Models for Predicting Water Use and Crop Yields – A Cuban Experience

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Introduction

Modeling has come into agriculture because of several reasons: 1) More comprehension about the processes that take place at the soil water atmosphere continuum SWAC, 2) Specialists from different fields come to work together, 3) Different and more efficient codes for obtaining the solutions of complex equations were introduced, 4) Amazing development of hardware and supporting softwares, 5) Large data banks coming from a lot of years of experimental laboratory and field work (mainly at the developed countries) and 6) Desires to put together as much SWAC processes as possible to get a better comprehension of such a complex system. Here we briefly present some of the results obtained in Cuba using simulation model SWACROP for estimating water use and yields in potato and model SWAP for sugar cane yields.

Materials and Methods

Figure 1 illustrates the processes that model SWAP takes into account according to (Van Dam et al., 1997; Kroes et al., 1998). SWAP is derived from the Feddes et al. (1978) model. The first application of SWAP in Cuba was made for a potato crop in order to determine water use and yields. The first initial version of SWAP devoted to the potato crop was called SWACROP. The first task was to calibrate the model for tropical conditions for a Rhodic Ferralsol. Several field experiments were carried out in order to obtain the soil hydraulic properties as well as the crop functions necessary for using the model. Later a validation procedure was made in the same soil but in another location. Yield, evapotranspiration, and soil moisture data coming from a four-year irrigation field experiment were used to find out how well the model estimated potato production. A detailed explanation is available Ruiz (1998).

The same procedure was followed for sugar cane crop. The leaf area index LAI and root water extraction functions were determined. The crop-dependent coefficient necessary to split evapotranspiration into transpiration and evaporation was also determined. Later and in another location, sugar cane yields obtained for crop seasons between 1991 and 1995 in three soils types and seeded in different months were collected for validation proposes.

Finally, an interface (Garea, 1999) between SWAP and the GIS ILWIS was made in order to more easily facilitate the model input of the data corresponding to small fields and not average values of larger domains.

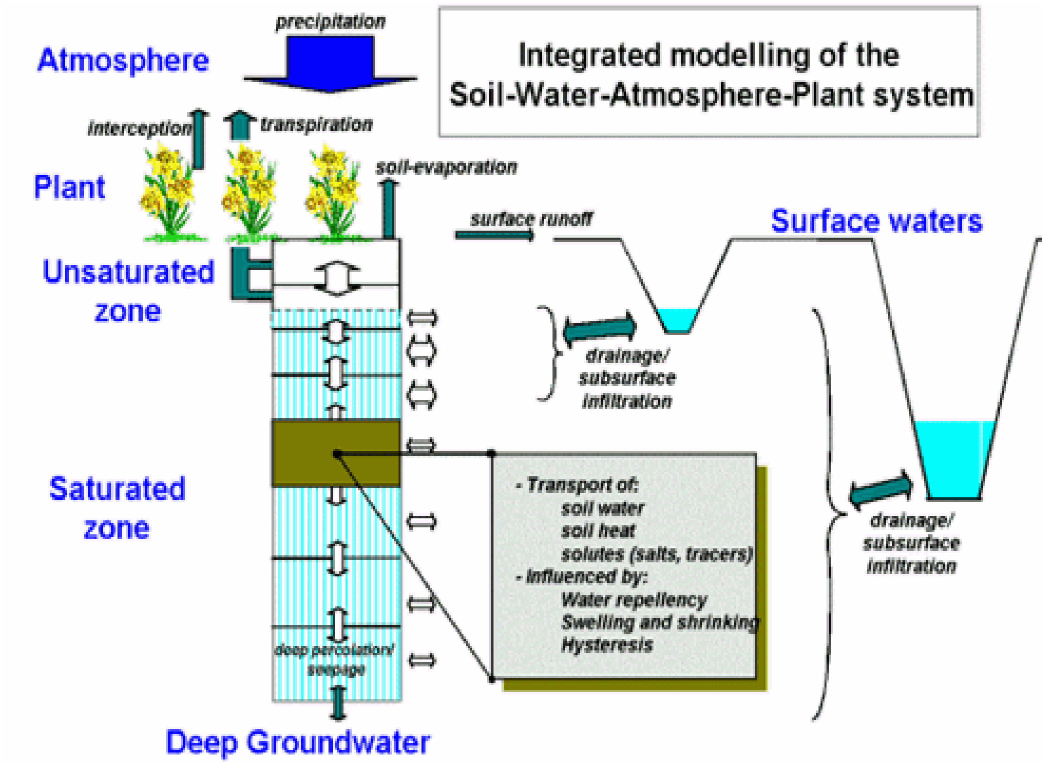


Fig. 1. Conception of model SWAP after Van Dam et al. (1997); Kroes et al. (1999).

Results

Fig. 2 shows the relationship between estimated and measured soil moisture contents for two different irrigation treatments for potato in a Rhodic Ferralsol. The graph to the left shows the results when more water was applied. Simulated values matched better the measured values for the higher water level.

Estimated and measured potato yields are shown in Fig. 3. A determination coefficient of 0.69 was obtained for a 95 % of confidence limit. Although this value could be considered somewhat low, it should be remembered that the soil hydraulic properties used for the simulation were taken from the results of Ruiz and Utset (1992) for this kind of soil, but not determined at the same location where potato yields were measured. Moreover, all the data considering the different irrigation treatments were considered.

For sugar cane, a calibration was made for a Rhodic Ferralsol. Later the model was tested for another location. The data of crop yields, seeding dates corresponding to three different soils were used for comparing with simulation results. Fig. 4 shows the results A) for each year, B) for the three soils present and C) for different seeding months. In all three cases, the SWAP simulations agree with the measured data. However, when averaged values for the input parameters are used in the model, a determination coefficient between simulated and measured output was only 0.40.

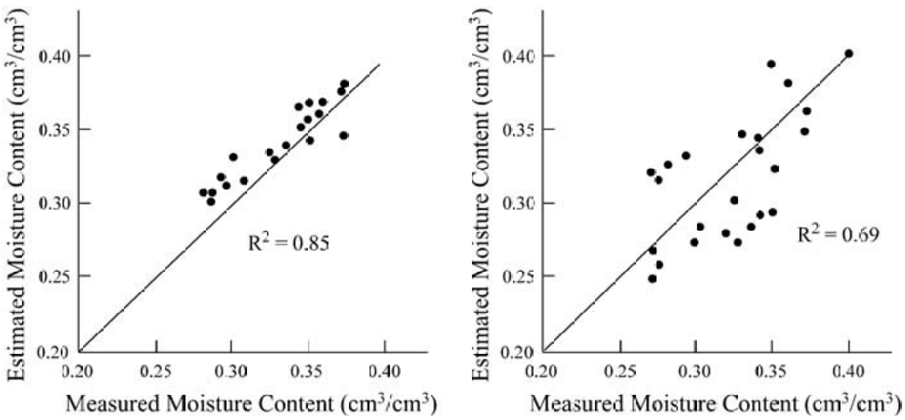


Fig. 2 Estimated and measured moisture content for high (left) and low (right) water irrigation level.

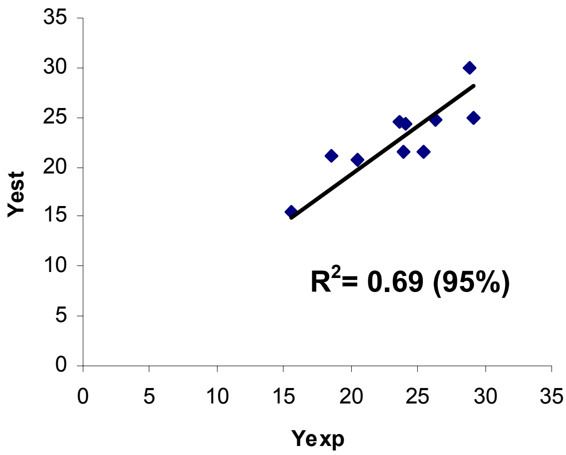
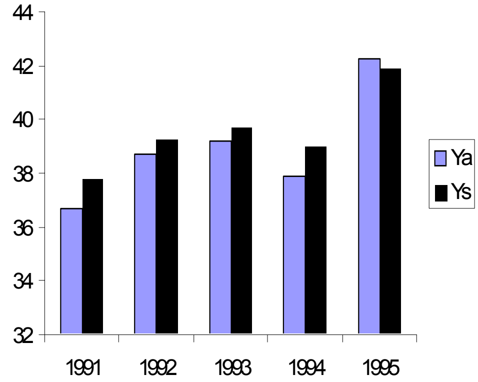
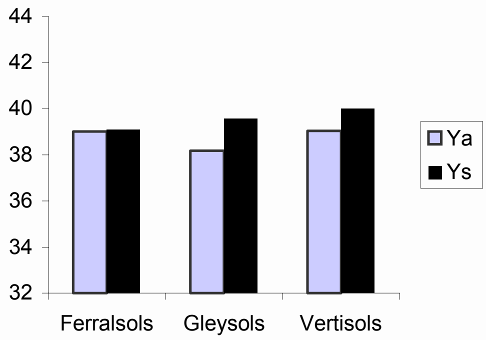


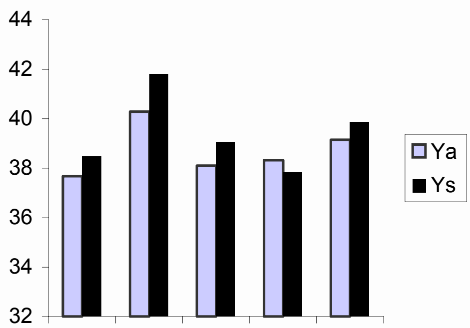
Fig. 3. Estimated and actual potato yields.



A-Yearly averaged.



B-Averaged by soil type.



C-Averages by seeding month.

Fig. 4. Estimated and actual sugar cane yields for different years (A), soil types (B) and seeding months (C)

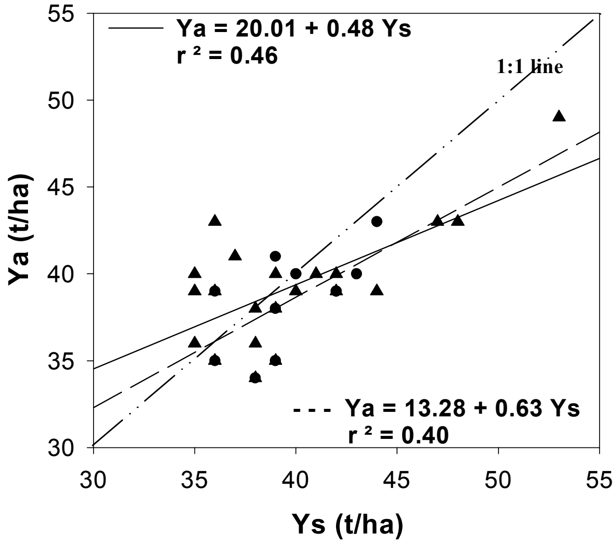


Fig. 5. Sugar cane estimated yields considering seeding dates for small fields ($r^2 = 0.46$) as well as block with seeding date averages ($r^2 = 0.40$)

When the interface was used allowing the input of the individual parameter values for each of the fields, better coefficients of determination were obtained. Nevertheless, because some data came from production areas of a sugar cane factory, some requirements for the model were not adequately fulfilled.

Conclusions

Not only is it necessary to improve estimations of the soil hydraulic properties, but mechanisms should be introduced into the model to take into account sugar cane crop fertilization. Irrigation scheduling for potato crops can be improved by using the SWAP simulation model. Because a sugar cane crop has a very large cycle, it is difficult to model. Problems were found when trying to satisfy the SWAP model assumptions.

All the possibilities of SWAP model have been not explored, and it remains necessary to evaluate the errors involved in SWAP simulations.

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