SHORT COMMUNICATION

ESTIMATES OF REGIONAL SCALE WATER USE FOR SUGARCANE IN SOUTH AFRICA*

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Abstract

Water use of rain-fed sugarcane has come under the spotlight in South Africa, largely as a result of changes in legislation and a focus on streamflow reduction activities. In this study, Thompson's (1976) relationship between sugarcane yield and evapotranspiration is applied in conjunction with regional cane production records. These were used to provide regional estimates of water use of commercial rain-fed and irrigated sugarcane as affected by environmental limitations. The mean water use of sugarcane at an industry scale was 598 mm/annum. This included irrigated cane and is approximately 40% of the mean industry potential evapotranspiration for a full canopy crop. An estimate of water use of rain-fed cane is approximately 36% of potential evapotranspiration. The results given in this paper provide strong evidence that simple comparisons of the potential evapotranspiration of different crops or land covers are of little value in determining potential hydrological impacts.

Keywords: sugarcane water use, Thompson model, modelling, evapotranspiration, streamflow reduction activities

Introduction

The water use of rain-fed sugarcane has come into focus in South Africa, largely as a result of the 1998 South African Water Act which, *inter alia*, regulates streamflow reduction activities (SFRA). Kruger *et al*. (2000) used Potential Evapotranspiration (PET) rates of different land uses to target potential SFRA. Sugarcane has high PET rates and was targeted for further investigation. A key question, however, is to establish whether PET is a reasonable parameter to estimate hydrological impacts.

This short communication reports on the work by Bezuidenhout *et al.* (2006). Thompson's (1976) robust relationship between sugarcane yield and actual evapotranspiration (AET) was applied in conjunction with historical cane yield records to provide regional estimates of the actual water use of sugarcane as affected by environmental limitations. The hypothesis was that, in reality, growing conditions are seldom ideal and, as a result, the actual water use/AET of a crop is distinctly different to PET. In addition, the AET of different crops can be similar when grown under water limited conditions, such as in shallow soils, despite large differences in PET rates.

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Methodology

Thompson (1976) derived a robust relationship between sugarcane yield and AET (Eq. 1).

$$Yield = 9.53\frac{\Sigma E_P}{100} - 2.36 \qquad (1)$$

where:

ΣE_P (mm) is total AET since crop initiation
Yield (t/ha) is cane yield

Equation 1 is representative of the typical harvesting windows in commercial sugarcane crops in South Africa, and provided a reputable benchmark for several research studies (e.g. Coombs, 1984; Schulze, 1995; Lumsden *et al,* 1998; Singels and Bezuidenhout, 2002). Thompson's model has been widely referenced and acknowledged, including in Brazil (Scarpari and de Beauclair, 2004), Australia (Muchow *et al*, 1994; Robertson *et al*, 1996; Evensen *et al*, 1997), Thailand (Brzesowsky and van Vilsteren, 1988), the USA (Legendre and Burner, 1995) and Mauritius (Cheeroo-Nayamuth *et al*, 2000).

Regional total annual sugarcane production from 1979 to 2002 was estimated from annual historical mill crush data. The estimates were corrected for seedcane schemes, cane spillages, losses associated with harvest to crush delays, changes in milling configurations and changes to crop age (Bezuidenhout *et al*, 2006).

Results and Discussion

The mean water use of sugarcane at an industry scale was 598 mm/annum. This estimate, which includes irrigated cane, is 40% of 1400 mm/a potential water use of a fully canopied crop, as calculated using the Penman-Monteith equation (McGlinchey and Inman-Bamber, 1996). Figures 1a-e depict probability of non-exceedance plots of AET for the South African sugarcane growing regions. The mean AET values are illustrated in Figure 2 to depict spatial trends.

Water use in the Northern Irrigated regions of Mpumalanga and Pongola is significantly higher than in the other regions. Zululand (Figure 1b) has a wide range of climatic regions, stretching from high altitude mistbelt conditions at Entumeni to floodplain and large irrigated areas at Umfolozi. It was noted that water use on the South Coast is similar to that of the Midlands, even though the evaporative demand on the coast is higher. This is probably attributed to:

- poorer sandy soils and hence more water stress on the coast
- the inclusion of some irrigated cane in the Midlands.

The South Coast is the only region where the influence of irrigated cane on water use estimates can be neglected. The median water use as a percentage of PET in this region is 36%.

It is apparent that soil water availability is limiting in the evapotranspiration process for rain-fed sugarcane in South Africa. This implies that, although differences between the AET of different crops may be small, the PET of these crops may be distinctively different. Furthermore, rooting characteristics of different crops, which affect soil water availability, are important determinants of hydrological impacts and are, under rain-fed conditions, probably more important than any differences in PET.

The use of PET to determine potential SFRAs is over-simplified. Comprehensive systems analyses with representative process-based hydrological models are needed to determine whether or not there are any significant differences between the AET of different crops, and how these differences will impact on water availability between competing users. The results of this paper provide a good benchmark of AET for sugarcane, which will be valuable in such a modelling exercise.

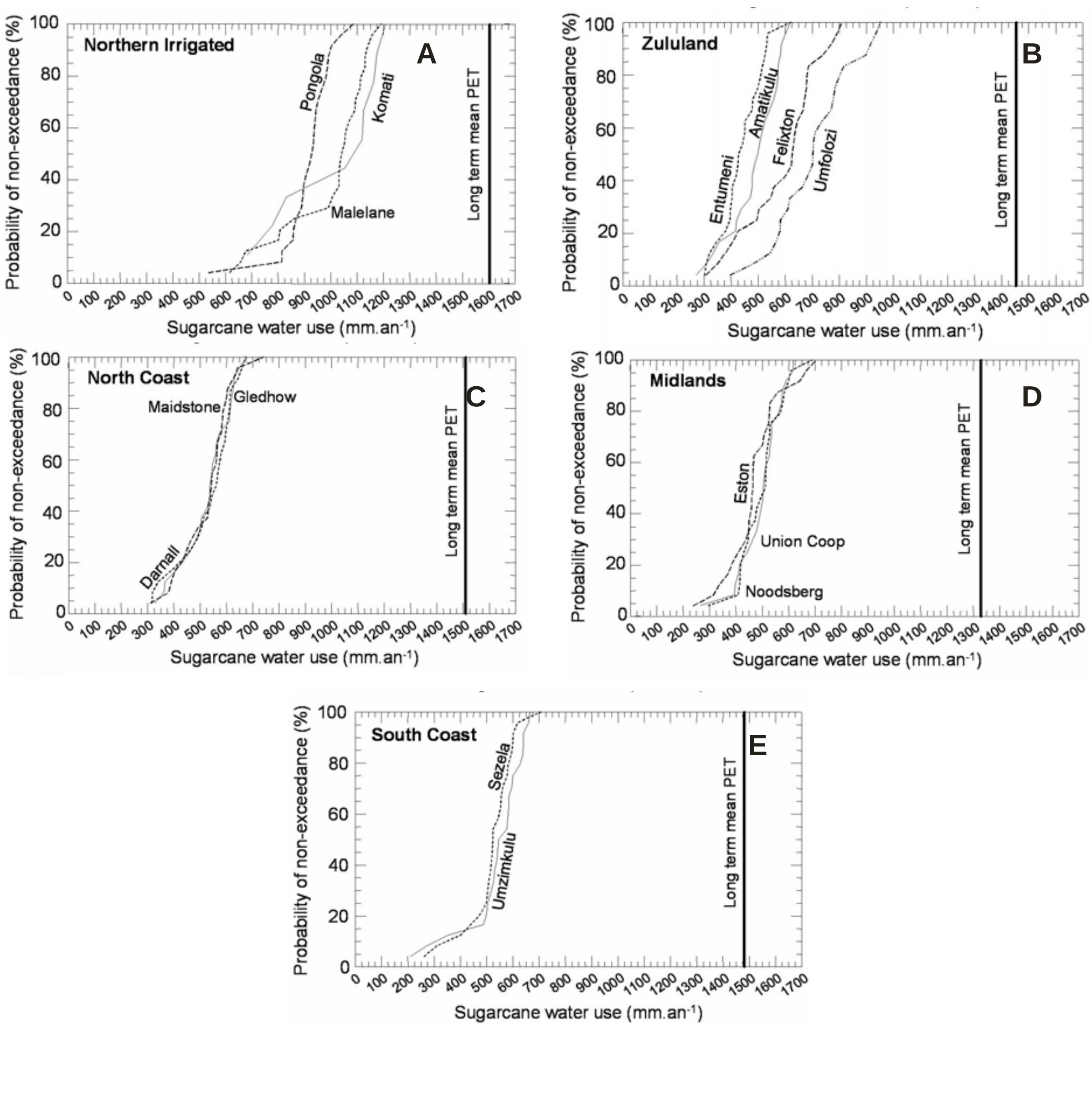

Figure 1. Probability of non-exceedance plots of mean annual regional water use based on the 1978 to 2002 seasons. Solid lines to the right of these plots depict long-term mean potential water use values (from Bezuidenhout *et al*, 2006).

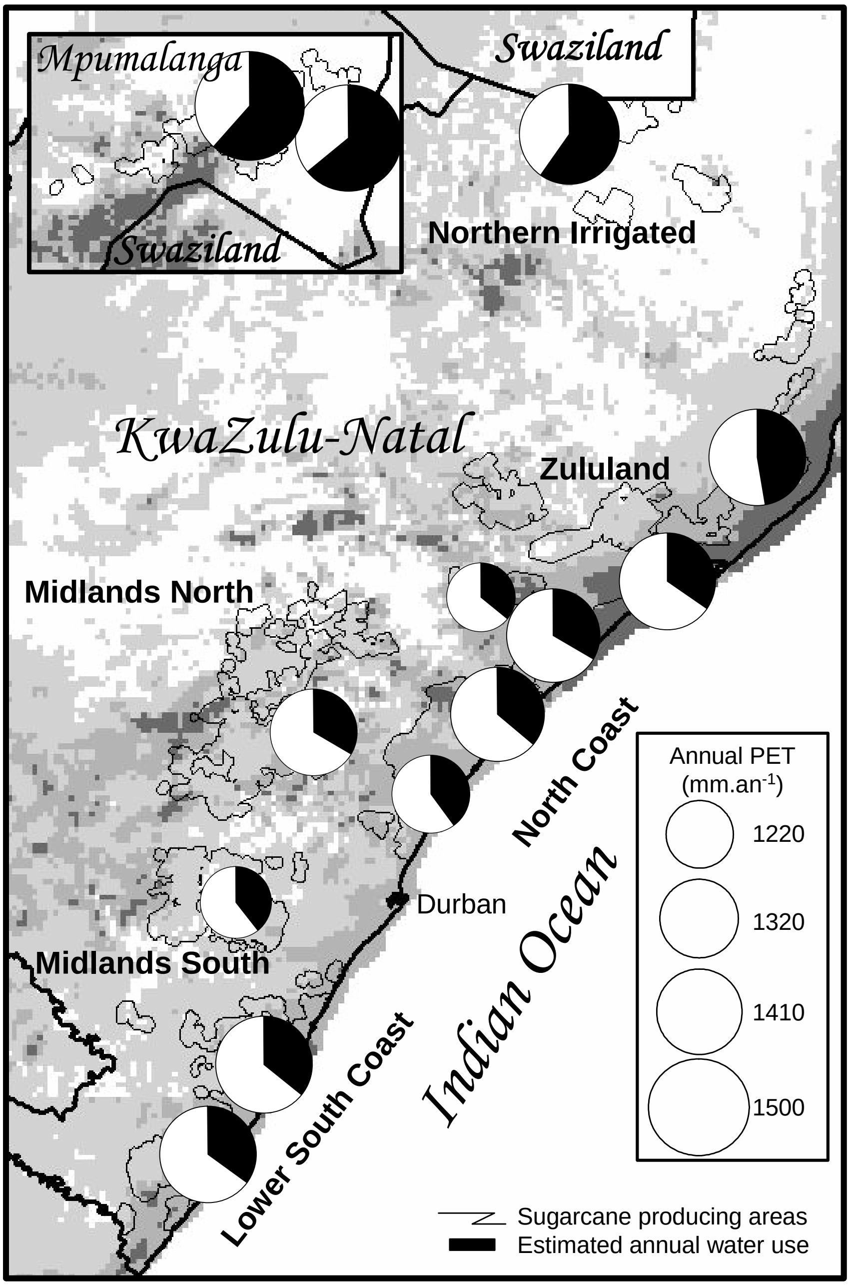

Figure 2. Spatial distribution of annual estimated water use by sugarcane (black areas in pie charts) relative to mean annual potential evapotranspiration (PET) (indicated by the size of each pie chart) (from Bezuidenhout *et al*, 2006).

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REFERENCES

Bezuidenhout CN, Lecler NL, Gers C and Lyne PWL (2006). Regional based estimates of water use for commercial sugar-cane in South Africa. *Water SA* 32(2) (in press).

Brzesowsky WJ and van Vilsteren AEM (1988). An economic-evaluation of sugar-cane production under different water-supply systems in Thailand. *Agric Water Manage* 13(1): 83-91.

Cheeroo-Nayamuth FC, Robertson MJ, Wegener MK and Nayamuth ARH (2000). Using a simulation model to assess potential and attainable sugar cane yield in Mauritius. *Field Crops Res* 66(3): 225-243.

Coombs J (1984). Sugar-cane as an energy crop. *Biotechnol Gen Eng Rev* 1: 311-345.

Evensen CI, Muchow RC, Elswaify A and Osgood RV (1997). Yield accumulation in irrigated sugar-cane .1: Effect of crop age and cultivar. *Agron J* 89(4): 638-646.

Kruger FJ, Bosch JM, Everson C and Burger C (2000). Land-based activities that may be declared Stream Flow Reduction Activities in terms of Section 36 of the National Water Act (Draft 1). Report to the Sub-Directorate: Stream Flow Reduction Activities of the Department of Water Affairs and Forestry, South Africa.

Legendre BL and Burner DM (1995). Biomass production of sugarcane cultivars and early-generation hybrids. *Biomass Bioenergy* 8(2): 55-61.

Lumsden TG, Lecler NL and Schulze RE (1998). Simulation of sugarcane yield at the scale of a mill supply area. *Proc S Afr Sug Technol Ass* 72: 12-17.

McGlinchey MG and Inman-Bamber NG (1996). Predicting sugarcane water use with the Penman-Monteith equation. *Proc Evapotrans Irrig Sched,* Am Soc Agric Eng, San Antonio, USA. pp 592-597.

Muchow RC, Spillman MF, Wood AW and Thomas MR (1994). Radiation interception and biomass accumulation in a sugarcane crop grown under irrigated tropical conditions. *Aust J Agric Res* 45(1): 37-49.

Robertson MJ, Wood AW and Muchow RC (1996). Growth of sugarcane under high input conditions in tropical Australia. 1: Radiation use, biomass accumulation and partitioning. *Field Crops Res* 48(1): 11-25.

Scarpari MS and de Beauclair EGF (2004). Sugarcane maturity estimation through edaphic-climatic parameters. *Sci Agric* (Piracicaba, Brazil). 61(5): 486-491, ISSN 0-103-9016.

Schulze RE (1995). Hydrology and Agrohydrology: A Text to Accompany the ACRU 3.00 Agrohydrological Modelling System. WRC Report No. TT 69/95. Water Research Commission, Pretoria, South Africa. 552 pp.

Singels A and Bezuidenhout CN (2002). A new method of simulating dry matter partitioning in the CANEGRO sugarcane model. *Field Crops Res* 78(2-3): 151-164.

Thompson GD (1976). Water use by sugarcane. *S Afr Sug J* 60: 598-600, 629-635.