DIFFERENCES IN CANOPY DEVELOPMENT OF TWO SUGARCANE CULTIVARS UNDER CONDITIONS OF WATER STRESS: PRELIMINARY RESULTS

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Abstract

The effect of water stress on canopy development of sugarcane cultivars N22 and NCo376 was evaluated in a rain shelter facility at the South African Sugarcane Research Institute at Mount Edgecombe. The crop was grown under unstressed conditions for four months. Subsequently, water was withheld from one half of the trial for a period of 42 days. Soil water content in the stressed plots decreased from field capacity of 26% at the start of drying to 15% on day 15, and to a permanent wilting point of 10% at approximately day 40.

Shoot survival in N22 was more sensitive to water stress than in NCo376. Water stress caused a simultaneous reduction in leaf appearance rate and an increase in leaf senescence rate, and consequently markedly reduced green leaf number in both cultivars. Leaf senescence appears very sensitive to water stress, with increases apparent at high relative soil water content (RSWC). Interception of radiation was not as sensitive to water stress as leaf area, and in both cultivars decreased only after RSWC dropped below 0.5.

NCo376 was able to maintain canopy development processes longer under conditions of increasing water stress, and thus maintained a higher green leaf area index for longer than N22. This was achieved by extracting more water from the profile than N22, thereby maintaining a high turgor for longer, and supporting growth processes for longer.

The information obtained in this study will be used to refine and test crop canopy algorithms in crop models. This will allow better application of models to assist management of sugarcane production, especially under conditions of limited water supply.

Keywords: sugarcane, crop canopy, leaf area, soil water content, fractional interception

Introduction

The crop canopy plays an important role in the formation of sugarcane yields. It intercepts solar radiation that drives the processes of photosynthesis and crop evaporation. The canopy also shades out possible weed growth. It has been shown that canopy development is a function of genotype (Singels and Donaldson, 2000), environmental conditions, i.e. temperature (Inman-Bamber, 1994), and management practices, i.e. row spacing (Singels and Smit, 2002). Water stress also negatively affects canopy development by slowing down the production of new shoots and leaves, and by accelerating shoot and leaf senescence (Inman-Bamber, 2004). A better understanding of these dynamic interactions and their impact on yield is necessary for improved management of sugarcane under drought conditions.

Sugarcane crop models are often used to support decision-making in the South African sugar industry for example, crop forecasting (Bezuidenhout and Singels, 2001) and yield benchmarking (Inman-Bamber, 1995). The usefulness of these applications relies on the ability of these models to accurately simulate the effect of various management, environmental and genotypic factors on canopy development. Both the Canesim (Singels and Donaldson, 2000) and the Canegro (Inman-Bamber, 1991) models lack the ability to accurately simulate the effect of water stress on canopy development. Quantitative information on this aspect is essential to improve the models.

The aim of the study is to gain a better understanding of the effects of water stress on various canopy development processes and the interception of radiation in cultivars N22 and NCo376.

Methods

An experiment was carried out at the South African Sugar Association Experiment Station rainshelter facility at Mount Edgecombe (29º 24. S, 31º 54. E, 96 m elevation). Cultivars NCo376 and N22 were planted on 16 September 2002 in rows 1.2 m apart, in soil with 22% clay, 950 mm rooting depth and a capacity to store 126 mm of plant available water. Sufficient nutrients and water were supplied. Water was withheld from half the plots from 25 February 2003 onwards. Leaf appearance and senescence, shoot senescence, leaf area and fractional interception of radiation were recorded weekly. Soil water content was measured weekly with a neutron water meter. Relative soil water content (RSWC) was calculated as the amount of plant available water present in the profile, expressed as a fraction of the maximum capacity of the profile to hold plant available water. Leaf water potential (LWP) of the third leaf from the top was measured regularly at midday using a Scholander pressure chamber.

Results

Both cultivars showed an accelerated senescence of shoots under water stress . Water stressed N22 shoots senesced more rapidly than water stressed NCo376 shoots. At the final sampling, N22 had senesced 8.04 shoots/m2 more than the well-watered treatment, while NCo376 had senesced 4.44 shoots/m2 more. This suggests that shoots of N22 are more susceptible to water stress than those of NCo376.

Water stress caused a marked reduction in leaf appearance rate and a simultaneous increase in leaf senescence rate, with consequent reduction in green leaf numbers in both cultivars (N22 data is shown in Figure 1). The thermal time (base 10) required for leaf 26 to expand fully, increased from 94 for the well-watered N22 to 435oC.days for the stressed cane. The corresponding values for NCo376 was 140 and 714oC.day respectively. The thermal time required to senesce leaf 16 decreased from 95oC.days for well-watered N22 to 49oC.days for the stressed cane. The corresponding values for NCo376 were 122 and 36oC.days respectively. The rate of leaf senescence increased four-fold and linearly as RSWC dropped from 0.7 to 0.3. The senescence process appears fairly sensitive to water stress, with responses apparent at relatively high RSWC.

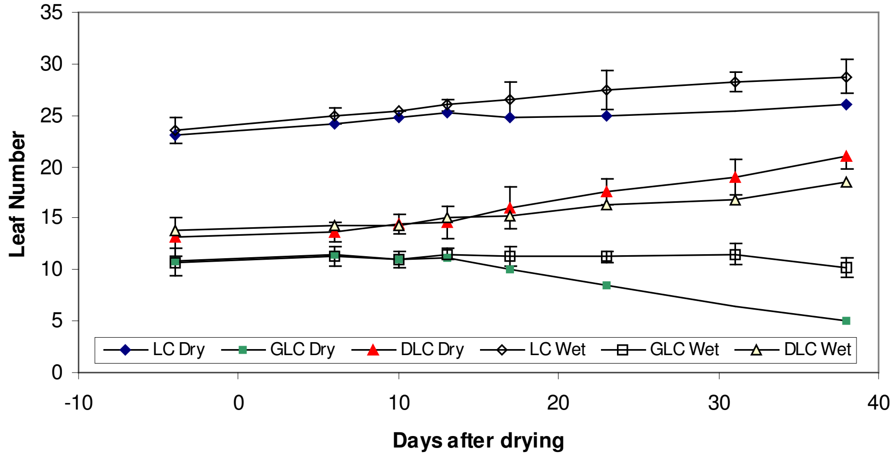

Figure 1. Total number of leaves (LC), number of green leaves (GLC), and number of dead leaves (DLC) for the well-watered and water stressed N22. Error bars indicate one standard deviation.

Water stress resulted in a significant reduction in leaf area index (LAI) in both cultivars (Figure 2). The cultivar NCo376 maintained a LAI of approximately 4 up to 28 days after drying-off was initiated, after which LAI decreased at a faster rate than that of N22. The main cause of LAI reductions was a decrease in leaf area per shoot due to increased rates of leaf senescence and decreased rates of leaf appearance, rather than reduction in shoot density.

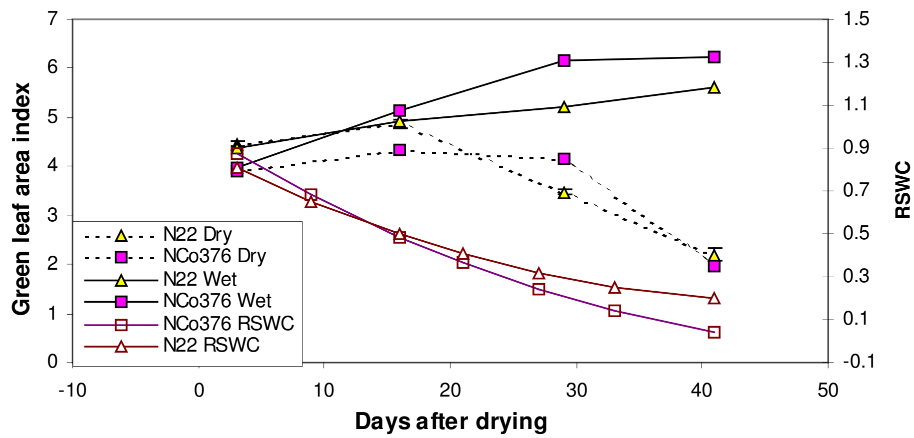

Figure 2. Leaf area index and relative soil water content (RSWC) for well-watered and water stressed NCo376 and N22. Error bars indicate one standard deviation.

Results suggest that NCo376 was able to maintain canopy development processes longer under conditions of increasing water stress, and thus maintain a higher LAI, than N22. This observation is supported by leaf water potential (LWP) measurements. NCo376 maintained high LWP up to a RSWC of as low as 0.26, whereas N22 maintained high LWP only above RSWC values of 0.37. It also seems that NCo376 was able to extract more water from the profile than N22 (Figure 2), thereby maintaining a high turgor for longer.

Radiation interception of both cultivars was affected only after RSWC dropped below 0.5 and is therefore much more resilient to water stress than LAI. Water stress initially caused the lower leaves in the canopy, which contribute little to radiation capture, to senescence. The impact became significant when LAI was reduced to levels of 3.5 and less. This agrees well with the findings of Inman-Bamber (1991).

Discussion

Key findings from the study were:

- Shoot survival in N22 was more sensitive to water stress than in NCo376.
- Water stress caused a simultaneous reduction in leaf appearance rate and an increase in leaf senescence rate, and consequently reduced green leaf numbers markedly in both cultivars. Leaf senescence appears very sensitive to water stress, with increases apparent at high RSWC.
- NCo376 was able to maintain canopy development processes longer under conditions of increasing water stress, and thus maintained a high green LAI for longer than N22. This was achieved by extracting more water from the profile than N22, thereby maintaining a high turgor for longer, and supporting growth processes for longer.
- Interception of radiation was not as sensitive to water stress as leaf area and only decreased after RSWC dropped below 0.5 in both cultivars.

The information obtained in this study will be used to refine and test crop canopy algorithms in crop models. This will allow better application of models to assist management of sugarcane production, especially under conditions of limited water supply.

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