

EXECUTIVE SUMMARY

Background

This project, which was funded by the Water Research Commission, Langeberg Foods and the University of Pretoria, was aimed at the *maximisation of economic water use efficiency in processing tomato production*. A computer program, TOM-MAN, was developed as a prototype model with processing tomatoes as an example, and will eventually be incorporated in the SWB (Soil Water Balance) irrigation scheduling program which is currently under development by the University of Pretoria.

It is indisputably clear from numerous reports that irrigation management is the most important factor towards economic optimization of processing tomato production. *The most crucial decision about irrigation management for processing tomatoes is to decide on when and to what extent irrigation should be reduced in order to apply the right amount of stress*. This "right" amount of stress is not only a function of the physical situation, but is determined to a great extent by the economic situation as far as expected costs and benefits are concerned. In order to optimize economic water use efficiency for the processing tomato industry, the total cost of the global process (production as well as processing) should be minimised. In order to achieve this, the processor's quality based price for the producer's tomatoes, should be structured in a way that the farmer's profit is maximised at the yield/quality combination where the total cost of the global process is minimised. Producers need to be able to identify this optimum for their own situations and must then be able to manage the production system to achieve the target set. Optimization of this system requires integration of all variables and constants affecting the crop-soil-climate-irrigation-management system, as well as the economic situation of the producer and processor.

A modelling approach seemed to be the only practical way of integrating all the different variables into a single decision making process. Therefore, in order to facilitate this integration, a management tool in the form of a computer program was developed. The TOM-MAN program integrates the TOMYIELD crop growth model, which is based on SWB, and an economic optimization model, TOM-ECON, which was developed during this project.

Approach

In order to create a management tool which could be applied under a wide range of climatic and soil conditions, a mechanistic modelling approach was followed. Several growth analyses were conducted at various localities and during different seasons to generate data sets of growth and development as well as climate and the soil water balance. Data from some of the data sets were used to calculate input parameters during model development. The model was evaluated by running it with the calculated input parameters and the initial soil water content, rain, irrigation and weather data from the evaluation sites in the Western Cape Province and Northern Province. Simulated results of growth, development, yield and quality are compared to measured data to determine the accuracy of the model.

TOMYIELD differs from SWB mainly in its ability to simulate fresh yield and quality of processing tomatoes, as SWB only simulates dry matter yield of the different plant components. In order to simulate fresh yield and quality of processing tomatoes, procedures were developed for the following processes:

- * loss and gain of fruit water;
- * translocation of a portion of the dry matter from senesced leaves to fruits;
- * partitioning of fruit dry matter to the various fruit components;
- * fruit ripening;
- * maintenance and climacteric respiration of fruits; and
- * final fresh yield and percentage of soluble solids (brix).

Other modifications were also introduced to improve the accuracy of the simulation of growth and development, as well as the soil water balance procedure of SWB:

- * improved simulation of seedling growth rate;
- * influence of shading on the senescence rate of leaves;
- * storage of assimilates in the leaves;
- * changes in canopy structure during the season;
- * hastening influence of water stress on ripening; and
- * senescence rate.

Results

The structure and functioning of the model is described, with full details on all the modifications to SWB.

The input parameters needed to run TOMYIELD were established and evaluated. The model is evaluated by simulating the fresh yield, brix and water use of the Vredendal, Platskraal and Messina trials. The simulation of development rate according to thermal time was not sufficiently accurate to enable using a single set of thermal time parameters. Individual, site specific requirements were instead determined.

The water use efficiency, as well as the radiation extinction coefficient also varied between localities and individual parameters are recommended. Simulated versus measured data indicated that the following aspects were simulated fairly accurately:

- * leaf area index;
- * fractional interception of solar radiation;
- * total and harvestable dry matter; and
- * cumulative evapotranspiration and drainage.

The simulation of fresh yield and brix still needs attention, especially if the model is not calibrated for the area of use.

The function of TOM-ECON is to establish the desired irrigation strategy for processing tomatoes for application by TOM-MAN during routine scheduling. The user can define a set of potential irrigation strategies in terms of the allowable depletion levels of soil water during the different growth stages of the tomato crop. For each of these strategies a simulation of required irrigation and the resulting yield and quality is simulated by TOM-MAN.

TOM-ECON quantifies the costs of the TOMYIELD simulated inputs required for different strategies, as well as the income generated from the simulated outputs (yield and quality). In

order to optimize a specific situation, the user can enter the cost of inputs and the applicable tomato price structure. Because TOM-ECON's simulation of the net benefit is based on TOMYIELD's simulation of the yield and quality, the accuracy of TOMYIELD's simulation is of utmost importance.

For the calculation of the total variable production cost, variable running costs and the cost of risk are calculated.

Net income is calculated per unit of land area, water, and the contracted tonnage of yield, in order to enable the user to select the optimum irrigation strategy according to the factor, which is most limiting to increased profits. The user selects the criteria (land, water or contract tonnage of yield) on which basis he would like to optimize net income. TOM-ECON will then sort the irrigation strategies, based on the selected criteria, in a descending order. The user then selects the best irrigation strategy from the sorted list, which is applicable to his particular situation. The selected strategy is then applied as the irrigation guideline for scheduling irrigation.

Application

TOM-MAN, as a management tool for the optimization of the production of processing tomatoes, can be applied to assist management of both producers and processing companies in the following respects:

- * selection of optimal irrigation schedules by producers; and
- * routine scheduling of irrigation.
- * optimization of the price structure for processing tomatoes;

Conclusion

It is concluded that:

- * Integration of an irrigation scheduling model and an economic optimization model is appropriate and feasible;
- * Simulations of canopy development and dry matter production of processing tomatoes are fairly accurate;
- * The simulation of the water balance is good and practical irrigation scheduling can be implemented with confidence; and
- * The simulation of fresh yield and brix are not yet accurate enough and fine tuning of the parameters and/or a more mechanistic approach is required.

Further research needs

Various needs for further research have been identified during the project. The priority for further development is to enhance technology transfer through improved user friendliness and wider applicability to other crops through the establishment of model crop parameters.