

## THE EFFECT OF PLANT RESIDUE LAYERS ON WATER USE AND GROWTH OF IRRIGATED SUGARCANE

OLIVIER F C and SINGELS A

*South African Sugarcane Research Institute, Private Bag X02,  
Mount Edgecombe, 4300, South Africa*  
[francois.olivier@sugar.org.za](mailto:francois.olivier@sugar.org.za) [Abraham.singels@sugar.org.za](mailto:Abraham.singels@sugar.org.za)

### Abstract

The industry is under pressure to use water more efficiently. One way of achieving this is through the retention of a layer of plant residues to reduce wasteful evaporation from the soil. However, a residue layer could also inhibit crop growth. This communication reports on the results obtained from a field experiment conducted at Pongola on three weighing lysimeters, to measure the impact of residue layers on crop water use, canopy development, crop growth and final yield.

*Keywords:* plant residue, trash, water use, irrigation, evapotranspiration, stalk population, canopy development

### Introduction

The South African sugar industry is under pressure to demonstrate that limited water resources are being used efficiently. One way of achieving this is through the retention of a layer of plant residues from the previous crop to reduce wasteful evaporation from the soil surface. Other reported advantages of such a cropping system include improved soil health and better weed control (de Beer *et al*, 1995). Reported disadvantages include reduced crop growth rate and yield (Gosnell and Lonsdale, 1978) higher harvesting and transport costs and an upsurge of insect pests (Meyer *et al*, 2005). The change to a system of retaining crop residues has therefore been slow among farmers, and as a result, only 20% of the cane in KwaZulu-Natal and less than 5% in Mpumalanga is harvested as green cane.

The objective of this study was to determine the effect of different types of residue layers on (i) crop growth, (ii) water use and (iii) cane yield of fully irrigated sugarcane. This information could be used to improve the ability of crop models to accurately simulate crop growth and water use in a residue layer cropping system. It could also assist in formulating best irrigation management practices for profitable and sustainable sugarcane production.

### Methods

A field trial was conducted at the South African Sugarcane Research Institute (SASRI) research station at Pongola on a trial site that contained three weighing lysimeters, each 2.44 m long, 1.52 m wide and 1.22 m deep. Cultivar N14 was planted on 24 April 2004 in rows 1.4 m apart in a Hutton soil containing 30% clay. Lysimeters, as well as the area surrounding each lysimeter, had (i) no residue cover (Bare), (ii) soil covered by a light layer

of cane tops (Tops) or (iii) soil covered by a heavy layer of tops and dead leaves (Trash). Plant residue layers were applied one month after germination at a rate of 8.3 t/ha (14 cm thick) for Trash and 1.8 t/ha (10 cm thick) for Tops. Hourly changes in weight of individual lysimeters were detected electronically (to the nearest 0.1 mm) via load cells (Route Calibration Services) connected to a CR10X (Campbell Scientific Inc.) data logger. Tipping bucket rain gauges (Texas Instruments) measured deep drainage under each lysimeter. Lysimeters were irrigated individually according to demand, on reaching a deficit of 20 mm as indicated by lysimeter readings. A watering can was used to apply exact irrigation amounts and to mimic an overhead irrigation system. The cane fields surrounding the lysimeters were irrigated with a drip irrigation system according to the Canesim program (Singels *et al*, 1998) and weather data.

Stalk population, stalk height and fractional interception of photosynthetic active radiation (measured with a model PAR-80 Ceptometer, Decagon Devices, Pullman, WA, USA) were determined biweekly. At harvest (12 months of age) cane yield was determined and the total crop water use calculated. To account for the effect of crop characteristics on crop water requirements, crop coefficients ( $K_c$ ) were calculated to relate reference crop evapotranspiration ( $ET_0$ ) to crop evapotranspiration ( $ET_{crop}$ ) according to FAO 56 guidelines (Allen *et al*, 1998).  $ET_{crop}$  was calculated as the daily change in lysimeter mass (converted to mm water), plus irrigation (mm), minus deep drainage (mm). Suspect data, e.g. negative  $ET_{crop}$  values, were removed from the dataset.

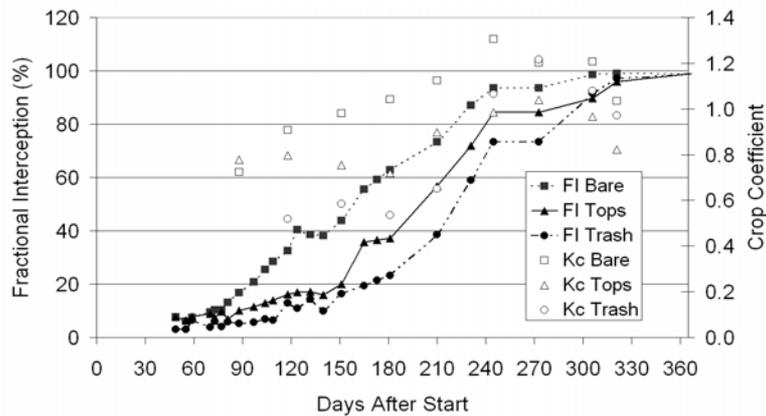
## Results and Discussion

### *Crop growth*

Plant residue layers had a negative effect on rate of canopy development and crop growth. The Bare treatment reached 80% radiation capture 20 days before the Tops treatment and 45 days before the Trash treatment (Figure 1). Thermal times (base 16) required to reach 50% and 80% radiation capture for the Bare, Tops and Trash treatments were 267, 481 and 622°Cd and 622, 815 and 1046°Cd respectively. All treatments, however, intercepted close to 100% of the radiation towards the end of the growing season. Wood (1991) reported similarly that a residue layer could have a negative effect on the crop by slowing down initial growth, tillering and radiation interception due to lower soil temperatures.

Cane stalks of the Tops and Trash treatments were slightly shorter than those of the Bare treatment throughout the growing season. Peak tiller population of the Tops and Trash treatments were reduced by 38% when compared with those of the Bare treatment. Final stalk population was, however, similar for all three treatments, namely 23 stalks/m<sup>2</sup>.

Although both residue treatments reduced final cane yield by an average of 14%, yields were not statistically different from that of the Bare treatment (125 t/ha). A similar, but less pronounced trend was observed in cane grown on the areas surrounding the lysimeter scales. Significant yield responses to residue blankets have been reported for rainfed cane by Wood (1991) (10 t/ha), van Antwerpen *et al.* (2001) (9.3 t/ha) and for low rainfall areas by de Beer *et al.* (1995).

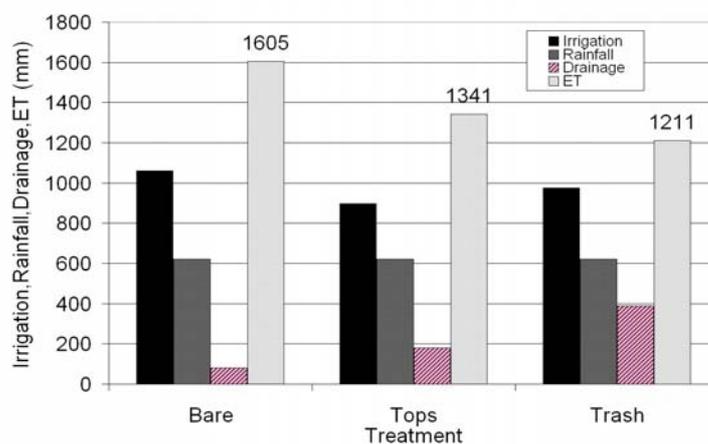


**Figure 1. Fractional interception (FI) of photosynthetic active radiation as affected by different residue layers. Corresponding crop coefficients (Kc values) for the FAO 56 methodology (Allen *et al*, 1998) are represented by the open symbols.**

*Crop water use*

The presence of residue layers had a marked effect on daily average crop water use, especially in the period leading up to full canopy closure. During this period, daily average crop water use in the Tops treatment was reduced by an average of 22%, and that of the Trash treatment by 40%, compared with the Bare treatment (data not shown). After full canopy closure, daily crop water use of all treatments was fairly similar. As a result, seasonal crop water use was reduced by 16% and 25% for the Tops and Trash treatments respectively (Figure 2). A significant amount of drainage was measured in the Trash treatment. This was partly due to over-irrigation on a few occasions. Thorburn *et al*, (1999) indicated that a residue blanket could reduce soil water evaporation by an amount equal to 16% of annual rainfall.

Crop coefficients for the period of partial canopy differed significantly between treatments, and hence irrigation scheduling needs to account for this. Crop coefficients calculated for use in a crop residue system were much lower than for the bare soil scenario (Figure 1). The value of 1.2 for the mid-growth phase of bare soil is in general agreement with results obtained by Inman-Bamber and McGlinchey (2003).



**Figure 2. Seasonal water balance for a 12-month old plant crop grown in Pongola, as affected by different crop residue layers.**

## General

It is noteworthy that, despite the reduction in initial growth and radiation interception under residue layers, the crop recovered towards the end of the growing season so that no significant yield loss was observed. The biggest impact was on the reduction of evaporation from the soil surface, that ultimately resulted in reduced seasonal crop water use. It is vital that normal irrigation scheduling practices be adjusted to take advantage of these savings.

## Conclusions

- Initial crop growth and radiation capture were affected negatively by crop residue layers, but without significantly reducing final cane yield.
- Seasonal crop water use was reduced by 16% and 25% for the Tops and Trash treatments respectively.

These results justify a concerted effort by the industry to further explore the application of green cane harvesting and trash blanketing in irrigated sugarcane production. Results could also be used to improve the ability of the crop models to accurately simulate crop growth and water use in a residue layer cropping system.

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