SHORT COMMUNICATION

THE EFFECT OF A TRASH BLANKET ON THE ENERGY BALANCE OF A SUGARCANE CROP: PRELIMINARY RESULTS

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Abstract

Although crop responses to plant residue layers (trash blanket) are well documented, mechanisms are poorly understood. The partitioning of the available energy at the crop surface is important, as it affects the microclimate and drives processes such as crop water use and growth. This communication gives preliminary results of attempts to quantify the impact of a trash blanket on the energy balance and its effects on crop microclimate, water use and growth.

Keywords: residue layer, soil temperature, surface renewal, eddy covariance, irrigation

Introduction

Harvesting sugarcane green and using crop residues as a mulch layer (trash blanket) for the subsequent ratoon (instead of burning residues) is a desirable alternative production system (Olivier *et al.,* 2009). Partitioning of the available energy at the crop surface affects the microclimate and drives processes such as crop water use and growth (Inman-Bamber and McGlinchey, 2003). However, knowledge of how a trash blanket affects the surface energy balance is limited and, as a result, prevents confident situation specific recommendations regarding trash management.

The net irradiance (R_n) less soil heat flux (G) is the energy available at the surface to drive various physical and physiological processes. Net irradiance is defined as the balance between incoming and reflected solar irradiance and outgoing and returned infrared irradiance. This energy flux is used primarily for heating of the soil (soil heat flux, G), evaporation of water (latent energy flux, LE) and heating of the atmosphere above the soil (sensible heat flux, H). The shortened energy balance can be written as:

$$R_n - G = LE + H \quad (1)$$

This communication gives preliminary results of attempts to quantify the impact of a trash blanket on the energy balance and its effects on crop microclimate, water use and growth.

Methods

A drip irrigated trial was conducted in a first ratoon crop of variety N46 (cut back in April 2009) near Komatipoort, Mpumalanga (25°37'S; 31°52'E, 187 m a.s.l.) on a Glenrosa form soil. Two treatments were applied (i) a trash blanket applied at a rate of 18 t/ha, 160 mm thick, and (ii) control treatment with no trash blanket. Dual rows spaced 1.4 m apart (each row in the dual configuration was 0.6 m apart) were used and surface drip lines placed (underneath the trash blanket in the trash treatment) at the centre between dual rows, 2.0 m apart. Standard cultivation, fertiliser and weed control practices were followed. Irrigation was scheduled when the measured deficit reached 10 mm.

Destructive cane samples were taken monthly from a 1.5 m line of cane in five random locations per treatment. Interception of photosynthetic active radiation was measured fortnightly with an AccuPAR linear ceptometer (Decagon Devices Inc., WA, USA). Stalk population and stalk height was measured fortnightly in five replicate plots of 2.0 m each.

Soil water content was measured at 0.15 m intervals, commencing at 0.25 m soil depth to a maximum depth of 0.55 m, with a neutron water meter (Model 503DR CPN Hydroprobe, Campbell Pacific Nuclear, CA, USA). The measured change in soil water content, total irrigation, total rainfall and total estimated drainage was used to derive cumulative crop water use using the standard water balance equation. Growing point and soil temperature was measured with copper-constantan thermocouples.

Energy fluxes were determined by direct measurement (R_n and G) and H by eddy covariance (Jarmain *et al.,* 2009) and surface renewal (Mengistu and Savage, 2010) techniques. Latent heat flux (LE) was derived by difference using Equation 1.

Results and Discussion

Energy balance, crop water use and the microclimate

On sunny and cloudy days available energy flux (R_n-G), H and LE followed the diurnal variation in R_n (Figure 1). On a sunny day with a **partial canopy**, G accounted for 12 and 21% of R_n in the trash and control treatments respectively. Therefore, approximately 88% and 79% of R_n in the trash and control treatments respectively was available energy flux that could be partitioned between H and LE. In the trash treatment, H generally dominated over LE, while the opposite was true for the control. Maximum midday values of R_n-G in the trash treatment was 17% lower, H 52% greater, and LE 64% lower than corresponding values for the control treatment (Figure 1a).

On a sunny day with a **full canopy**, G accounted for 14 and 6% of R_n in the trash and control treatments respectively. Approximately 86% and 94% of R_n was thus available energy flux in the trash and control treatments respectively. No noticeable differences could be observed in the energy fluxes and partitioning of trash and control treatments (Figure 1b).

All components of the water balance were remarkably similar for the two treatments (mean irrigation application was 1182 mm, rainfall 334 mm, drainage 201 mm and crop water use 1309 mm). This was unexpected as the energy balance measurements indicated that more energy was used to evaporate water. The trash treatment could have been over-irrigated and drainage underestimated. This issue will need further investigation.

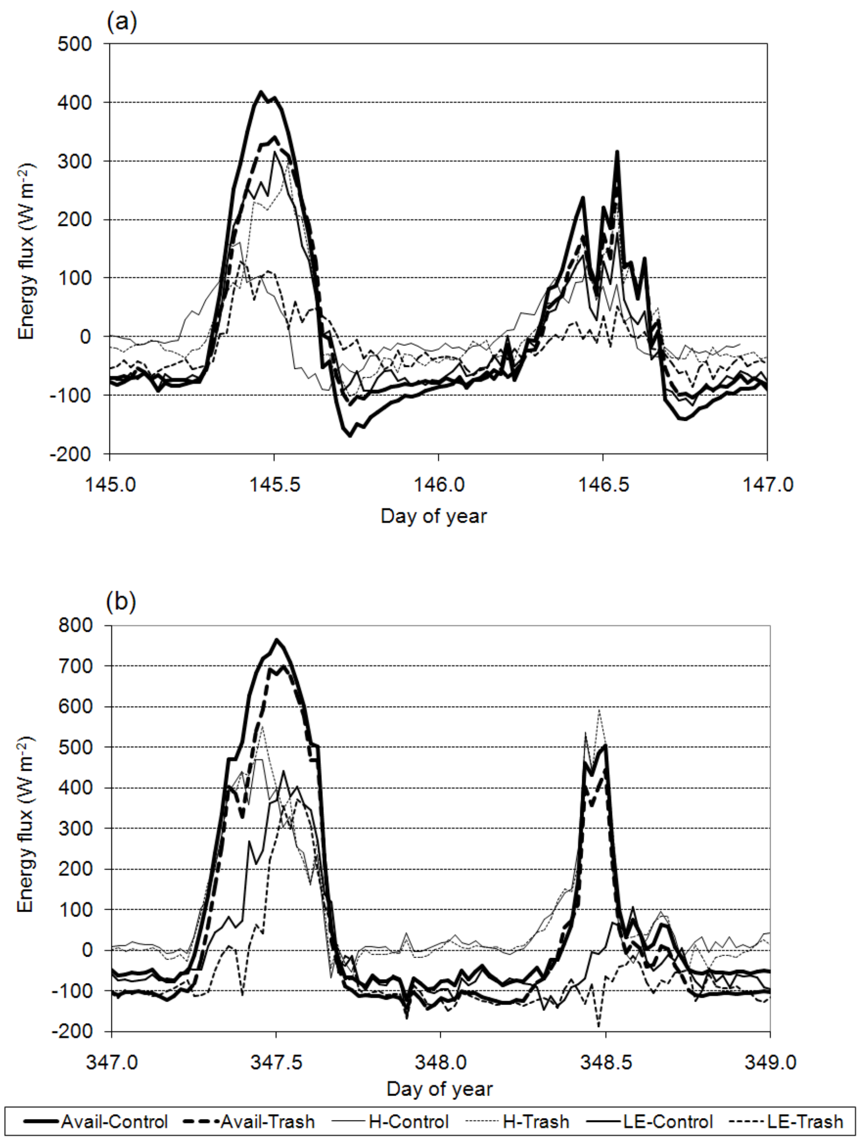

Figure 1. Available energy flux (R_n-G), sensible heat flux (H) and latent energy flux (LE) for the two treatments for a partial (a) and full canopy (b).

Soil temperatures observed at 60 mm depth were on average 4-5^{o}C lower under the trash treatment in the partial canopy period as compared to the control. An interesting observation was that the midday growing point temperature of the trash treatment between 90 and 210 days after the crop start (July to October) was 3-4^{o}C greater than that of the control treatment and corroborates the greater H values observed in the trash treatment during the same period (Figure 1a). No significant differences in soil and growing point temperatures could be observed in the full canopy period.

Crop growth

Interception of photosynthetically active radiation by the canopy was not severely affected by the presence of the trash blanket (data not presented). The trash treatment reached 80%

radiation capture 10 days after the control treatment and both treatments intercepted close to 100% of the radiation towards the end of the growing season.

Initial stalk population in the trash treatment was 50% lower than the control treatment and reached peak stalk population 16 days after that of the control treatment (data not presented). Lower soil temperatures measured under the trash blanket as well as the added barrier could partly explain the slower initial stalk emergence rate. Similar conclusions were made by Wood (1991). Furthermore, frost was observed in the trash treatment on three occasions during June and July which could have had a further negative effect on stalk appearance rate. No differences were observed in the peak (51 stalks/m^2) and final stalk population (16 stalks/m^2). At harvest, cane stalks in the control and trash treatments were of similar length.

Aboveground biomass of the trash treatment was slightly greater than the control treatment throughout the growing season, but these differences were not statistically significant (Figure 2). Similar trends were observed for cane yield. Higher growing point temperatures in the trash treatment could possibly be the reason for the greater aboveground biomass.

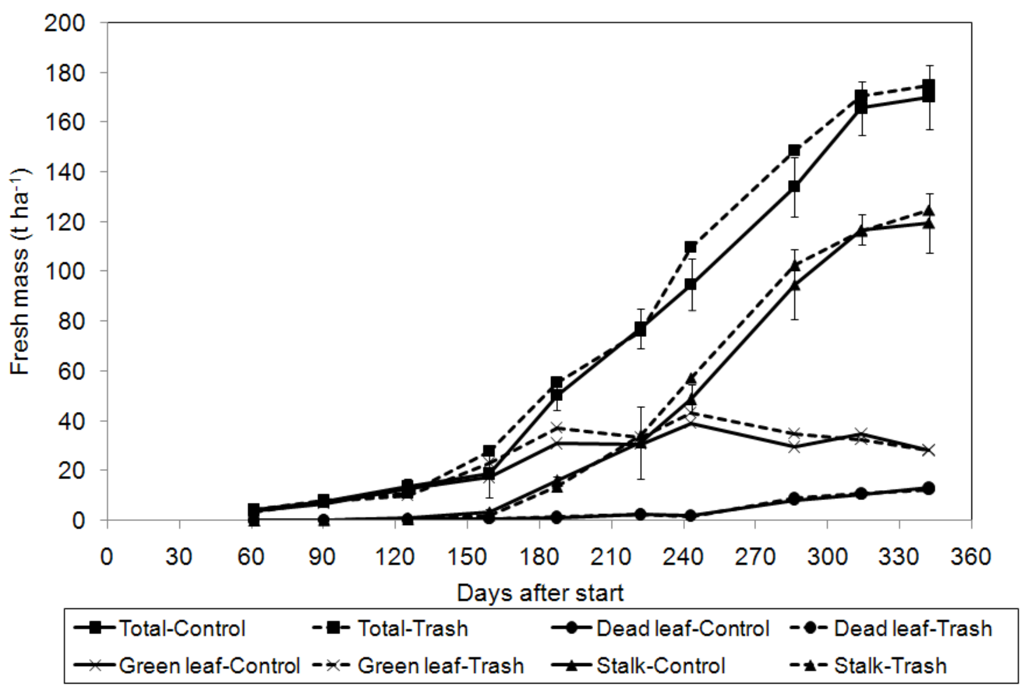

Figure 2. Aboveground biomass, green leaf (blade and sheath) mass, dead leaf mass and stalk mass (all on a fresh mass basis) for the two treatments as a function of days after crop start.

General

Lack of any significant difference in crop biomass and cane yield between control and trash treatments are in contrast with previously reported results under overhead irrigation (Olivier *et al*., 2009). The N46 variety used here may be more tolerant to trash conditions than N14.

Conclusions

- Under partial canopy conditions maximum midday values of R_n-G in the trash treatment was 17% lower, H 52% greater, and LE 64% lower than corresponding values for the control treatment.
- Under full canopy conditions no real differences could be observed in maximum midday values of R_n-G, H and LE for trash and control treatments.
- The changed partitioning of energy caused by the trash blanket led to lower soil and higher growing point temperatures compared to the control treatment.
- Early stalk emergence was the only growth parameter that was affected negatively by the trash blanket, due in part to lower soil temperature.

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