

# STRATEGIES FOR CROP MODELLING RESEARCH AT SASEX

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We have heard some of the constraints and opportunities of the breeding programme. The modelling approach offers the option of making the distinction between constraints that we cannot change and those that we can. If we have a model good enough to mimic the growth and development of our varieties so that yields and quality of the crop can be predicted accurately in just about every soil type and climatic mix possible in our industry, we can compare options within the constraints we have set as well as options outside these constraints. We may even be able to examine some of the constraints posed by the sugarcane plant itself to see what would happen if these were changed and then speak to the breeders to see what they can do to make the kind of plant that fits in with the most cost efficient means of converting solar energy to sucrose. Let me explain with some examples.

## Radiation – harvest season

Firstly, consider solar radiation. Solar radiation is the most limiting factor because we can do least about it. A lot of radiation goes to waste in our industry and perhaps we can do something about that. While building the CANEGRO model we measured light interception of crops starting at different times of the year and found that crops starting in winter wasted a lot more radiation than those starting in summer (Figure 1).

Of course radiation is lower in winter than in summer, but the summer crop develops rapidly compared with the winter crop. It is, therefore, the winter crop that we want to avoid rather than the summer crop from the point of view of radiation interception. We close our mills in summer because cane quality is so bad. Perhaps our breeders could develop varieties that would give acceptable quality in summer.

Figure 2 gives the model's view of how stalk dry matter (DM) yields would vary for crops starting at different times of the year. Water was regarded as non-limiting and the harvest age was 12 months. We need to convert the DM to

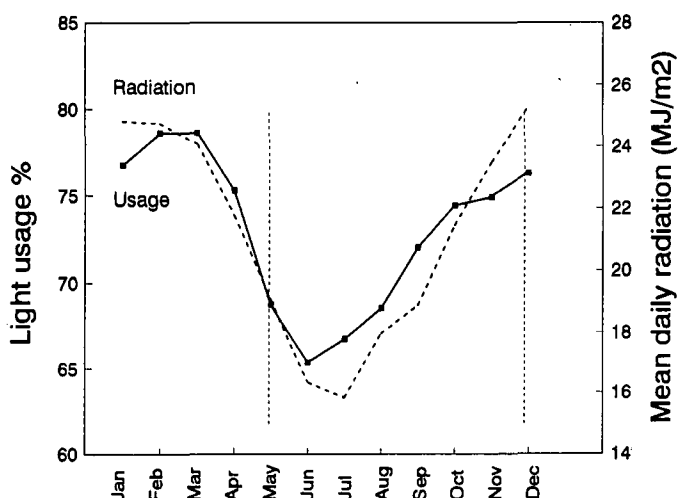


FIGURE 1 Simulated efficiency of light usage by crops in the Eastern Transvaal starting at different times of the year and mean daily radiation for different months.

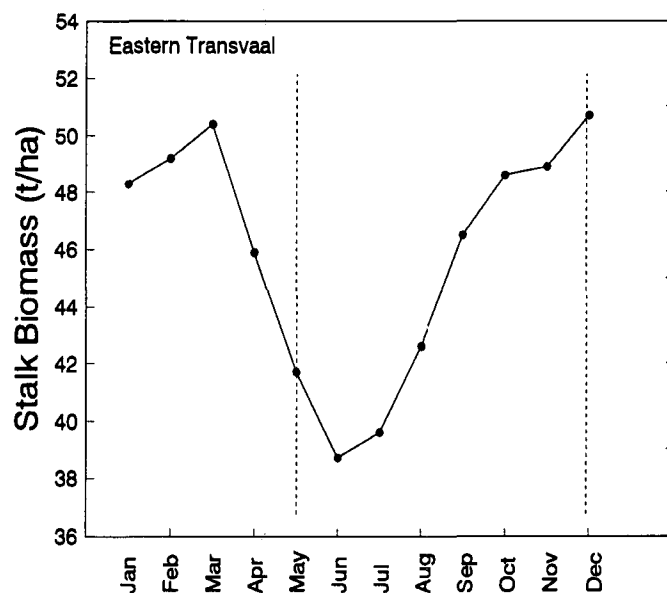


FIGURE 2 Simulated stalk yield of crops in the Eastern Transvaal starting at different times of the year.

sucrose yield for this information to be of any use. In the past and for some time to come we have used and will have to continue to use historical mill or experimental data to do this. The model needs to be developed to the stage of being able to predict sucrose content from knowledge of the physiological processes involved before we can explore beyond the constraints of the present milling season, which seldom starts before May and seldom ends later than December.

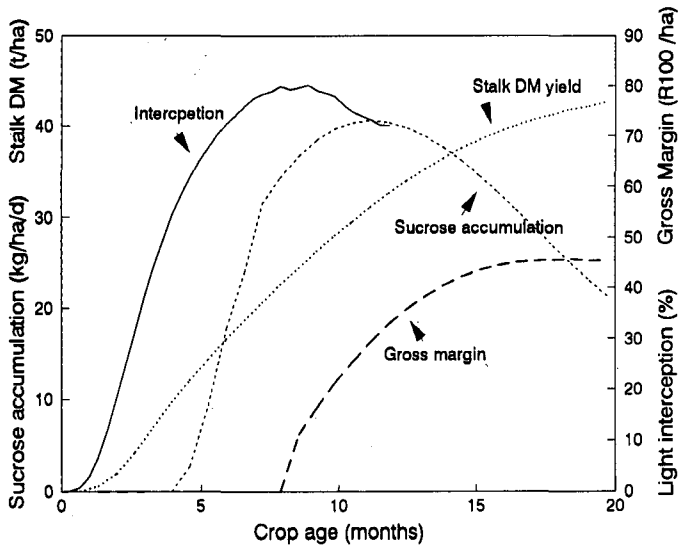
## Radiation – harvest age

The other means of limiting radiation wastage is to reduce the proportion of our crop that is not at full canopy. This could be done by extending the harvest age or perhaps by reducing the row spacing.

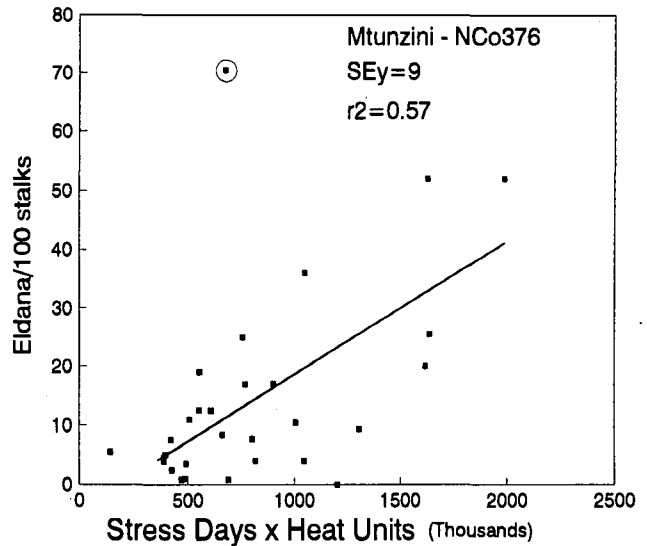
Figure 3 shows the development of an average crop on the north coast in a moderately deep soil (eg Swartland soil form). The CANEGRO model was used to stimulate hundreds of crops in these conditions so that we can analyse the 'average' crop. The better we understand the processes leading to sucrose yield the more reliable this sort of analysis will be. The 'average' crop on the north coast develops as follows:

- 1 month: Leaves start to grow rapidly
- 2 months: Stalks start to develop
- 4 months: Sucrose starts to accumulate in stalks
- 5 months: Leaves form a complete canopy (70% light interception)
- 8 months: Financial gain begins
- 12 months: Sucrose accumulation rate reaches a maximum
- 16 months: Gross margin reaches a maximum

For five months this crop wasted solar radiation and, if we cut it at 12 months, we curtail sucrose accumulation at its maximum rate and fail to achieve the maximum gross margin (based on average variable costs).



**FIGURE 3** Development of an average crop on the North Coast showing light interception by leaves, stalk dry matter yield, sucrose accumulation rate and gross margin.



**FIGURE 4** Association between eldana larvae per 100 stalks and the product of stress days and heat units for all crops of NCo376 assessed for eldana in released variety trials at Mtunzini.

**Radiation – row spacing**

Many physiologists have been puzzled by the slow development in the canopy of sugarcane, which takes as long to form a complete leaf canopy as some crops do to produce a yield. This leads to questions about hastening canopy closure and possibly stalk development by altering the row spacing. It also leads to the question of tillering and what happens to the carbon fixed by tillers that go missing by the time harvest comes around. The modelling groups at Mount Edgecombe and at Tropical Crops and Pastures (CSIRO, Brisbane) have independently focused on the loss of these tillers as a yield constraint. We have some projects aimed at gaining insights into these matters, with the objectives of controlling tillering and the loss of tillers perhaps through row spacing and breeding. However, the considerable evidence gathered at SASEX in the past indicates that crop development cannot be hastened by reducing the row spacing.

**The eldana constraint**

I think that many growers would like to extend their harvest age but the threat of eldana is too great. We need to be looking at improving our ability to predict eldana and to assess the risk we are taking when extending harvest age. Clearly the cost of eliminating risk is not acceptable in some areas.

Figure 4 shows that eldana damage in NCo376 was related to heat units and stress days. We are researching the possibility of predicting eldana damage in this way and quantifying the long term risk involved in extending harvest age in different varieties.

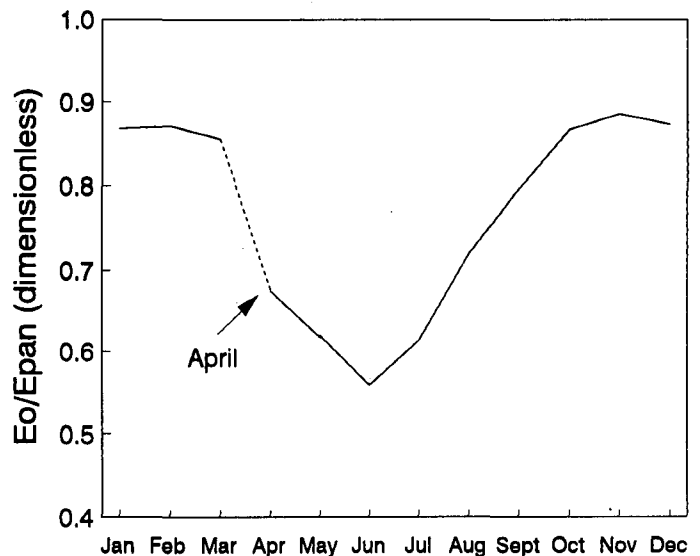
**The constraint of water**

Next to radiation this is our most limiting factor, but we can do something about it. I think we can anticipate that water for agricultural use is going to become more expensive and will be more severely contested by industry. We will have to be as clever and as efficient as we can with the use of irrigation water. Modelling the processes of water flow in

the soil, plant and atmosphere has already helped to reduce water use on some irrigated farms. This has been done firstly by using more accurate methods of estimating crop water use, such as the Penman-Monteith method. This method has been backed by the FAO organisation of the United Nations as the most reliable means of predicting crop water use.

Figure 5 shows the ratio of Penman-Monteith evaporation to class A pan evaporation. The ratio reaches a maximum of 0.9 during summer for a crop starting in April and is as low as 0.55 in winter. It can be shown that about 20% water can be saved using this method rather than the class A pan to schedule irrigation for sugarcane.

Another way of saving water is to apply water just before the crop experiences stress that affects sucrose yield. We know we can keep the plant in a state of stress that affects



**FIGURE 5** Long term mean ratio of weekly Penman-Monteith evaporation and evaporation from the class A pan at Big Bend, Swaziland for a crop starting in April.

cell growth more than photosynthesis and, in this state, the reduction in assimilation is offset by the reduction in the assimilate required for new cell growth, so sucrose yield is not reduced. We have shown that the model in its present form can simulate plant extension (cell growth) accurately and we are testing its ability to schedule irrigation so that sucrose accumulation is optimised.

### **Conclusions**

Models are being developed for and by agricultural research at an increasing rate. These models will get better and give us more opportunities to analyse the way we produce sucrose and sugar and provide us with better guidelines about the type of production system we need to be a world class sugar industry. Our breeders and biotechnologists will then have clearer targets for the type of canes required for these systems.