SHORT, NON-REFEREED PAPER

QUANTIFYING CANE YIELD AND PRODUCTION TRENDS IN THE SOUTH AFRICAN SUGARCANE INDUSTRY: RESULTS FOR THE SOUTH COAST REGION

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Abstract

The aim of this study was to quantify rates of change in the productivity of sugarcane land, attributable to factors other than climate variability and harvest age in the South Coast region of the South African (SA) sugar industry for the period 1980/81-2009/10. Long-term trends in annualised actual yields and area under cane (AUC) were derived from data supplied by the SA Cane Growers' Association and the SA Sugar Association's Industry Affairs division. Crop growth and yield in eight agro-climatic zones making up the South Coast region were simulated for each season using the Canesim crop model. Harvest ages for coastal zones were inferred from percentage AUC harvested. Canesim model yield simulations provided yield benchmarks as influenced by the climatic potential and harvest age. Any trend over time in the ratio of actual to simulated yields, termed the Agronomic Performance Index (API), was taken as a measure of yield decline or increase. Actual sugarcane yields decreased, on average, by 0.08 t/ha/year (2.43 t/ha ≈ 5.5% over the 30 years). The API fell from 58.2% to 52.4% over the same period, a statistically significant (15% confidence level) yield decline of over 10%. The effects of introducing improved technology (e.g. better varieties) were not considered in the study, but should have increased yields. AUC in the region decreased by 2% per year for the period 2006-2010 (1800 ha/year ≈ 80 000 t/year). The reduction in productivity of land under cane, and decreasing AUC, threaten future cane supply in the South Coast region. This study is to be extended across the industry.

Keywords: yield decline, Canesim, potential production, yield plateau, cane supply, area under cane

Introduction

Anecdotal evidence exists of yield decline in the South African sugar industry. The perception of yield decline probably derives from the decrease in industry cane production, from ~24 million tons in 1999/2000 to ~16 million tons in 2010/11 (Singels *et al.*, 2011). Several authors have published detailed strategies for combating sugarcane yield decline in SA, without formally exploring the extent or spatial distribution of yield decline (e.g. Lagerwall *et al.*, 2010). Jones (2010) indicated declining per-area harvested yield trends in many regions from 1995/96 until 2009/10, but did not attempt to make corrections for climatic variability. A sugarcane yield plateau was identified in Australia in the early 1990s (Garside *et al.*, 2000), which was attributed to consequences of intensive monocropping of sugarcane – a common feature of the South African industry. Climate change could also have impacted on yields (e.g. Singels *et al.*, 2005). Decreasing area under cane (AUC) would result in reduced production, but not necessarily yields. It is therefore important that losses due to climate or AUC be separated from those due to increasingly sub-optimal agronomic practices.

The objectives of this study were to develop a methodology for quantifying yield decline, and then to apply it to the South Coast (SC) region. This methodology is to be extended to other regions, and to the industry as a whole. The authors are not aware of any studies where yield decline in the SA sugar industry has been scientifically quantified.

Two factors were identified over which growers have little control, which may have affected yields on the SC: the reduction in harvest age, in response to the *Eldana saccharina* stalk borer (Inman-Bamber, 1991); and climate variability. The authors' definition of yield decline is intended to be pragmatic and useful to industry stakeholders: it is the decrease in productivity of sugarcane land, excluding the effects of changes in harvest age and climate. This is broader than the definition by Garside *et al*. (2000), "the loss in the productive capacity of sugarcane soils", which focused solely on soil health. Both climatic variability and harvest age effects are taken into account by crop models such as Canesim (Bezuidenhout and Singels, 2007).

Materials and Methods

Cane deliveries (t), area harvested (AH, ha) and AUC data, per season 1980/81 to 2009/10, for all deliveries to the Umzimkulu and Sezela mills, were obtained from the SA Cane Growers' Association (SACGA) and the SA Sugar Association's Industry Affairs.

Average actual yields (Y_a, t/ha) per season were calculated by dividing total cane delivered by total AUC, which is consistent with our definition of yield decline and mathematically equivalent to annualising yields.

The Canesim crop forecasting (CF) system (Bezuidenhout and Singels, 2007) was used to estimate seasonal yields. Bezuidenhout (2005) identified eight distinct agro-climatic zones (homogenous climate zones (HCZs)) in the SC region. Soil water holding capacities of 64 to 100 mm and harvest ages of 14-22 months were identified for these HCZs. These ages at harvest were adjusted for each season, by inference from the ratio of AUC to AH, with an adjustment for proportion of land fallowed (assumed to be constant over the 30 years). Harvest ages decreased over time only in coastal growing areas, remaining constant in hinterland areas (personal communication[1]).

Yields of crops harvested from mid-April until mid-December were simulated, for each combination of soil and weather/rainfall station for each HCZ, using daily weather data from seven weather stations and 20 rainfall stations. Yields were weighted by HCZ area to calculate seasonal simulated yields for the region as a whole. Although relative areas of HCZs were assumed to remain fixed over time, the contribution of coastal zones to weighted average seasonal simulated yield ($Y_{s,i}$, for season *i*, t/ha) increased (relative to hinterland zones) as their harvest ages decreased, because more of the area was harvested each season. Finally, the agronomic performance index (*API*) for season *i* was calculated:

$$API_i = \frac{Y_{a,i}}{Y_{s,i}} \qquad \text{Equation 1}$$

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Y_s reflects climatic potential yield and is responsive to harvest age, so any trend in API over time reflects a change in productivity (yield) attributable to factors other than climate or harvest age. A decreasing API trend (smaller actual yields relative to simulated yields) would indicate that growers are farming less effectively (yield decline), and *vice versa*.

Statistical testing (R^2 and F-test) was applied to yield, AUC and API trends to establish significance of differences over time.

Results and Discussion

Cane production and AUC

Cane production increased on average (~6100 t/year) over the 30-year period, but decreased at a rate of ~80 000 t/year from 2000/01 to 2009/10, a 23% decrease over the 10 years. AUC decreased at a rate of over 1000 ha/year (2000/01 to 2009/10), accelerating to 1800 ha/year (2% per year, 2005/06 to 2009/10).

Despite net and average increases in production and AUC overall, their rapid and statistically-significant decreases in recent years is concerning, particularly if these trends continue.

Yields

Actual yields (t/ha AUC) declined at a rate of 0.084 t/ha/year, a decrease of 5.5% (Figure 1). However, simulated yields increased at 0.03 t/ha/year (1.0% increase 1980/81 to 2009/10) (data not shown). These were not statistically significant. There is no evidence to suggest that climate variability/reduced harvest age have unfavourably impacted yields.

API (Figure 1) declined at 0.002 /year, from 0.58 to 0.52 between 1980/81 and 2009/10, a decrease of 10.9%. Inter-season variability in API was caused by simplifications in model inputs (i.e. representing the whole SC as eight homogenous zones), model error and operational factors not considered by the model (e.g. variation in pest and disease impacts).

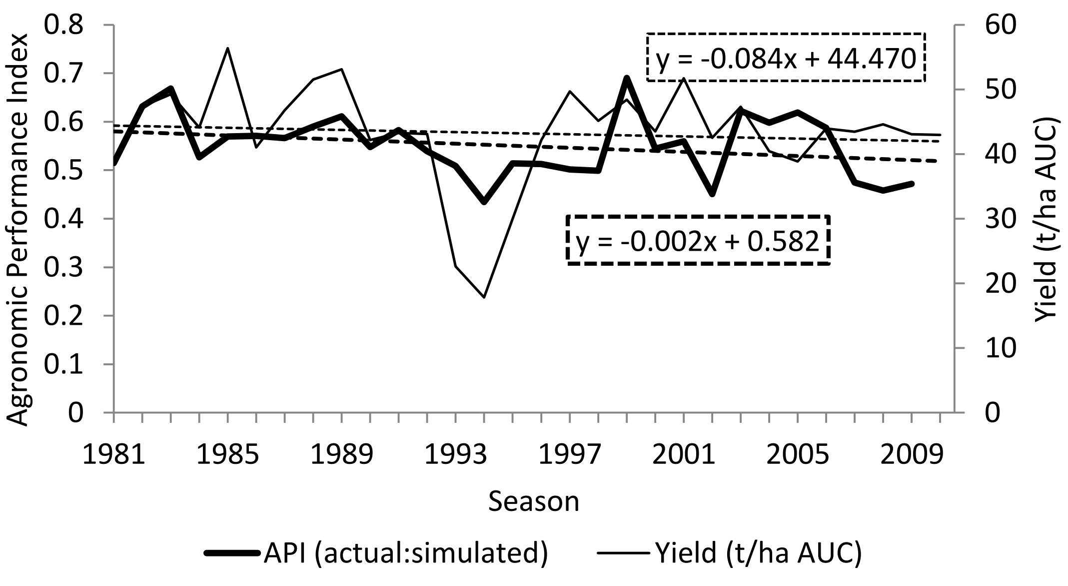

Figure 1. Agronomic performance index (API, ratio of actual to simulated yields), yield (t/ha under cane), and linear trends for the South Coast region.

The trend in API indicates that sugarcane was grown nearly 11% less effectively in 2009/10 than it was in 1980/81, and this cannot be blamed on climate change or reduced harvest cycles. If technology improvements – better varieties, techniques and equipment – had been included, it is likely that the API would have shown an even greater decline. The API trend was significant at the 15% confidence level, suggesting that yield decline is present in the SC region.

Conclusion

Yields decreased by 5.5% from 1980/81 to 2009/10. When the effects of climate variability and reduced harvest age were factored out, a more rapid and statistically significant yield decline rate became evident – nearly 11% over the 30-year period. Technology improvements ought to have increased yields in this time. It can be concluded that both yield decline and decreased AUC have contributed to reduced cane production on the South Coast. This study is to be extended across the SA sugar industry.

Acknowledgements

The authors wish to thank Nithia Govender, Nikki Sewpersad (SASRI), Tshepo Pilusa (SACGA) and Wellington Sikuka (SASA Industry Affairs) for their assistance.

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