WHY DOES SUGARCANE GROW SLOWLY?

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Introduction

It had seemed, from juxtaposing results in a number of papers, such as those of Bull and Glasziou (1975), Begg (1965) and Wilson *et al*. (1973), that sugarcane grows more slowly than some other tall tropical grasses. To assess the significance of this with respect to sucrose production, unpublished data of RJ Haslam was used to directly compare sugarcane with Napier grass (*Pennisetum purpureum*), a tropical grass which is morphologically similar and is also vegetatively propagated, but produces little sugar.

Methods

Sugarcane variety NCo376 and a local strain of Napier grass were grown in four replicates on adjacent blocks at the Zimbabwe Sugar Association Experiment Station, with standard management for sugarcane. Samples of shoots were harvested at approximately four-weekly intervals, but generally on different dates for the two crops. Leaf number and area, and dry mass of the parts of the shoot, and for the sugarcane, leaf nitrogen (N) concentration and stem composition, were determined. Time was expressed as growing degree days (GDD, the accumulation of daily average temperature minus 12).

Results and discussion

Tillering began earlier and reached a maximum sooner in the Napier (Figure 1a). The initiation of stem elongation coincided with the time of maximum tiller number, so began earlier in the Napier than the sugarcane. Growth rate expressed as total dry mass per unit ground area was low until stems began elongating (Figure 1b). It then increased and remained high until near final harvest in the Napier, but in the sugarcane it decreased from about the time that stem elongation rate decreased. This is in keeping with the observations of Lingle (1997). About 50% of sugarcane final stem dry mass consists of non-structural material, of which nearly 90% is sucrose.

Leaf number increased nearly linearly with GDD (and hence with temperature) in both species, but faster in the Napier (Napier, 0.023 leaves/GDD, R^2 = 0.88; sugarcane, 0.0085 leaves/GDD, R^2 = 0.96). Slow leaf production was probably the cause of slow tillering in the sugarcane, as tillers grow from axillary buds. This would also account for the late start of stem elongation in sugarcane.

The near simultaneous start of stem elongation and rapid total dry mass growth (Figure 1a,b) can be explained by the elongating stem forming a strong new sink (Green and Vaidyanathan, 1986). Thus a late start of fast dry mass growth seems ascribable, ultimately, to the low response of development (reflected by rate of leaf production) of sugarcane to temperature.

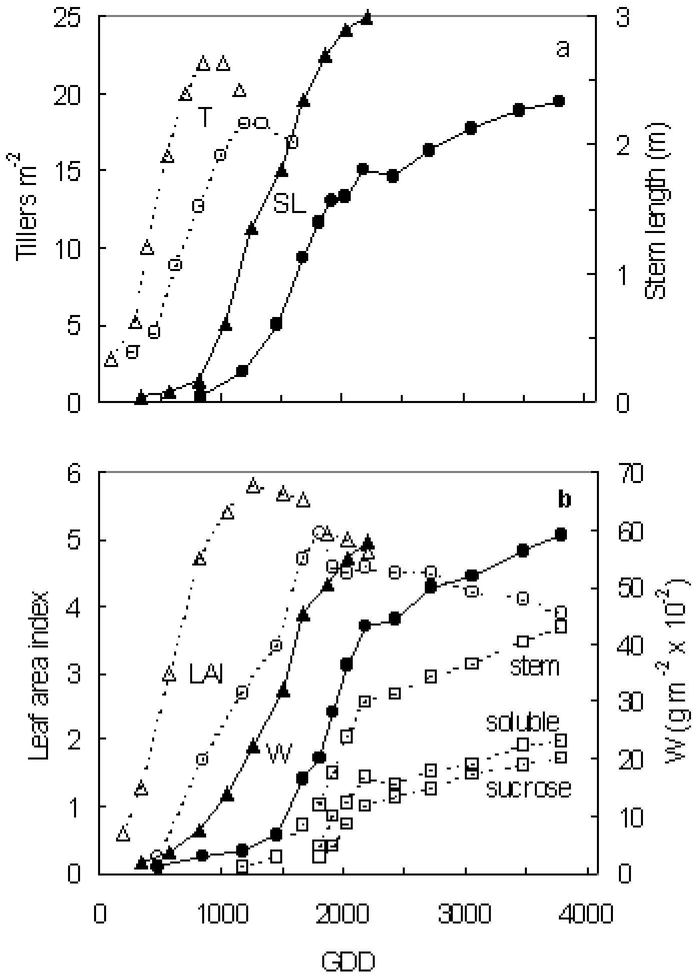

Figure 1. Changes with thermal time in (a) tiller number (T) and stem length (SL); (b) leaf area index (LAI), total dry mass per unit ground area (W) and sugarcane component masses. Napier, △, ▲; sugarcane, ○, ●, □.

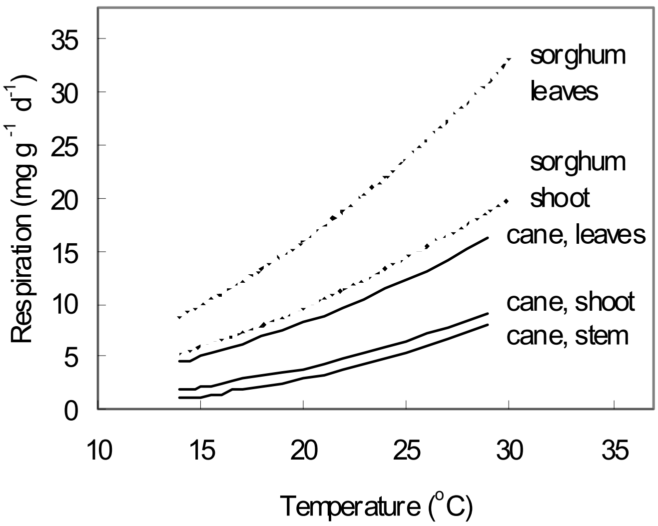

Figure 2. Effect of temperature on respiration rate of sorghum and sugarcane.

The decrease in sugarcane dry mass growth rate (Figure 1b) was associated with a decrease in stem elongation rate (Figure 1a), with a lower specific leaf N content (SLN) (*c*. 0.8 g/m^2 compared with *c*. 1.3 g/m^2 during the phase of rapid mass growth), which probably depressed photosynthetic potential, and with accumulation of considerable stem non-structural mass (and hence respiratory substrate). This could place a potentially large maintenance respiration requirement on assimilate supply at a time of depressed photosynthesis. However, respiration rate is evidently comparatively low in sugarcane (Figure 2; data for sugarcane from Glover, 1973; for sorghum from McCree, 1983, 1988), to a certain extent reducing the respiratory carbon losses.

Conclusions

The low response to temperature in sugarcane leads to a late start of the 'grand' period of growth, but this is offset by comparatively slow respiration, which limits respiratory loss of assimilate during the main period of sugar accumulation. Photosynthesis during this period is depressed by low SLN, but if SLN reflects N concentration in the meristem, low N-level here could limit stem structural growth (Lawlor *et al*., 1988). Reduced structural growth should leave more assimilate for sugar accumulation.

Thus sugarcane improvement evidently entails balancing the effects of attributes likely to limit sugar yield with those that are likely to increase yield. Limiting attributes include delayed growth associated with slow respiration; attributes potentially increasing yield are slow respiration, which limits carbon loss, and restricted production of structural material, which makes proportionally more carbon available for sugar accumulation.

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