SHORT COMMUNICATION

CONTINUOUS NON-DESTRUCTIVE MONITORING OF STALK ELONGATION IN SUGARCANE

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Abstract

Sugarcane stalk elongation is a good indicator of crop stress, dry matter partitioning and hence cane quality. Accurate records of stalk elongation rate could therefore be useful in crop management and physiological research. The objective of this communication is to briefly describe the development and testing of a second-generation growth transducer with improved accuracy, reliability and ease of use in the research and production environment.

Keywords: growth transducer, resolution, accuracy, temperature, stalk elongation rate

Introduction

Sugarcane stalk elongation is a major component of cane growth and a good indicator of dry matter partitioning and hence cane quality. Elongation is highly sensitive to water stress (Inman-Bamber, 1995) and well correlated with temperature (Glasziou *et al*. 1965). Accurate and timeous records of stalk elongation rate (SER) could therefore be useful in crop management and physiological research. It could be used by sugarcane producers to schedule irrigation, or as a tool to benchmark crop growth and identify possible limitations for correction. Researchers could use it to characterize genotypes, study cultivar response to changing environment, and to gain better understanding of the physiology of assimilate partitioning into structural growth and sucrose storage.

Inman-Bamber (1995) described a growth transducer for measuring plant elongation. The limitations of this instrument were:

- the logger used with the instrument restricted the resolution of measurement to 0.25 mm which is not sufficient to measure hourly SER
- extensive rigging is required to mount the transducer in the field
- independent stalk or sensor movement as a result of wind is a real problem
- the dial cord tends to over-wind on the potentiometer drum.

The objective of this communication is to briefly describe the development and testing of a second-generation growth transducer with improved accuracy, reliability and ease of use for use in the research and production environment.

Methods

Design, assembly and performance

A Spectrol 10 KΩ 10-turn potentiometer is mounted on a lightweight, 10 mm aluminum tubing that clamp onto the cane stalk just below the extending top internodes. A fishhook is secured to the collar of the youngest fully mature leaf (top visible dewlap), and an 80 g brass counterweight inside the tubing keep the non-stretchable dial cord under constant tension.

Winding over a pully on the potentiometer is sufficient to allow approximately 300 mm travel, which equated to the full spectrum from zero to the full 5 V being passed by the potentiometer. Testing the transducer for linearity gave a satisfactory R^2=0.999. The mounting of transducer is rigid and possible movement of the stalk or leaves did not affect transducer performance.

A dedicated logger, using a Texas Instruments ADS1251U precision sigma delta 20 kHz, low power, analogue-to-digital converter with a 24-bit resolution, was designed to log data from five potentiometers and one LM35DZ temperature sensor. The combination of transducer and converter demonstrated a sensitivity of approximately 0.066 mm/mV (R^2=0.999). This is a five-fold improvement over that reported by Inman-Bamber (1995). Precision was determined by assessing signal output at a static sensor position and was found to be 0.006 mm or 0.00002%. Data is downloaded from the logger via a RS232 cable. The logger is able to store in excess of 9000 recordings (a month's data from six sensors sampled every 30 minutes).

A prototype of the instrumentation is depicted is depicted in Figure 1.

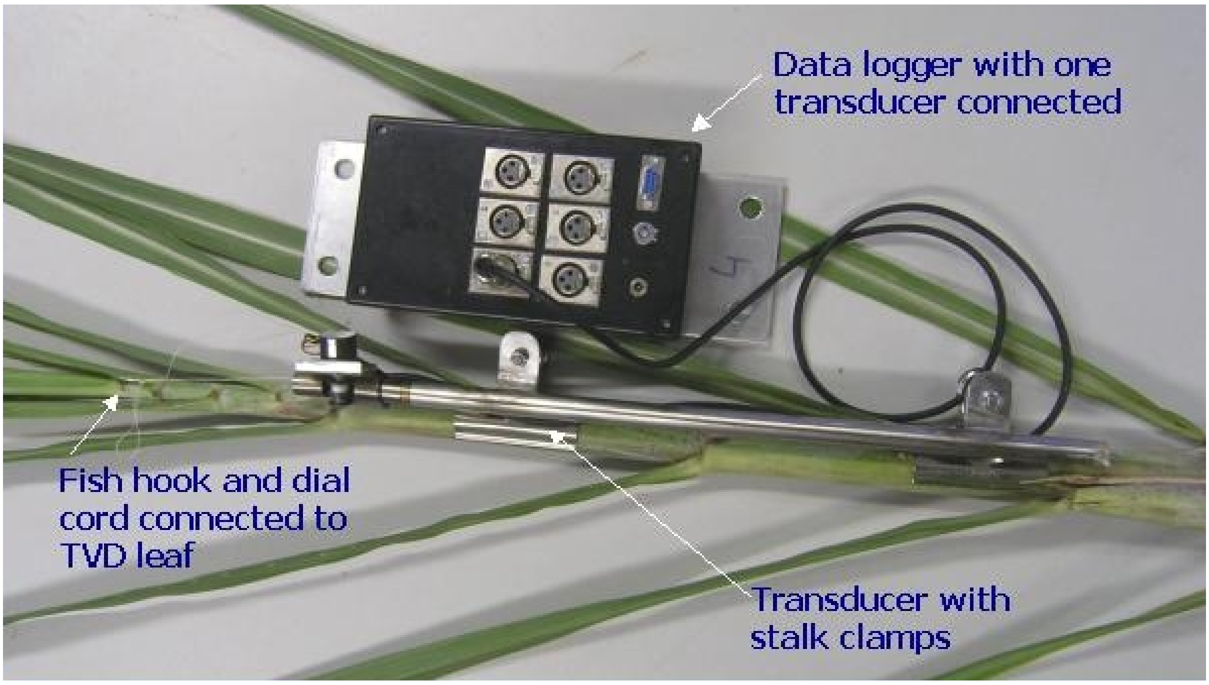

Figure 1. Photograph showing a dedicated logger and growth transducer clipped to the stalk.

Testing

The instrument was used to measure SER on five month old, well-watered and well-fed NCo376 growing in 80 L bins in a controlled climate glasshouse of the University of KwaZulu-Natal at three 12 h day/night temperature regimes (12/22, 17/27 and 22/32 ^{o}C). SER was measured on the five oldest stalks of one stool from each regime. The selected stool was surrounded by eight other stools to eliminate border effects. This communication will only deal with data for the first secondary stalk. Air temperature was measured within the crop canopy. Solar radiation was measured with a LiCor 190SB pyronometer positioned above the canopy inside the glasshouse.

Data was recorded at 30 min intervals for a duration of 10 days. The average and standard deviation of SER for day and night periods respectively, was determined by averaging stalk elongation for each day (06:01-18:00) and night (18:01-06:00) period over the 10 days.

Results

Manual (tape measure) checks of transducer measurements of SER recordings indicate that the latter underestimates true SER by approximately 10%.

Hourly SER responded quickly to the imposed temperature changes between day and night. There was a clear pattern within the day periods respectively, that was not associated with temperature or radiation changes. Daily radiation totals showed little effect on day period mean SER.

Mean SER and temperature for day and night periods are shown in Figure 2. Generally, the data confirm the strong relationship between SER and temperature and suggest that it is non-linear. Results suggest that the equation used in the CANEGRO model (Inman-Bamber, 1994) underestimates SER at high temperatures (e.g. at Mpumalanga) and overestimates at low temperature (e.g. in the Midlands). Linear extrapolation from data for the 12/22°C temperature regime indicates a base temperature for SER of 10.6°C (Figure 2). This differs considerably from the values of 15.9 to 19.7°C reported by Liu *et al*. (1998).

Grouping data across regimes into day and night periods, suggest that the SER vs temperature relationship differs between day and night periods (Figure 2). This could imply that different mechanisms regulate the relationship between SER and temperature during day and night. The fact that SER differed significantly between day and night time at a common temperature of 22°C, could suggest that night temperature affects SER on the following day, as was suggested by Glasziou *et al*. (1965).

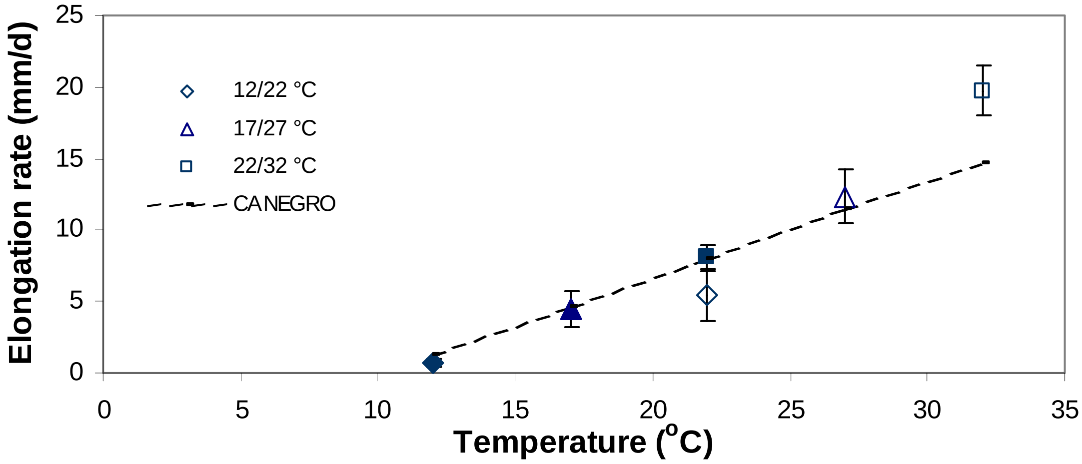

Figure 2. Mean SER for day (open symbols) and night (closed symbols) periods as a function of temperature at three temperature regimes. Error bars indicate two standard deviations. The relationship used in the CANEGRO model is also shown.

The growth transducer used in this study has potential for research and commercial applications. Further refinement and testing would be required. For example, an algorithm could be developed and stored in logger memory to calculate unstressed cultivar specific SER from observed temperature. This will enable the calculation and logging of relative SER, a useful measure of water stress. Modern communication technology offers opportunity for automatic, remote downloading of data onto computers or cell phones.

Conclusions

A user-friendly, stable, high-resolution growth transducer was developed for automated measurement of stalk elongation in sugarcane. It provided reliable measurements of stalk elongation.

Measurements reconfirmed that the stalk elongation rate for unstressed cane is strongly related to temperature. Results also suggest that night temperature may have an effect on the SER of the following day.

The growth transducer used in this study has potential for research and commercial applications.

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