

# Sugar Research & Development Corporation

## Final Report

**Project No** UQ034  
**Title** Analysis of sugarcane productivity trends in the wet tropics at a district level

**Restriction** Normal/Unrestricted

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## Funding

<u>Milestone Number</u>	<u>Date</u>	<u>SRDC Funding</u>	<u>Task Description</u>
1	1/3/99	4,609	Signing of agreement; appointment of RA
2	1/9/99	19,375	Determination of methodology
3	1/3/00	35,000	Preliminary analysis
4	1/9/00	24,375	Detailed analysis
5	1/3/00	<u>2,742</u>	Completion of papers and project
		<b>\$116,101</b>	

## Disclaimer

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## **Abstract**

This study aimed to develop a methodology for the regular analysis of mill district data to assess productivity trends over time, accounting for variety and variety  $\times$  environment interaction effects. Restricted maximum likelihood methodology can be used in a mixed model analysis to produce best linear unbiased predictors for random effects and best linear unbiased estimates for fixed effects.

It was applied to data on cane yield (TCH), sugar content (CCS) and their product, sugar content per hectare (TSH), from three mill districts (Mulgrave, Babinda, and Tully) for 1958-1995. In the combined analysis over districts, Q124 was the top ranking variety for TCH, and Q120 was top ranking for both CCS and TSH. Overall production for TCH increased over the 38-year period. Some of this increase can be attributed to varietal improvement, although the predictors for TCH have shown little progress since the introduction of Q99 in 1976. While smaller gains have been made in varietal improvement for CCS, overall production for CCS decreased during this time due to non-varietal factors. Varietal improvement in TSH appeared to peak in the mid-1980's. Overall production for TSH remained stable over time due to the varietal increase in TCH and the non-varietal decrease in CCS.

## **Non-Technical Summary**

This project provided an in-depth re-analysis of district level data for cane yield, sugar content, and sugar content per hectare for the mill districts of Mulgrave, Babinda, and Tully and an evaluation of the estimates of changes in productivity for the period from 1958 to 1995, as derived by Leslie and Wilson (1996).

Restricted Maximum Likelihood (REML) methodology (Patterson and Thompson, 1971) was shown to be applicable to the analysis of productivity data at the district level. Importantly, this methodology can now be implemented with readily available computer software (Gilmour et al., 1996). Its capacity to deal with unbalanced data sets (varieties change over time and across districts) is particularly useful. REML enables a more rigorous and complete estimation of productivity trends over time when adjusting for variety and variety  $\times$  environment interactions than previously used methods.

For the period under investigation, some of the increased cane yield (tonnes of sugarcane per hectare) was due to improved varieties while the decrease in sugar content was due to other factors. As a result, sugar content per hectare remained relatively stable during this time.

## **Background**

Productivity data has the potential to be used to evaluate varieties over the full range of growing and management conditions relative to the limited range of conditions under which formal varietal trial data are collected. This type of data set has not been examined thoroughly in the literature, possibly due to lack of availability and of appropriate

methods of analysis. Its investigation should complement the results found using varietal trial data and enable further insight into the underlying biological system.

In a previous study (Leslie and Wilson, 1996), single variety indexing methods and linear time trend analysis were used to estimate proportionate changes in commercial cane yields and sugar content in the wet tropics due to varietal improvement from 1958 to 1995. This permitted estimates of the residual changes in productivity for that period due to non-varietal causes. The estimates for Mulgrave, Babinda, and Tully mill districts were used to interpret the causes of productivity changes in each of those districts, and priority areas for research and development for the wet tropics were then defined.

Statistical methodologies based on restricted maximum likelihood (REML) are now available for unbalanced data. They can be applied to productivity data which are unbalanced in the sense that varieties change over time and across districts. The results from such analyses are best linear unbiased predictors or estimates for varieties, districts, years, and their interaction terms. It was deemed important to re-analyse the Leslie and Wilson data to see if both methods gave similar interpretations.

## **Objectives**

1. In-depth re-analysis of district level data for cane yield (TCH) and sugar content (CCS) for Mulgrave, Babinda, and Tully and evaluation of the estimates derived by Leslie and Wilson (1996).
2. Development of a methodology for regular analysis of productivity data in all relevant mill districts for assessment of productivity trends over time, adjusted for variety and variety  $\times$  environment interactions effects.

## **Methodology**

Data on tonnes of sugarcane per hectare (TCH), sugar content (CCS) and their product, tonnes of sugar content per hectare (TSH) were analysed for the districts of Mulgrave (1958-1995), Babinda (1961-1995) and Tully (1960-1995, excluding 1988) by Leslie and Wilson (1996) using a single variety indexing method. The yearly mill data were made available to them in order to produce a report commissioned by SRDC and the CRC for Sustainable Sugar Production. Their methodology, which was used to estimate the impact of varieties on TCH, CCS and TSH, was investigated in the present project and the results shown to be dependent on the years of overlap among the varieties. The subjectivity created by determining the period of overlap could (and did) produce significantly different results.

Restricted maximum likelihood (REML) methodology was used to overcome the above subjectivity in determining overlap area, and also to help in accommodating the unbalanced nature of the data set in that varieties changed over time and across districts. It was implemented via the computer software package ASREML (Gilmour et al., 1996). Separate and combined district data were considered and best linear unbiased predictors

(BLUPs) for random effects and best linear unbiased estimates (BLUEs) for fixed effects were computed in mixed model analyses. The BLUPs and BLUEs were then utilised to evaluate productivity improvements separately associated with variety, district and year, as well as their interactions.

## **Results and Discussion**

REML was useful in detecting varietal production trends that were not evident in raw trends and helped identify anomalies that were confirmed from other sources. TCH generally increased due to varietal improvement in each district, but yield seemed to have plateaued since 1990. Although varietal improvement in TCH peaked with Q124 in 1987, little increase in TCH has occurred since Q99 in 1976. CCS has seen moderate varietal improvement since the early varieties in the 1960s, but overall CCS production has declined due to non-varietal effects. TSH remained fairly constant due to the increased production of TCH and the decreased production of CCS. Overall, there was no evidence of varietal improvement in TSH since the introduction of Q117 in 1983 and Q120 in 1984. These general inferences were consistent with those of Leslie and Wilson (1996).

REML proved to be appropriate for the analysis of productivity data at the district level and therefore provides the required methodology for regular analysis of such data. A manual (Ellis *et al.*, 2001c) is being prepared to enable others to follow the procedures with their own data. Input and output relevant to the above data set will be included for easy of transfer of this technology.

## **Assessment and Recommendations**

This study achieved its purpose of developing and/or determining a straight-forward methodology for the analysis of productivity data at the mill level to allow assessment of productivity trends over time, accounting for variety and variety  $\times$  environment interaction effects. Once identified, this methodology was used to re-analyse the data considered by Leslie and Wilson (1996).

The impact of this work is that the Sugar Industry in Australia and elsewhere can use the procedures outlined in the resulting publications, Ellis *et al.* (2001a and 2001b), for the analysis and interpretation of similar data sets. This will help to effectively interpret the causes of productivity changes in the relevant mill districts and define priority areas for research and development.

The emphasis in that work is on the cross-district analysis using combined district productivity data. Another manuscript, Ellis *et al.* (2001c), uses the same methodology but concentrates on the nature of genotype  $\times$  district interactions, and compares the results found using mill productivity data with the results found by analysing sugarcane multi-environment trial data.

## References

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\* Publications arising from this project.