closer to optimal geometry;
- the responses to close rows extend into at least 1R with similar magnitude;
- there is no basis for assuming that 0.5m rows and the millable stalk densities achieved in the trials are an optimal array for cane stands;
- the responses are independent of fertiliser regimes;
- negative effects of water stress, poor drainage and susceptibility to lodging can be anticipated with further extension of trials.

4.8 Simulation of Density Effects

Simulations of cane yield for densities typical of 0.5m and 1.5m rows were obtained from BSES and CSIRO.

BSES's model is driven by leaf intercepted radiation, average temperature and soil water availability. It uses a 3-fold density difference between 0.5m and 1.5m rows. Simulations for 1996 planted cane at Bundaberg for stressed (rainfed) and non-stressed (irrigated) conditions predicted yield responses of 53% and 54% respectively.

CSIRO's APSIM-SUGAR simulation for autumn and spring 1996 ratons at Bundaberg provided a 20% and 17% response of 0.5m over 1.5m cane for May and September plant respectively.

The models are not directly comparable nor can they be employed to simulate the effects of plant geometry varying in both density and rectangularity. However the ca 30% difference in simulated yield, does reflect actual differences in field measurements of LAI for 1.5m cane; BSES measured LAI's ranged from 3.5-4.0 compared with LAI's of 6.0-7.0 reported by CSIRO.

The questions arising from this issue are:

a. Is BSES’s measured close row response due to comparisons with suboptimal LAI’s and slow canopy closure of 1.5m cane which can be partially overcome with 0.5m rows?

b. Can a proportion of this yield improvement be obtained through a less costly option of attending to husbandry issues for suboptimal 1.5m cane?

c. Does this yield response persist over well grown 1.5m commercial crops?

One could speculate that a 50% close row response may be expected where poor commercial establishments are the norm; this in turn may reduce to a 20% response, in line with APSIM SUGAR simulations, when dealing with well grown 1.5m controls.

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10 T. Bull, BSES and R. Muchow & B.A. Keating CSIRO.
5.1 Strategic Objectives

At this point the strategic thrust of BSES's activities should be directed towards the key objectives of:

1. Addressing the outstanding areas of uncertainty identified in Section 4;
2. Developing and implementing the best program to facilitate the adoption of HDP as a commercially productive system.

The following preliminary project proposals submitted by BSES were evaluated following discussion with the project proposers and Group Coordinator. Observations and recommendations are provided for each proposal which are presented in order of ranking, assigned from lowest to highest priority.\(^\text{11}\)

As previously stated, dual rows are not considered, based on our assessment that industry-wide gains/losses are likely to be highly variable and average only 10%, which is below the difference required for statistical significance.

The following recommendations are based on our general conclusion, that close row systems have the potential to provide a net industry benefit corresponding to a 20-50% yield response over 1.5m single rows for plant and 1R cane. There are however still a number of uncertainties to be resolved.

5.2 P035 e "NQ PRODUCTIVITY – High density planting – an opportunity for improving N Qld profitability"

5.2.1 Observations

This project proposal correctly acknowledges the complexity of the on-going program to determine the causes of declining CCS in the wet tropics and the pressing urgency of arresting this trend. The ultimate solutions will no doubt be multifaceted and include issues of husbandry, mechanization and varietal improvement/selection.

HDP practices employing cultivars resistant to suckering and lodging, may ultimately play a role in alleviating this problem. It is however difficult, as the proposal suggests, to view close row systems as a "short term" panacea to declining CCS. HDP systems could in fact indirectly exacerbate the problem through increased field losses of cane during harvesting at high pour rates, as discussed below.

This proposal should therefore be viewed as a component of the declining CCS program and be positioned as a potential flow-on benefit, following the successful industry adoption of HDP systems.

5.2.2 Recommendations

The impact of HDP on minimising CCS losses in the wet tropics should not be considered within the context of this review, since there are larger, more fundamental strategic issues associated with facilitating industry adoption of HDP systems. During this review, BSES Bundaberg agreed that P035e was peripheral to its mainstream HDP objectives and consequently should be deleted for funding considerations.

\(^{11}\) Ranking was assigned by a BSES focus group during our discussions in Bundaberg in December 1998; our review team agreed with the ranking.
5.3 P022e “High Density Planting - Breeding and selection for close rows”

5.3.1 Observations
As stated in Section 4.5, the initiation of a major breeding program may be argued against on two grounds:

1. Insufficient trials have been conducted to assess the potential of major commercial varieties.
2. Clonal experiments hitherto conducted, have failed to demonstrate the influence of genotype in responsiveness to close rows.

It would be sensible in continuing experiments and site replicated strip trials (SRST’s) to obtain information on the responsiveness of the main varieties. There is considerable strategic danger in a shift to high density, based on one or two varieties however good they may appear to be at present.

The best position would be if varietal choice for high density planting could be based on qualities other than HD responsiveness. Present evidence indicates that this may be so, and that any gains achievable from further advances can feed in as and when they accrue.

This proposal has a medium to low priority at present. The PPP is well considered and if HDP becomes a reality, the work will need to be done. A higher priority may be argued given the 10-12 year lead time, however it should at this stage be viewed as fine-tuning of a system to provide a potentially small incremental benefit.

5.3.2 Recommendations
It is more important to determine what proportion of the average 49% TCH response can be achieved commercially with current varieties across environments than to pursue a possible further 10% through genetic adaptation to close rows.

Initiating a breeding and selection program to generate incremental yield benefits for HDP systems is premature.

This project should be deferred until –

a. sufficient data accrues via SRST’s, on the responsiveness of the main varieties and
b. more definite pilot research establishes clonal variation with stability across environments and ratoon classes.

5.4 P039 e “High Density Planting – Effective furrow irrigation of high density planted sugarcane”

5.4.1 Observations
The adoption of HDP systems in the Burdekin, Central and Mareeba regions will be contingent upon the successful development of furrow irrigation systems capable of servicing 0.5m rows at 2.1m centres.

It is most likely that suitable systems can be adapted from current practices in other industries. The proposal cites narrow and ultra-narrow row cotton under furrow irrigation as one such potential source of information.

An extensive review of relevant industry practices by an individual, suitably experienced in irrigation techniques, should provide the basis to underpin subsequent field trialing at extension level.
5.4.2 Recommendations

The project proposal has low priority in its submitted format.

*It is recommended that an initial travel grant be provided to inspect and evaluate furrow and bed irrigation techniques in other narrow row cropping systems.*

The most promising options can be tested in the regional unit/extension proposal.

5.5 P066 e “High Density Planting – Economical insecticide rates for control of canegrubs in high density plantings”

5.5.1 Observations

Total hectares susceptible by canegrub species and region are tabulated in Appendix 4, reinforcing the magnitude of the potential problem.

This proposal will investigate the application of the current battery of pesticides (suSCon, Mocap, Rugby and BioCane) used to control canegrub species. Trials with Mocap can probably be deleted from the proposed program since Rhone Poulenc is ceasing supply; Rugby is a suitable replacement. The key issues involve in the proposed project are:

a. determining the most economical rate for each combination of pesticide/target species, under HDP conditions. Extrapolation of the current cost for suSCon ($300/ha) to HDP systems on a row-metre basis, will increase costs to $900/ha for plant cane. BSES opined that growers would view this as a major cost impost. Of note the eSYS report\(^{12}\) calculates gross margins for close row, plant cane using a pesticide cost of $466/ha, which presupposes a reduced row metre application rate for suSCon;

b. obtaining NRA approval for use at the modified concentrations; a 12 month lead time must be included for registration following determination of application rates and residue limit barrier data;

c. solving application techniques and related equipment design issues eg how is a wide band of suSCon applied at 20cm depth, when its envisaged that only narrow band disturbance will occur when planting close rows? This will place demands on engineering expertise.

It is accepted that the need for an extensive number of trials is compounded by the fact that only one in three trials may yield efficacy data.

5.5.2 Recommendations

This proposal assumes a medium to high priority given that:

- canegrubs are widely endemic and their interaction with the different root and stool architecture of close rows is a complete unknown;
- the absence of pest control, could result in a potential industry cost of $200-$300 million pa based on BSES estimates\(^{13}\) for yield reduction and abnormal replant costs;
- pesticides represent a significant in-put cost to growers and extension of permitted metre-row application rates to close rows will contravene present regulatory limits on a per hectare basis;
- a three year lead time is required to gather efficacy data for plant through to third ratoon crops, followed by a further year to attain registration.

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\(^{12}\) “The Economics of High Density Planting” by eSYS Development June 1997.

\(^{13}\) Source: Dr Peter Allsopp, BSES
The PPP should be invited to proceed to full proposal and is recommended for funding in the present format with perhaps some modification to the allowance for trials with Mocap.

5.6 **P036 e “High Density Planting – Establishing a regional unit to support large scale testing of high density planting” & P061 e “High Density Planting – Facilitation of adoption of high density farming systems for sugarcane”**

5.6.1 Observations

These proposals are effectively subsets of a single project. Their primary objective is to develop mechanization systems to facilitate industry adoption of close row systems through the establishment of regional units based on commercial scale, non-replicated trials.

Capital and labour components are separately covered in P036e and P061e respectively.

Each project in isolation, can be assigned a medium to low priority as submitted. When combined however, the projects represent the principal vehicle for implementing BSES’s most important strategy – facilitating industry adoption of high density planting.

The following restructuring of the proposals was agreed in discussions with BSES:

- amalgamate P036e with P061e;
- modified the non-replicated trial concept;
- develop an alternative strategy for the commercialisation of machinery.

These details and rationale are covered in the following recommendations.

5.6.2 Recommendations P036 e - Establish Regional Unit & P061 e - Adoption Programs

5.6.2.1 *Modified Regional Development Concept*

Projects proposals P036e and P061e should, in concert, be considered the hub of the HDP development program.

The proposed regional unit program (P036e), based on non-replicated commercial scale plantings should be replaced with mechanically harvested site replicated strip trials (SRST’s) to extend the work on varietal screening in possibly three major geographical regions.

This approach will provide meaningful data and extended experience for HDP yield gains across varieties and regions as well as supporting the development of prototype machinery.

The trials should specifically focus on close rows. All reference to dual rows should be deleted from P061e, together with objectives to address issues of canopy effects in frost prone areas of the Harwood Mill.

The SRST’s comparing 0.5m close to 1.5m conventional rows should have explicitly defined objectives and measured variables eg record of paddock history and trial management, stalk numbers, yield, CCS, establishment counts etc.

The SRST’s should be designed to address identified uncertainties by:

- extending current experience with autumn versus spring planted crops, greater crop ages and time of ratooning;
- determining the impact of the inevitable effects of severe moisture stress;
- determining the extent of suckering and lodging problems and earlier times of ratooing;
- dimensioning mechanization and other issues associated with adaptation of close row systems to 2 year cropping cycles in NSW;
- conducting SRST’s under optimal husbandry ie conditions, which achieve high early growth rates and cane yields for single row 1.5m cane and measuring the 0.5m response and its component dynamics under such conditions.

A proposed timetable for the modified regional development concept, follows.

<table>
<thead>
<tr>
<th>Table 5.3 Modified Regional Unit Extension Program Agreed with BSES Bundaberg</th>
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</thead>
<tbody>
<tr>
<td>Autumn 1999</td>
</tr>
<tr>
<td>Spring 1999</td>
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<tr>
<td>Spring 2000 planting</td>
</tr>
<tr>
<td>Spring 2000 harvesting</td>
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<tr>
<td>Spring 2001 harvesting</td>
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</tbody>
</table>

*Source: Discussions with T. Bull December 1998*

It is envisaged that prototype machinery currently under development by BSES will be employed in these SRST’s, together with commercial prototypes as they become available.

**5.6.2.2 Present Resourcing of Process Development**

Our review team conducted numerous discussions and process inspections with the Agricultural Engineering Group (AEG) at Bundaberg BSES to ascertain details of the prototype planter and harvester development program and the nature of AEG’s interaction with P&H Rural and Austof.

This exploration also extended to discussions with the senior management\(^{14}\) of the two commercial equipment manufacturers to gain an understanding of their business expectations for HDP systems. The inferences drawn are discussed in the next section.

*It was apparent that harvester and planter prototype development work at BSES is presently under-resourced and in urgent need of funding support during 1999.*

Harvester design is presently funded through an internal budget of $150K, which includes $25K for 50% of an engineer and $20K for 75% of a technical officer’s time. BSES has already utilised the labour component of this budget. The AEG indicated that the prototype

\(^{14}\) Meetings were held at Austof, Bundaberg with Frank Lukacs, General Manager (tel 07 4155 4555) & Mal Baker, General Manager Engineering (tel 07 4155 4538) and at P&H Rural, Bundaberg, with Errol Schuh (tel 07 4152 9555) General Manager.
development would be greatly assisted, if an additional engineer (50% equivalent) was assigned to the project.

This work is considered pivotal to the success of industry adoption of HDP systems; it is vital that the momentum does not languish for want of funding. It should be noted that no request for support has been included in this range of proposals.

5.6.3 Austoft and P&H Rural

Proposal P036e includes a capital allowance of $944K for 1999/2000. Major capital items include 1 multithrow harvester ($450K), 1 transporter ($300K) and 2 haulouts ($150K). This allocation presupposes that BSES will drive and fund close row mechanization.

The wisdom of this strategy must be questioned. Our conclusions based on meetings with Austoft and subsequent discussions with BSES, were that a significant proportion of this capital could be more productively channelled into commercialisation of harvester design through a direct, well managed relationship with Austoft.

This should provide the best strategy to fast-track commercial development. The basis of this recommendation stems from discussions with Austoft and P&H Rural which are summarised as follows:

- Austoft has broad global experience within the sugar industry at micro (process development) and strategic levels. Our discussion on the failure of close row harvesting and haulout systems in Louisiana, provided insight into Austoft’s detailed knowledge of industry specifics in that State.
- Austoft are not convinced of the heralded benefits of dual and close row plantings and during conversation, recalled the industry disadoption of pineapple rows.
- Austoft and BSES have differing views on commercial harvester development, which must be encouraged to converge since both parties have vital contributions to make to the project.
- Austoft are ultimately driven by a need to develop a cost effective harvester design with appeal across all market segments. The optimal outcome is considered to be a single design, which provides flexibility to enable harvesting of conventional, dual and close row configurations. This also addresses switching costs in the transition phase.
- Austoft’s traditional development time from initial concept stage to launch of a completely new machine is 3-5 years.
- The anticipated development cost was cited as $2-3 million.
- Austoft does not necessarily see an overlap between BSES’s present prototype development and the design of a commercial version. BSES is aware of Austoft’s criticism of its base cutter design which Austoft links to wrap-up, jamming, poor stool profiling and excessive cane left in field.
- Our discussions with Austoft’s general manager extended to BSES’s R&D on shortfalls in Austoft’s current harvester technology reflected most acutely in the significant CCS losses caused by glutting and billet shredding during harvesting. This is viewed as the most important factor contributing to declining CCS in the wet tropics.
- In contrast P&H has less R&D expertise and is amenable to research direction delivered by BSES Engineering.
- P&H management is aware of Austoft’s present attitude to close row systems and will not consider a commercialisation phase unless they are convinced of Austoft’s commitment to harvester development.

The implications of this line of argument are as follows:
1. The measurement of commercially achievable narrow row yields, cannot occur unless mechanization of narrow row systems optimizes cane production and ratoon longevity in respect of tillage, planting, harvesting and haulout machinery.

2. Risk capital is required to fund the development of this prototype equipment which should ideally be driven by the commercial parties (Austoft and P&H) ultimately involved in the subsequent manufacturing and marketing activities.

3. Austoft will be reticent to inject such risk capital alone, unless it is convinced of the likelihood of HDP adoption by the industry, which in turn cannot occur in the absence of mechanization.

SRDC is able to provide a solution to this conundrum by:

1. Establishing a formal relationship/agreement between Austoft and SRDC plus other parties as appropriate, to develop a commercial multirow harvester; this will be predicated on Austoft’s willingness to accept the significance of BSES’s trial data and foreshadowed industry benefits to accrue from the adoption of close row systems.

2. Directly contributing to the funding of commercial development. Mal Baker flagged the possibility of SRDC sharing risk capital with Austoft on a dollar for dollar basis. There are obvious implications of on-going benefits for SRDC through profit sharing, running royalties etc.

3. Exploiting that relationship to facilitate more fundamental reengineering of Austoft’s harvester design, based on the present R&D effort of BSES’s engineering group into peripheral, but highly relevant areas, namely:
   a. CCS losses in Toft harvesters at high pour rates, which could become even more significant if substantial increases in cane yields flow from narrow row systems;
   b. soil compaction, which may be leading the industry towards controlled traffic and precision guidance systems;
   c. extraneous matter and dirt contamination problems of standard rows and current harvesters, which may be quite distinct and require different solutions if high density cane differs materially in suckering, lodging and stalk death.

4. Timing should if possible be synchronised with the modified regional development program.

To these issues may be added those already the subject of high density related, process development by BSES engineers viz

a. narrow row harvester fronts;

b. high quality planting material;

c. narrow row precision planters;

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15 The ready adaptation of conventional harvesters to dual rows is, we believe, the major driving force behind the present spate of grower trials. There is a major concern that the inherent variability of dual row responses under commercial conditions will reflect poorly on close rows if they are viewed as extensions of the same system. This is possible since there is a general ignorance of the underlying density/rectangularity interactions.
5.6.4 Cameco Industries Inc

Cameco is an alternative partner for the design and development of commercial harvesting and haulout equipment in Australia. Discussions with its Louisiana head office provided some insight into the similarity of its attitude to that of Austoft’s, on the question of product development costs:

- Cameco has no current program to develop harvester equipment for close rows - it is vaguely aware of the HDP research in Australia but not of the specifics.
- Cameco attempts to avoid the costs of development work until there is grower pressure backed by extensive trials. When Brazil commenced growing dual row cane, Cameco responded by redesigning the front-end of its harvester, only to see industry disadoption some seasons later. This example was offered to support Cameco’s view that new cultural practices are frequently transient and potentially costly for the early adopter.
- Research may be conducted under a range of potential arrangements eg 50/50 shared costs with industry groups or 100% funding by Cameco or industry etc.
- IP is a problem where costs are shared, or industry claims ownership of the original concept. Cameco discourages the concept of royalties. It has never found a successful formula for structuring a final harvester selling price to allow equitable sharing of profit from co-development of a design concept.
- If HDP can be demonstrated to generate sufficient grower interest in Australia, Cameco naturally wishes to be involved in related harvester development.

5.7 Research Needs

The foundation for commercial development of high density cane is limited by the fact that experiments with 0.5m rows and standard lineal planting rates have sampled relatively narrow segments of the response surfaces relating:

- plant density to planting rates,
- millable stalk densities to plant densities, and
- cane yields to millable stalk densities.
for a practicable range of rectangularities.

Further research is needed to establish those surfaces and it can be undertaken in parallel with the development phase. In particular:

- There is a need for thorough analyses of all data from all 29 trials to exhaust their contribution to a general understanding of the response, before further work is undertaken.
- Experimentation to establish the principles underlying the response surface of sugar cane to plant density and rectangularity is essential. This was discussed as an experiment within current project BS212. It should be resolved between SRDC and BSES in the first instance, as to whether wider collaboration is required to guarantee the depth and exploitative power of understanding required.
- Associated with such work, there is a need to study the influence of planting rate and the unevenness thereof, on plant density and on the eventual determinations of millable stalk densities and cane yield for a range of rectangularities. This is particularly important to resolution of commercial planting rates.
- Finally, there is a case to measure the 0.5m response and its components’ dynamics under conditions which achieve ceiling early growth rates and cane yields for 1.5m cane. This would probably need to use methyl bromide fumigation as a treatment variable and should be considered as a collaborative study with the Yield Decline Program.

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16 Source: Ken Rodrigue Vice President Production and Engineering, Cameco Industries, Thibodaux La., tel +1 504 447 7285, fax +1 504 447 5735
6. INDUSTRY BENEFITS

6.1 Millers’ Attitude toward HDP and Dual Rows

The major milling groups were surveyed to ascertain potential implications, which may stem from wide scale industry adoption of dual and close row systems. The major points are summarised as follows:

6.1.1 CSR\(^7\)

- Grower agreements for extended season length are in place at Herbert, Plane Creek, Invicta and Pioneer Mills. Similar agreements are awaiting ratification for additional mills in the Burdekin.
- In 1998, CSR milled 14 million tonne cane against a budget of 15.6 million. The season length agreements will provide total capacity of 18 million tonne cane \(pa\). Beyond this, CSR has a moratorium on further expansion of milling capacity.
- CSR’s estimates for the industry benchmark costs for expansion of milling capacity are \$300K–\$400K/tonne cane/hour. Invicta’s \$185 million expansion in the early 1990’s was achieved at a cost of \$330K/tonne cane/hour.
- Current investment guidelines based on returning at least CSR’s cost of capital cannot be satisfied (at a price of \$340/tonne sugar) under the present co-operative sharing which delivers 67% of the benefits of investment to growers (Section 6.6).
- CSR’s estimate for the replacement value of its mills is \$1.2 billion. 50% capacity expansion required to accommodate additional yield from full industry adoption of HDP systems will require capital of ca \$900 million\(^8\).

6.1.2 Mackay Sugar\(^9\)

- Mackay Sugar requires additional cane to satisfy current milling capacity.
- A quantum increase in cane supply through HDP systems will necessitate capital expenditure; Mackay Sugar’s estimates are at the upper end of CSR’s range.
- Mackay Sugar reiterated CSR’s comment regarding inadequate return on CAPEX for mill capacity expansion and the need to address this issue through the present cane payment system.
- A request was also made for research through the SRDC into evaluating/developing less costly alternatives for expanding milling capacity.

6.1.3 Bundaberg Sugar\(^10\)

- Of all the milling groups, Bundaberg Sugar has the largest spare milling capacity due to a shortage of cane and consequently the most to gain from high density planting.
- Two of the three mills in Bundaberg are operating 30-40% under capacity, equivalent to ca 600,000 tonne of additional cane.
- Season length discussions are progressing at the Moreton Mill. Babinda and Mourilyan Mills are operating in areas of declining cane production due to competition from alternative crops; together they account for an additional 300,000 tonne of surplus milling capacity. The Tableland mill is also cane limited.
- Bundaberg Sugar operates on water allocations in Bundaberg and the Tableland. The critical performance indicator is the yield of cane per megalitre of water.

\(^7\) Source: Dr John Baird, 07 4720 8860
\(^8\) Based on an additional 9 million tonne cane \(pa\), 26 weeks operation, 85% capacity utilisation and CAPEX of \$350K/tonne cane/hr.
\(^9\) Source: Dr Ron Swindells 07 4953 8400
\(^10\) Source: Dr Mike Smith 07 4150 8517
Mike Smith is responsible for growing the Group’s own crop, equivalent to 500,000 tC/yr – the largest in Queensland. He described himself as “one of the great doubters” of dual and close row systems based on:

- a perception of marginal to negative gains in dual row trials over a crop cycle;
- unjustifiably high investment costs associated with maintaining parallel systems during the changeover period (up to 5 years) from single rows to dual rows/high density planting;
- an expressed uncertainty regarding yield response under irrigated conditions.

6.1.4 Sugar North Ltd

- Mossman is investigating increased throughput based on season length extension (currently 20 weeks, 1.1 million tC/yr) and development of new cane areas.
- Mulgrave has limited additional farming area; HDP trials are in progress.
- Tully and South Johnson have a similar focus on season length.
- Capital rationing is not an issue if HDP generates significant future increases in cane.

6.1.5 Proserpine Mill

- Milling capacity has recently been expanded by 20% to 2.5 million tC/yr “at very little cost.”
- There are plans to extend the present 24 week season by 4 weeks ie capacity for an additional 380,000 tC/yr; extra cane is required to satisfy this expansion.
- The Proserpine region is actively trialing dual rows. The Proserpine Cane Protection and Productivity Board has compiled limited data from 1998 harvest of non-replicated, dual row trials. Predictably, results were extremely variable.

6.1.6 ISIS Mill

- ISIS has completed a $30 million expansion over the last 3 years to increase capacity to 430 tC/hr.
- There is ample opportunity to increase present throughput (1.1 million tonne cane pa) by 0.5 million tonne cane pa through continuous operation and the extension of season length.
- ISIS is actively encouraging vertical and horizontal expansion of regional cane production. To this end, progress in yield improvements in HDP and dual row systems is of vital interest.
- Irrigation (flood & winch) is an issue. The major variety, Q124, represents 29% of current cane and is expected to increase to 40% in 1999.

6.1.7 Maryborough Mill

- Present throughput is 830,000 tC/yr, under non-continuous operation at 300 tC/hr.
- During the next two years, Maryborough aims to increase milling capacity to 1.25 million tC/yr by:
  a. increasing capacity to 330 tC/hr by removing bottlenecks ($5 million CAPEX);

Source: Scott Grimley 07 4031 7088
Source: Alf Musumeci 07 4945 2701
Growing attitude to dual rows is mixed. The non-replicated trials gave apparent yield responses ranging from negative to high. The district’s best grower recorded a 10% decline in yield and will not re-trial dual rows (single row yield ca 143TCH). Dual row responses of 36-41% were recorded where 1.5m rows yielded 100TCH. The performance of Q124 varied. One farm plot (12ha) of Q117 was described as outstanding (reported as a 38% response). Source: Neil Judd, tel 07 4945 1844
Source: Mark Hochen, tel 07 4126 6166
Source: Tom Braddock and David Braddock, tel 07 4123 2361
b. operating continuously;
c. season length negotiations to extend the present 23 week crush by 2-3 weeks.

- Productivity improvements through varietal changes and irrigation will absorb all of the additional milling capacity. This is reflected in a budgeted yield gain of 8.75% for the period 1997 to 2005.
- There is no budgeted allowance for regional adoption of dual and close rows. Maryborough must invest capital to cover this eventuating. CAPEX is estimated at $300K/tonne cane/hr, based on using secondhand plant and achieving savings through existing surplus boiler capacity.
- Maryborough's financial modelling indicates that a sugar price of $340-$350 to required to achieve its post-tax hurdle rate of 10% on incremental milling capacity. Its breakeven price for sugar is $320/tonne from a profit & loss perspective.

6.1.8 Rocky Point Sugar Mill

- The Heck Group is cane limited, requiring over 400,000 tonne cane pa to remain viable at present capacity. The success of dual row and HDP systems is critical to consistently achieving this tonnage.
- BSES has agreed to large-scale plantings (50-100 ha), scheduled for autumn 1999.

6.1.9 NSW Sugar Milling Co-operative

- Scepticism was expressed on the ready translation of results from dual row and high density trial plots to commercial field experience.
- Lodging is a significant problem associated with the predominance of a two year crop cycle. The preponderance of difficult, wet weather harvesting conditions is considered a major impediment to the adoption of HDP systems as per Louisiana's experience.
- Installing additional milling capacity to accommodate significant crop increases is not considered to be a hurdle and will provide a step forward in current expansion plans.

6.2 QSC's Attitude toward HDP

QSC is estimating raw sugar production for 1999 at 5.4 to 5.6 million tonnes increasing to 6.8 million tonnes by the year 2007. The escalation is based on a recent industry survey which factors in the effects of vertical expansion and a marginal growth in yield through irrigation and improved husbandry. No impact from the adoption of HDP systems is included in these estimates.

The dynamics of the industry will be different in the next 5-10 years. QSC sees changes in future marketing challenges due to escalating global surpluses of raw sugar and depressed pricing; major causes are increased output from Brazil and declining Asian demand. Currently there is pressure on Queensland's storage system. QSC is considering a $75-100 million investment for an additional 0.5 million tonne of storage on the basis of the 2007 forecast. Lower capital cost alternatives are also being evaluated. The investment is valued at $107 million in present value (PV) terms. Justification will be based on the improved margins derived from timing flexibility & judicious opportunity sales of sugar into target markets spread across a year. Currently QSC is frequently forced to be a price-taker in order to clear inventory during the crush.

QSC expressed a keen desire to be made aware of the potential impact of HDP yield improvements, which may accelerate the timing of its forecasts and provide further justification for storage options under consideration.

---

26 Source: David Heck, tel 07 5546 1233
27 Source: Greg Messiter, tel 02 6640 0400
28 Source: QSC's principal economist Warren Males, tel 07 3231 0199
6.3 Implications for Austoft

The total harvester fleet in Australia is 1200 machines. The average age distribution is bimodal; 50% of the fleet is under 5 years, the second market segment comprises growers demonstrating a reluctance to purchase — average age of harvesters for this group exceeds 15 years. Annual sales of $40m comprise 100 machines at $400K each; Austoft has 80% market share.

Austoft suggested its sales may escalate 20% with the gradual adoption of close row systems ie an incremental $6.4m turnover, net of spare parts and other service related revenue.

Absolute profitability on Austoft’s harvester sales in Australia is difficult to assess in the absence of a complete knowledge of Austoft’s fixed cost structure. Some insight into associated gross margins can be obtained from the relationship between selling price and direct costs for coffee harvesters in the early 1990’s.

During this period, coffee harvesters were selling for $120K; total direct costs (labour, energy & materials) were $80K ie 50% gross margin. It is believed that the same GMC applies to cane harvesters.\textsuperscript{29}

*If this extrapolation is valid, Austoft would recoup the $2-3 million in close row harvester, development costs, via the GMC on its incremental sales in the first year.*

6.4 Financial Evaluation – Grower Benefits

Financial calculations at grower level are modelled on the 1997 eSYS financial analysis. Appendix 5 provides a calculation of gross margin/ha plus updated assumptions. The scenario is based on a Southern region crop cycle, at a sugar price of $335/t, the long run average price forecast for the industry. Standard 1.5m rows are compared with dual (20% response, 0.5m on 1.8m centres) and close row (50% response, 0.5m).

This logic was extended to determine the effect of yield response on gross marginal contribution (GMC) for sugar prices of $300/t, $335/t and $350/t to approximate projected 1999, ABARE long run average and 1997 prices respectively.

The incremental, average annual grower benefit expressed as GMC over a three ratoon fallow crop cycle for a 50ha farm is also tabled below.

<table>
<thead>
<tr>
<th>Table 6.1 Effect of Close Row Yield Response on Average Annual Gross Marginal Contribution ($)/ha for Southern Region P+3R crop cycle, Sugar $335/t, CCS 13.5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Close Row Yield Response over Standard (%)</strong></td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Farm Income av pa</strong></td>
</tr>
<tr>
<td><strong>Less Weighted av Costs/ha</strong></td>
</tr>
<tr>
<td>Planting</td>
</tr>
<tr>
<td>Seed</td>
</tr>
<tr>
<td>Land Preparation</td>
</tr>
<tr>
<td>Pesticides</td>
</tr>
<tr>
<td>Cultivation</td>
</tr>
<tr>
<td>Fertiliser</td>
</tr>
<tr>
<td>Irrigation</td>
</tr>
<tr>
<td>Harvesting</td>
</tr>
<tr>
<td><strong>Total Costs</strong></td>
</tr>
<tr>
<td><strong>Annual Gross Margin $/ha</strong></td>
</tr>
<tr>
<td><strong>Incremental Gross Margin vs Std $/ha</strong></td>
</tr>
<tr>
<td><strong>Incremental Annual Farm Benefit – 50ha</strong></td>
</tr>
</tbody>
</table>

\textsuperscript{29} Industry Sources
Table 6.2 Effect of Sugar Price on GMC and Yield Response Relationship – Southern Region Crop Cycle

<table>
<thead>
<tr>
<th>Close Row Yield Response over Standard (%)</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar $350/t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incremental Gross Margin vs Standard $/ha</td>
<td>$104</td>
<td>$353</td>
<td>$603</td>
<td>$853</td>
<td>$1,102</td>
</tr>
<tr>
<td>Incremental Annual Farm Benefit – 50ha</td>
<td>$4,154</td>
<td>$14,137</td>
<td>$24,119</td>
<td>$34,102</td>
<td>$44,084</td>
</tr>
<tr>
<td>Sugar $335/t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incremental Gross Margin vs Standard $/ha</td>
<td>$82</td>
<td>$318</td>
<td>$555</td>
<td>$792</td>
<td>$1,029</td>
</tr>
<tr>
<td>Incremental Annual Farm Benefit – 50ha</td>
<td>$3,262</td>
<td>$12,734</td>
<td>$22,206</td>
<td>$31,679</td>
<td>$41,151</td>
</tr>
<tr>
<td>Sugar $300/t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incremental Gross Margin vs Standard $/ha</td>
<td>$30</td>
<td>$237</td>
<td>$444</td>
<td>$651</td>
<td>$858</td>
</tr>
<tr>
<td>Incremental Annual Farm Benefit – 50ha</td>
<td>$1,181</td>
<td>$5,321</td>
<td>$17,743</td>
<td>$26,024</td>
<td>$34,305</td>
</tr>
</tbody>
</table>

Source: eSYS Development 1997 analysis & Assumptions Appendix 5

An identical relationship is demonstrable for a Central Region crop cycle, involving marginally different plant/ratoon yields and a higher CCS of 14.1. The salient points from this analysis are:

- **A 20% yield response for close rows over 1.5m standard rows is required as a minimum to obtain a positive incremental GMC; the magnitude of this gain undoubtedly fails to cover the business risk associated with adopting close rows especially at lower sugar prices. Yield responses closer to 30%, should be considered a prerequisite.**

- **Yield responses of 40-60% provide phenomenal grower returns.**

- **Additional threats are associated with the potential for higher pesticide and water requirements than budgeted. The model assumes a constant water usage per hectare for close and standard rows. Pesticide costs are increased at a rate which is less than would be the case if the lineal row application was maintained.**

- **The returns to growers are based on the assumed close row responses persisting to the 3R crop. Returns will diminish if this fails to transpire. Alternatively if a 4R crop eventuates, crop cycle profitability will increase.**

- **There may be a real opportunity to lower planting and seed inputs, which are based on labour and sett costs on a constant lineal row basis. At present there is no knowledge of the influence of intrarow sett spacing on stalk numbers and yields for close rows. There is a possibility that sets can be more widely spaced and that tilling may result in similar millable stalk densities. This may also modify the need for precision planting. Experience must be derived from appropriate research (Section 5.7).**

### 6.5 Financial Evaluation – Return on Capital

One of the obvious attractions of close rows is the incremental return from a sunk capital cost i.e. growers do not require additional capital for land. Close rows also provide growers with the flexibility of maintaining total tonnage of cane and deploying land for other higher margin crops and/or increasing the proportion of fallow land.

There may be a requirement for harvesting equipment. The assumptions used by this and the eSYS report incorporates contract harvesting and hence a defacto return on capital. Capital expenditure becomes an issue where additional milling capacity is required e.g. CSR. Section 6.6 is illustrative of an anticipated return on capital from an industry perspective. The assumptions are based on a mill located in the Southern Region and include actual industry yields following discussions with milling groups.

The results indicate an overall return in excess of 10% IRR at the higher end of capital expenditure of $400K/tonne cane/hr ($335/tonne sugar). Achieving the return is however, contingent upon combining miller and grower benefits.
### Return on Capital for Mill Expansion inc. Grower GMC from HDP

*Mill location, Southern Region, 13.5 CCS, $335/tonne sugar*

<table>
<thead>
<tr>
<th>Increase in Milling Capacity</th>
<th>0%</th>
<th>20%</th>
<th>30%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cane tonne</td>
<td>400,000</td>
<td>480,000</td>
<td>520,000</td>
</tr>
<tr>
<td>Total operating hours</td>
<td>3,200</td>
<td>3,200</td>
<td>3,200</td>
</tr>
<tr>
<td>TCH av</td>
<td>125</td>
<td>150</td>
<td>163</td>
</tr>
<tr>
<td>Incremental Capacity - TCH</td>
<td>-</td>
<td>25</td>
<td>38</td>
</tr>
</tbody>
</table>

**Incremental tonne of cane**

- **Capex per tonne cane/hr**: 400,000

**Total Capex for additional tonnage**: 10,000,000

<table>
<thead>
<tr>
<th>CCS</th>
<th>13.5</th>
<th>13.5</th>
<th>13.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>COW</td>
<td>98</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>Cane Payment</td>
<td>29.82</td>
<td>29.82</td>
<td>29.82</td>
</tr>
<tr>
<td>Tonnes of Sugar</td>
<td>52,920</td>
<td>10,584</td>
<td>15,876</td>
</tr>
<tr>
<td>Price of Sugar</td>
<td>335</td>
<td>335</td>
<td>335</td>
</tr>
<tr>
<td>Molasses</td>
<td>14,000</td>
<td>2,800</td>
<td>4,200</td>
</tr>
<tr>
<td>Price of Molasses</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

**Revenue**

<table>
<thead>
<tr>
<th></th>
<th>Existing Operation</th>
<th>Incremental Tonnage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar</td>
<td>17,728,200</td>
<td>3,545,640</td>
</tr>
<tr>
<td>Molasses</td>
<td>420,000</td>
<td>84,000</td>
</tr>
<tr>
<td>Total Revenue</td>
<td>18,148,200</td>
<td>4,629,640</td>
</tr>
</tbody>
</table>

**Less Costs**

- Cane payment: 2,385,480, 3,578,220
- Levies: 20,000, 30,000
- Process Additives: 36,000, 24,000
- Freight - Sugar, $3/tonne sugar: 31,752, 47,628
- Harbour Dues, $1.20/tonne sugar: 12,701, 19,951
- Freight Molasses - $5/tonne: 14,000, 21,000
- Maintenance - $4/tonne cane: 320,000, 480,000
- Cane Transport $1.59/tonne cane: 127,200, 190,800

**Total Costs**: 2,947,133, 4,390,699

**Gross Margin**: 682,507, 1,053,761

**Incremental Gross Margin - Growers 40% Response**

- Av 45% GMC: 1,073,466, 1,610,199
- Total GMC: 1,755,973, 2,663,960
- Depreciation @4%: 400,000, 600,000

**Profit before interest & Tax**: 1,355,973, 2,063,960

- Tax @ 36%: 488,150, 743,026
- Profit After Tax: 867,823, 1,320,934
- Plus Depreciation: 400,000, 600,000

**Net Cash Flow**: 1,267,823, 1,920,934

**CAPLEX**

<table>
<thead>
<tr>
<th></th>
<th>10,000,000</th>
<th>15,000,000</th>
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</thead>
<tbody>
<tr>
<td>Residual Value Plant Year10</td>
<td>6,000,000</td>
<td>9,000,000</td>
</tr>
</tbody>
</table>

**Net Present Value, 10% hurdle rate**: 103,483, 273,197

**Internal Rate of Return**: 10.2%, 10.3%
7. APPENDIX 1 - Figure 1: A Schematic - Cane Yields vs. Stalk Numbers for a Range of Rectangularities
8. APPENDIX 2 - Figure 2: Narrow Row Response (%) - Plant Cane vs. Ratoon Cane 78 Clones
Figure 3: BSES Analysis of 78 Clone Data – Evidence for “Correlation” of Narrow Row Response (%) - Plant vs Ratoon Cane
<table>
<thead>
<tr>
<th>Species</th>
<th>Mosman Babinda</th>
<th>Innisfail Tully</th>
<th>Herbert</th>
<th>Proserpine Sarina</th>
<th>Burdekin</th>
<th>Dundagberg Isis</th>
<th>Maryborough Rocky Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greyback</td>
<td>20,000</td>
<td>20,000</td>
<td>3,000</td>
<td>2,000</td>
<td>26,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bundaberg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3,000</td>
<td></td>
</tr>
<tr>
<td>Caudata</td>
<td>1,000</td>
<td>1,000</td>
<td>7,500</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Childers</td>
<td>10,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consobrina</td>
<td>20,000</td>
<td>5,000</td>
<td>5,000</td>
<td>17,000</td>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>French’s</td>
<td>2,500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Froglatt’s</td>
<td>5,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graia</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nambour</td>
<td>4,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negatoria</td>
<td>15,000</td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Nocla</td>
<td>1,500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pleistolith</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Sororia</td>
<td>200</td>
<td></td>
<td>1,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southern-1-year</td>
<td>5,000</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Squamulata</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhoepea</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source: BSES 1996 Data*
APPENDIX 5 - Financial Assumptions & Calculation

Summaries of financial calculations presented in Section 6.4 are based on assumptions in the June 1997 eSYS Development assessment, with the following exceptions:

- Labour rate (planting) is increased to $15/hr to include 28% employment on-costs.
- The co-operative formula was amended to:
  
  Cane price ($/tc) = Sugar Price ($/ts) * 0.009 * (CCS-4) + 0.578 + 0.579

0.578 is an industry constant; the additional factor of 0.579 covers current grower payments for continuous operations etc

An example of the ensuing calculations for the Southern Region, Sugar price $335/tn, CCS 13.5 follows:

Cane price based on co-operative formula: $29.80/tc
Seed tc/ha employed: 5 tc/ha (single rows), 8 tc/ha (dual rows), 15 tc/ha (close rows) @ $29.80/tc

<table>
<thead>
<tr>
<th>Yield assumptions t/ha</th>
<th>Std 1.5m Rows</th>
<th>dual rows(20%)</th>
<th>close rows(50%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring Plant</td>
<td>100</td>
<td>120</td>
<td>130</td>
</tr>
<tr>
<td>First Ratoon</td>
<td>110</td>
<td>132</td>
<td>165</td>
</tr>
<tr>
<td>Second Ratoon</td>
<td>99</td>
<td>119</td>
<td>149</td>
</tr>
<tr>
<td>Third Ratoon</td>
<td>89</td>
<td>107</td>
<td>134</td>
</tr>
</tbody>
</table>

**Plant Cane Costs $/ha**

<table>
<thead>
<tr>
<th></th>
<th>Std 1.5m Rows</th>
<th>20%Response, Dual</th>
<th>50%Response, Close</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planting</td>
<td>$300</td>
<td>$450</td>
<td>$500</td>
</tr>
<tr>
<td>Seed</td>
<td>149</td>
<td>238</td>
<td>447</td>
</tr>
<tr>
<td>Land preparation</td>
<td>157</td>
<td>157</td>
<td>157</td>
</tr>
<tr>
<td>Pesticides</td>
<td>310</td>
<td>375</td>
<td>466</td>
</tr>
<tr>
<td>Cultivation</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>450</td>
<td>540</td>
<td>720</td>
</tr>
<tr>
<td>Irrigation</td>
<td>324</td>
<td>324</td>
<td>324</td>
</tr>
<tr>
<td>Harvesting</td>
<td>600</td>
<td>720</td>
<td>900</td>
</tr>
<tr>
<td><strong>Total P cane Costs</strong></td>
<td>$2,490</td>
<td>$3,004</td>
<td>$3,814</td>
</tr>
</tbody>
</table>

**Av Ratoon Costs $/ha**

<table>
<thead>
<tr>
<th></th>
<th>Std 1.5m Rows</th>
<th>20%Response, Dual</th>
<th>50%Response, Close</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pesticides</td>
<td>$50</td>
<td>$50</td>
<td>$50</td>
</tr>
<tr>
<td>Cultivation</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>300</td>
<td>360</td>
<td>480</td>
</tr>
<tr>
<td>Irrigation</td>
<td>324</td>
<td>324</td>
<td>324</td>
</tr>
<tr>
<td>Harvesting</td>
<td>596</td>
<td>715</td>
<td>894</td>
</tr>
<tr>
<td><strong>Total av R cane Costs</strong></td>
<td>$1,370</td>
<td>$1,549</td>
<td>$1,848</td>
</tr>
</tbody>
</table>

**Gross Marginal Contribution/ha**

<table>
<thead>
<tr>
<th></th>
<th>Std 1.5m Rows</th>
<th>20%Response, Dual</th>
<th>50%Response, Close</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm Income av pa</td>
<td>$2,965</td>
<td>$3,558</td>
<td>$4,448</td>
</tr>
<tr>
<td>Loss Weighted av Costs/ha</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planting</td>
<td>75</td>
<td>113</td>
<td>151</td>
</tr>
<tr>
<td>Seed</td>
<td>37</td>
<td>60</td>
<td>112</td>
</tr>
<tr>
<td>Land Preparation</td>
<td>39</td>
<td>39</td>
<td>39</td>
</tr>
<tr>
<td>Pesticides</td>
<td>115</td>
<td>132</td>
<td>155</td>
</tr>
<tr>
<td>Cultivation</td>
<td>125</td>
<td>125</td>
<td>125</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>338</td>
<td>405</td>
<td>540</td>
</tr>
<tr>
<td>Irrigation</td>
<td>324</td>
<td>324</td>
<td>324</td>
</tr>
<tr>
<td>Harvesting</td>
<td>597</td>
<td>716</td>
<td>896</td>
</tr>
<tr>
<td><strong>Total Costs</strong></td>
<td>1,651</td>
<td>1,915</td>
<td>2,342</td>
</tr>
<tr>
<td><strong>Annual Gross Margin $/ha</strong></td>
<td>$1,314</td>
<td>$1,648</td>
<td>$2,106</td>
</tr>
</tbody>
</table>

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30 It should also be noted that the eSYS analysis understates net grower income presumably due to an arithmetical error. This was discussed with Dr McClaod who has since released an amended excerpt; income for close rows (Southern region 60% response) is now $4,653/ha of $4,359/ha in the original study. Whilst the error does not affect the original conclusions which are based on comparisons with standard rows, there will be an influence on the breakeven point at which close rows become worthwhile for growers.