SHORT COMMUNICATION

PEAK TILLER POPULATION: RESEARCH SHEDS NEW LIGHT ON THIS PHENOMENON

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Abstract

Sugarcane stools typically produce more tillers than mature in both plant and ratoon crops. The maximum number of tillers (TPeak) can vary considerably and its significance and the underlying mechanisms are not well understood. The objective of this study was to investigate the effect of planting density, soil fertility and trash cover on TPeak and its relationship with fractional interception of photosynthetic active radiation (FIpar). FIpar is an important indicator of dry matter accumulation and is used in crop modelling.

Across trials, TPeak was not a function of thermal time. TPeak occurred sooner in treatments with higher tiller density per metre of row length and was closely associated with intra-row FIpar (FIintra). In unfertilised plots, tiller senescence was initiated at FIpar ratios as low as 0.6. Results indicate that FIpar by itself is not sufficient as a proxy for intercepted photosynthetic active radiation or of source becoming limited. Leaf chlorophyll content related to FI at the time of TPeak, and may explain the reason for the low FI max and inability of some treatments to attain higher TPeak or FI values. New knowledge gained from the reported results will enable improved management practices, and prediction of TPeak and dry matter accumulation in sugarcane.

Keywords: tiller population, radiation interception, soil fertility, trash cover, water stress

Introduction

Tiller development appears to be a continuous process that can result in stools with large stalk numbers under unrestricted conditions (Van Dillewijn, 1952). A plant density study by Boyce (1970) indicated that widely spaced stools continued to produce stalks up to the time of trial termination at 36 weeks. Under standardised cane production systems, tillering will peak relatively early during the growth cycle and then decrease due to senescence, before stabilising into a relatively constant population density.

Attempts have been made to characterise the timing to peak population (TPeak) and the final estimated stalk (TFinal) population for specific genotypes. In the Canegro sugarcane crop model (Inman-Bamber, 1991), the thermal time from emergence to TPeak is a constant 600ºCd, base 16ºC and a final population of 13.3 stalks/m^2 after 1 600ºCd, base 16ºC for the South African cultivar NCo376.

This communication reports on factors impacting on TPeak and suggests improvements in agricultural practices and for the Canegro crop model.

Methods

Data from two field trials conducted at the South African Sugarcane Research Institute (SASRI) at Mount Edgecombe (29º42'18.4"S; 31º02'48.5"E; 105 m a.s.l.) were used for this study. Experiment one involved a row spacing (RS) trial on a Mayo (USDA Mollisol) soil type with 35% clay and a 0.5-0.7 m depth. RS ranged from 0.25 to 3.00 m. Cultivar NCo376 was planted on 28 November 2002 and the trial was conducted on the first ratoon, which started on 29 August 2003. The crop received adequate water and nutrients, and weeds, pests and diseases were not a factor. Measurements relevant to this study included fractional interception (measurement below lowest green leaf over ambient) of PAR parallel to the cane row (FIintra) with a SF80 ceptometer (Decagon Devices, Pullman WA); shoot population over 5 m every 14 days; and total above-ground biomass sampled on six occasions (three replications of 1.5 m row length each) and dry matter calculated after drying at 80ºC.

The following measurements were recorded for the long-term trash management trial (BT1) at SASRI (Graham *et al*., 2000) from the date of ratooning on 8 September 2008: FIintra once a week as described above; shoot population for 8 m once a week; weekly indexed leaf chlorophyll content with a Minolta SPAD 502 Meter from Spectrum Technologies, Illinois, USA; and soil temperature at 5 cm depth on 23 December 2008. The experiment treatments were: (i) green cane harvested with retention of a trash blanket 100% cover (T), (ii) burnt cane with tops removed after cutting (Bt_0), and (iii) burnt with tops left scattered (Bt). These treatments were split for no fertiliser (F_0) or fertilised with 140 kg N/ha, 20 kg P/ha and 140 kg K/ha (F).

Thermal time was calculated as the cumulative (since emergence) sum of daily mean air temperature minus a base temperature of 16ºC (TT16). Date of emergence was estimated by retrofit on tiller population data.

Results and Discussion

Row spacing trial

In the row spacing trial, TPeak occurred simultaneously for all row spacings at approximately 102 DAR (435ºCd, TT16). The inflection point and levelling off in FIintra coincided with TPeak for all RS, irrespective of population density per unit area. Per metre row length there was not a significant difference in population density between treatments at the time of peak population and it is assumed that all rows responded the same because of similar conditions in competition for radiation within the row.

The ranking order at time of TPeak was maintained and the treatment with the highest TPeak ended with a significantly higher TFinal. The higher population density also resulted in a significantly higher biomass at time of final sampling at 326 DAR.

Biomass increase was approximately linear over time (R^2=0.99) and, with the use of the linear equation, the biomass was estimated to be 16%, 7% and 10% of final biomass respectively for the three RS treatments at time of TPeak. Inspection of the shoots that died indicated predominantly material without any stalk present.

Long-term trash management trial (BT1)

TPeak differed between treatments and from the RS trial. Treatments with the highest peak population density (Bt_0F and BtF) peaked at 106 DAR (529ºCd, TT16), the intermediate TF and Bt_0F_0 treatments at 112 DAR (568ºCd, TT16) and the two treatments with the lowest population density peaked last at 121 DAR (640ºCd, TT16). These results are in harmony with data by Boyce (1970) that variation in equidistant spacing of stools leads to variation in peak population density and in the time to peak population. It is concluded that time to TPeak is a function of population density within the row. Population density for BT1 ranged from a low of 23.44 (±3.94) stalks per metre row length for the unfertilised trash treatment, up to 59.31 (±3.96) for the fertilised bare soil treatment. The higher the population density within the row, the sooner TPeak was reached, and the lower the population density, the longer it took. The relationship between population density and thermal time to TPeak had a R^2=0.86.

FIintra in the rainfed BT1 trial did not give the same smooth trend lines over time as observed in the irrigated RS trial. FI was sensitive to water stress and recorded differences between treatments. The fertilised bare soil (Bt_0F) treatment showed the greatest response, fertilised plots with spread tops (BtF) less, and those with a trash cover (TF) the least, indicating that the trash cover was able to buffer the effect of water stress.

The inflection point and levelling off in FI approximated the TPeak event, thus supporting the relationship between intercepted radiation and shoot survival as illustrated in the RS trial.

FI is a good measure of progress in canopy development. When FI reaches levels above 0.9, it can be expected that competition for intercepted radiation will lead to a slow-down in shoot emergence. The continued increase in shoot and leaf size will continue to keep FI close to 1.0 and continue to put pressure on population density, resulting in continued shoot senescence. However, results from the BT1 trial indicate that the plotted FIintra trend lines for the unfertilised treatments levelled off before even reaching FI 0.6. This finding is indicative that full canopy cover is not a determinant of TPeak.

Stresses that involve deficiencies of N will adversely affect the amount of chlorophyll and the photosynthetic potential of plants. The leaf chlorophyll content was therefore measured to better understand the low FI max recorded for some treatments. The index chlorophyll content taken at time of TPeak ranged from 32 to 42 and its relationship with FI at TPeak was positive with an R^2=0.77. It is suggested that chlorophyll content together with FI should give a more accurate indication of effective radiation interception.

Conclusions

The main findings from this study are:

- Peak shoot density coincided with the inflection point or levelling off of intra-row fractional interception of PAR for all the tested conditions. This suggests that TPeak is a function of population density within the row.
- Unfertilised cane reached peak shoot density when fractional interception was still below 0.6, indicating that competition for intercepted radiation is not only a function of leaf area. Chlorophyll measurement related to FIpar and helped to explain the shortage of energy source needed to drive tillering.
- An inverse relationship between shoot density within the row and time to peak population was observed (r=-0.93).
- Ranking order for peak population in well fertilised and irrigated cane carried through to the final population and yield.

- Total biomass at time of peak population was less than 16% of final biomass. Senescing shoots generally did not contain stalk.
- Once-off fertiliser application resulted in significantly higher chlorophyll content initially. However, this declined over time and dipped below that of the zero fertiliser plots at 150 days. This coincided with a severe outbreak of rust on the fertilised plots.
- Trash cover reduced soil temperature at 5 cm depth by 4ºC but enhanced fractional interception by 27% at a time of water stress.

The practical implications of these findings indicate that TPeak constitutes very little of the final biomass, but that it forms the basis for yield potential. Results also demonstrated the consequence of encouraging high potential without continued nutrient supplementation through to final yield. Bell and Garside (2005) suggested that crop rotation offers an option to sustain higher population and yield. Trash cover was shown to reduce growth and lower the yield potential, although it benefited the crop by buffering the risk of soil water stress.

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