Is sweet corn just another maize hybrid?

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Introduction

The ability to predict the response of crop yield to fundamental environmental influences such as moisture, radiation and temperature is a prerequisite for sound economic analysis of simple management decisions such as those involving hybrid choice or time of sowing and irrigation. Simple mechanistic crop models can provide a useful tool for such predictions and analysis. Most models rely on accurate simulation of leaf area index for reliable calculation of yield. In maize this has been achieved by integrating three components of leaf production in a simple maize model (Muchow *et al.*, 1990; Wilson *et al.*, 1995): 1) the area and rate of leaf production on individual plants; 2) the loss of leaf area caused by senescence of successive leaves from the bottom of individual plants; and 3) plant population.

Given the close relationship between sweet corn and maize (mutant and 'wild type', respectively, of *Zea mays*), there is a good chance that the model developed for maize may, after simple modification, be as accurate and reliable when applied to sweet corn. Such a model would enable management decisions for sowing, harvesting and processing schedules to be made with greater accuracy than at present. Here we show that the methods required to describe canopy development in maize are likely to be similar for sweet corn.

Materials and Methods

Data from year one (1997/1998) were taken from previously published data for one sweet corn hybrid (Challenger) (Stone *et al.*, 1998a) and three maize hybrids (Stone *et al.*, 1998b). In year two (1998/99) twenty two hybrids of sweet corn comprising thirteen Shrunken 2 yellow (Sh2Y), three Shrunken 2 Bi colour (Sh2)Bi and six Standard endosperm (Su-1) types were hand-planted at a population of ca 71,000 plants/ha. Seeds were sown at 5 cm depth with an inter-row spacing of 70 cm and an intra-row spacing of 20 cm. Plots were 12 x 2.8 m and were replicated twice in a randomised complete block design. Twelve Shrunken 2 (Sh2Y) and all (Sh2)Bi hybrids were sown on 24 October 1998, while the Standard endosperm (Su-1) hybrids were sown on 18 November 1998. The experiment was performed at the Crop and Food Research Station at Hastings (a site description is given in Stone *et al.*, 1999). Fertiliser (200 kg/ha of 12:10:10 NPK and 200 kg N/ha as urea, giving a total of 224, 20 and 20 kg/ha of N, P and K, respectively) and irrigation (applied to maintain the potential soil moisture deficit above a critical deficit of 85 mm) were applied for maximum yield. Data for year two maize were obtained from experiments sown in an adjacent paddock (Sorensen and Stone, 1999). For all experiments with sweet corn and maize five tagged plants per plot were observed weekly and the times of leaf tip appearance, full leaf expansion (leaf collar visible at stem) and full leaf senescence were recorded for each plant. The leaf area profile was constructed for each hybrid by destructively measuring, on three occasions, the area of each leaf on five plants per plot. Leaf senescence, shown as fraction of senesced area, was calculated by dividing senesced leaf area by total leaf area. Canopy development characteristics were related to thermal time calculated from hourly mean air temperature above a base temperature of 8 °C. Weather data were collected at a NIWA weather station (agent number 15876) 10 m from the experimental site.

Results and Discussion

Leaf tip appearance was linear with thermal time in both sweet corn hybrid 'Challenger' and three maize hybrids (Fig. 1), although the phyllochron for the former (25 °C.d; r^2=0.99) was shorter than for maize (36 °C.d; r^2=0.99).

Similarly, the appearance of fully expanded leaves was quicker in sweet corn hybrid 'Challenger' than three maize hybrids (Fig. 2), with both the mutant (r^2=0.99) and wild type (r^2=0.99) showing an exponential relationship between fully expanded leaf number and thermal time.

While sweet corn hybrid 'Challenger' developed a canopy more rapidly than three maize hybrids, canopy

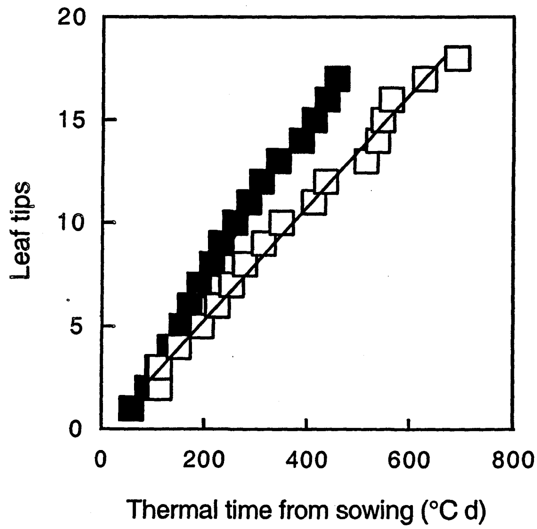

Figure 1. Leaf tip appearance in sweet corn (■) and maize (□). Data from year one experiments.

senescence was markedly slower in the sweet corn (r^2=0.98) than the maize (r^2=1.0) (Fig. 3). Consequently, on the basis of leaf appearance and death, sweet corn hybrid 'Challenger' was more effective at developing and maintaining a viable canopy than maize.

While Figs. 1-3 have shown data for only one sweet corn hybrid and three maize hybrids, unpublished data indicate that, within each of sweet corn and maize, relationships between thermal time and rates of leaf tip appearance (r^2=0.96), full leaf expansion (r^2=0.96) and senescence (r^2=0.93) were similar in all hybrids (data not shown). This generality indicates that it should be simple to predict 1) when leaves will appear; 2) their final size; and 3) longevity, as well as; 4) their distribution within the crop canopy, with the need for only minimal hybrid specific information.

The distribution of leaf sizes within the crop canopy is affected by the difference between the rates of leaf tip emergence (linear; r^2=0.96) and full expansion (exponential; r^2=0.96). Plotting the two curves on the same axis shows that the upper and lower leaves expand over a shorter period than the central leaves of the sweet corn plant (Fig. 4). This, when coupled with the greater width of the central leaves, explains why the relationship

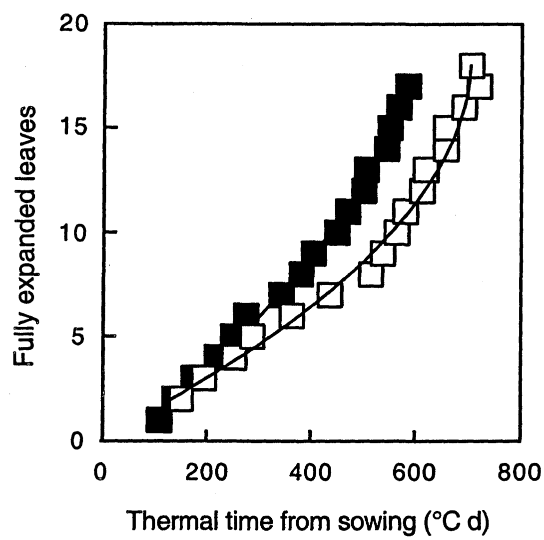

Figure2. Appearance of fully expanded leaves in sweet corn (■) and maize (□). Data from year one experiments.

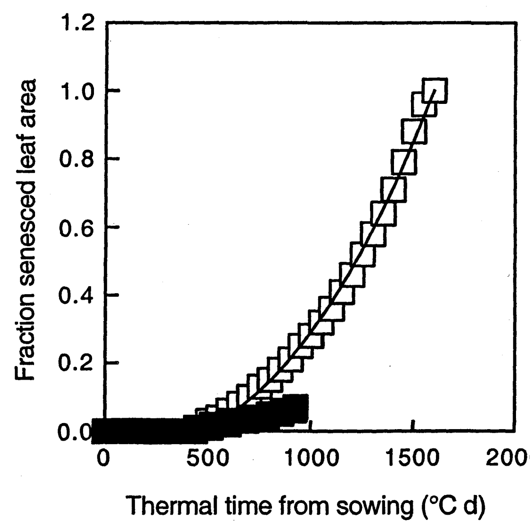

Figure 3. Canopy senescence in sweet corn (■) and maize (□). Data from year one experiments.

between size and number has a skewed bell shape. This relationship does not differ widely between sweet corn and maize, although it appears that the distribution is more 'peaky' in the former than the latter, at least for the genotypes examined (Fig. 5). It appears, therefore, that leaf size distribution in sweet corn can be calculated in much the same way as in maize (Dwyer and Stewart, 1986). Specifically, using the above relationship between leaf size and number, the total leaf area per plant is determined by simply summing the area of each fully green leaf, the number of which is determined with reference to the aforementioned data for leaf appearance and senescence.

As demonstrated for maize (Sorensen and Stone, 1999), in sweet corn there appear to be simple relationships between leaf number, area of the largest leaf and total leaf area per plant. When the data for the 22 sweet corn hybrids were grouped according to leaf number (as would occur in the execution of a model) there appeared to be simple relationships between total leaf number and area of the largest leaf (Fig. 6), total leaf number and total leaf area per plant (Fig. 7), and consequently between area of the largest leaf and total leaf area (Fig. 8). Unfortunately, the range of data was

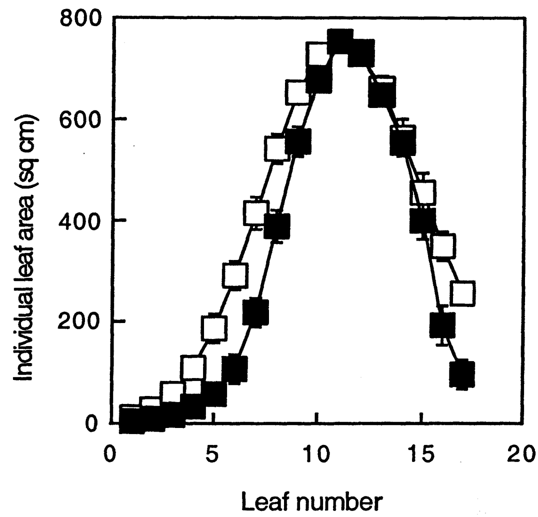

Figure 5. Relationship between individual leaf area and leaf number in sweet corn (■) and maize (□). Data from year 2. Error bars = std. dev.

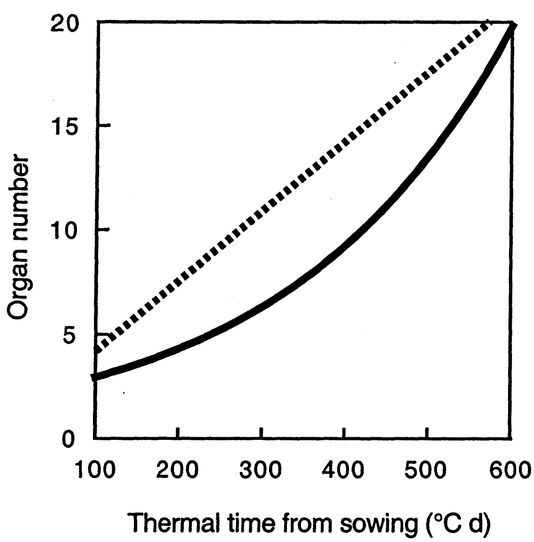

Figure 4. Appearance of leaf tips (--------) and fully expanded leaves (——) of sweet corn. Data from year two experiments.

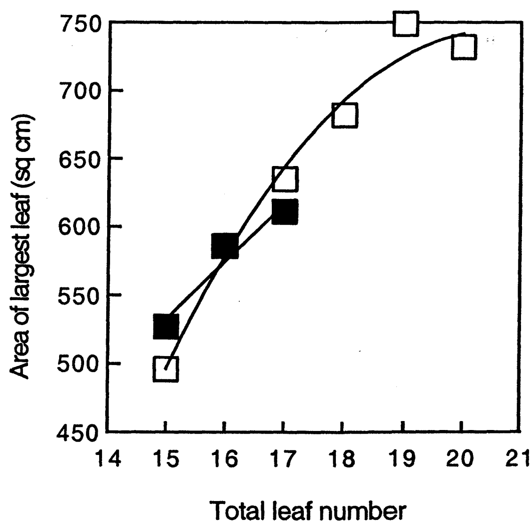

Figure 6. Relationship between area of the largest leaf and total leaf number in sweet corn (■) and maize (□). Data from year two experiments.

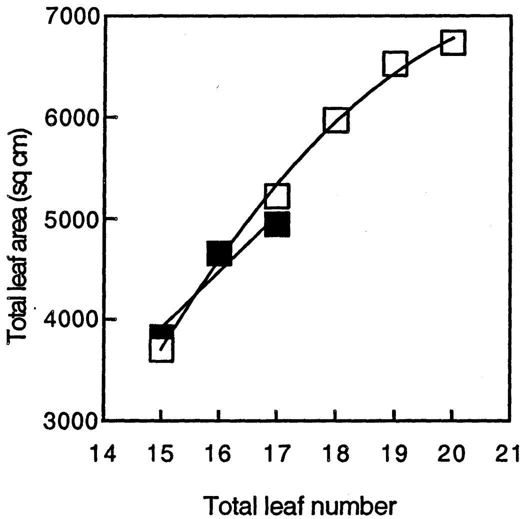

Figure 7. Relationship between total leaf area per plant and total leaf number in sweet corn (■) and maize (□). Data from year two experiments.

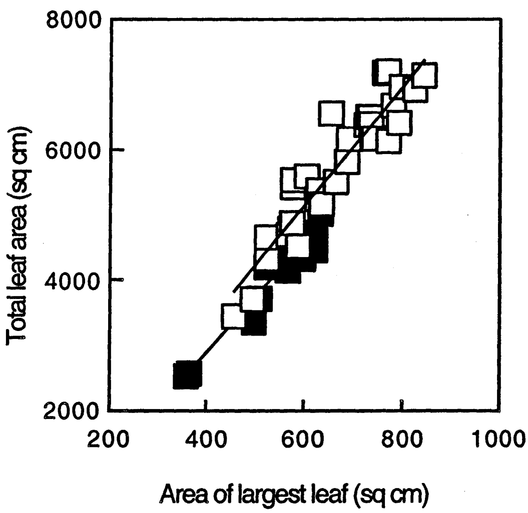

Figure 8. Relationship between area of the largest leaf and total leaf area per plant in sweet corn (■) and maize (□). Data from year two.

limited by the small variation in leaf number of the sweet corn hybrids examined. Nevertheless, the relationships between leaf number, area of individual leaves and total leaf area per plant appear to be sufficiently similar in sweet corn and maize to suggest that a model of sweet corn canopy development could be constructed using the same method used for maize.

Conclusions

Sweet corn is not just another maize hybrid. However, the similarities in pattern of canopy development suggest that it will be possible to develop a useful sweet corn model by altering the coefficients of the relationships between thermal time, leaf appearance and senescence and between leaf size and leaf number used in a maize model.

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