# Application of crop modelling in irrigated processing tomato

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**Abstract**
The water needs of processing tomato production is varying in different seasons. Irrigation substantially raises input costs, so the application of irrigation water must be based on sophisticated decision making. We can divide our fields according to their properties, and precision irrigation provides the possibility to apply different amount of water for these zones. Modelling crop production is a good option to support decision making. If we could simulate the effect of precision irrigation to our yields, then we could consider the results before making prescription maps for the irrigation machine. We have evaluated the efficiency of the model AquaCrop in processing tomato yield modelling. Deficit irrigation experiments were conducted on processing tomato under different water supplies. Final biomass production and dry yields were compared to the modelled results. Seven levels of water supplies were used for the comparison between 170.7 – 453 mm. Site specific soil and meteorology data were used as model input. The actual dry biomass yields ranged between 5.14 – 10.6 t/ha and the dry yields ranged between 2.48 – 5.93 t/ha . The correlation was r=0.88 for dry biomass yields and r=0.89 for dry yields. The model can be used for yield prediction, but larger errors occur when mid-level water supply is applied.
Keywords: AquaCrop, precision irrigation, decision making, deficit irrigation

**Introduction**
The availability of irrigation water in Hungary is good in general on the area of the extended irrigation systems. However, energy costs that required for pumping is high, therefore, irrigation water and energy saving is important. Planned irrigation is needed to reach these goals. Uniform irrigation of the field is not the best option in most cases because of the heterogeneity of fields in soil, relief, plant's development state etc (Figure 1). Variable rate irrigation (VRI) provides a tool to set management zones in the field. Deficit irrigation is a professional approach when we do not fully satisfy the evapotranspiration demand of crops.

This is a good way to save water or increase yield quality e.g. in processing tomato (Le et al., 2018) . Nevertheless, it is not simple to determine the irrigation levels for the most beneficial yield quality and quantity balance. Part of the solution may be crop modelling to support decision making.

AquaCrop is a crop production simulation model developed by FAO to describe interactions between plant and soil (Steduto et al., 2012) . This model is capable of simulating the effect of different irrigation water levels on crop parameters such as yield or stress induced by water depletion in the effective root zone (Takács et al., 2018a) . Many studies have been conducted to calibrate and validate the model for different crops and production areas (Montoya et al., 2016; Toumi et al., 2016) .

The aim of this study is to evaluate the performance of the model on modelling the yield (Y) and biomass (B) production of processing tomato grow under different water supply (WS).

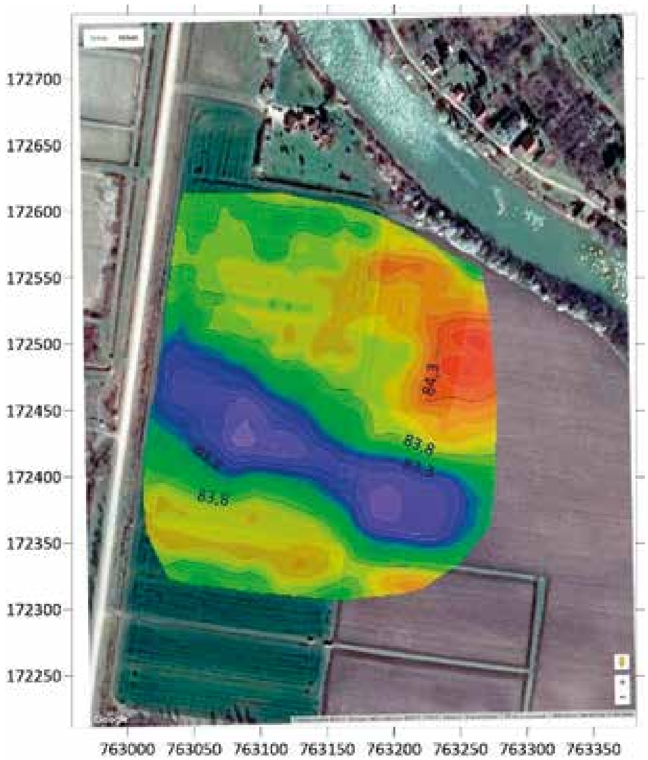


Figure 1.: Heterogenity of relief under a precision centre pivot. Blue colour represents low and red represents high relief.

**Materials and methods**
Two seasons of field experiments were conducted with processing tomato hybrid UG812J at Szarvas, Hungary on the experimental field of Szent István University. Three and four different levels of WSs were provided for the plots with a precision centre pivot equipped with VRI iS. The WS based on the potential crop evapotranspiration (ET) computed by AquaCrop. In 2017 the 50% (I50) and 100% (I100) of this ET were set in the experiment compared with control (C) irrigated only in the recovery period and by fertilization to avoid scorching. In 2018, 75% of ET (I75) was added to the experiment. Thus, seven different WS levels were tested. The differently irrigated plots were placed next to each other, but the overlap zones were considered by plant sampling and the irrigation uniformity in the different zones was also tested (Takács et al., 2018b) . The biomass was sampled 5 times during the 2018 growing season. Yield and biomass were sampled in the end of the season in both years.

Meteorological data (min. and max. temperature, relative humidity, rain, wind speed) for the modelling was collected by a meteorological station installed nearby the field. Only several modifications were carried out on the default tomato model. The reference harvest index was set according to the results of field experiments and the maximum canopy cover was set to 90% in irrigated plots and to 40% in C plots. Calendar dates were adjusted to season. Soil profile was made according to the results of soil surveying. Soil fertility and weed management was set as representative to season.

Pearson's correlation was used to reveal the connection between the modelled and measured values. Root mean squared error (RMSE) and mean absolute error (MAE) were used to examine how accurate the model is.

Results and discussion

The B development during the season was followed in the 2018 season under all four WS levels. The best results were found in the C and I100 treatments with the least errors and miscalculation of B. The modelled final B was above the measured with 0.18 t/ha . That means only 3% difference. The least error occurred in the C plot with 0.34 t/ha MAE and 0.45 t/ha RMSE. The second least error was found in the I100 treatment. This means 0.69 t/ha MAE and 0.95 t/ha RMSE. These errors mostly caused by the mid-season inaccuracy, because the final B was the most accurate in the plot without any water shortage. Less than 0.1 t/ha or 1% difference was found between the actual B and the modelled.

With these settings, large errors were found in the deficit irrigated plots. Large mid-season inaccuracy and miscalculation in the final B are present in these two models. Important to note that the small sample size can take part in large mid-season inaccuracy. In the I50 treatment the modelled B is above the measured with 1.59 t/ha . The miscalculation in the final B is almost the same in the I75 treatment, 1.52 t/ha .

The simulation of yields based on the modelled B and the harvest index. Thus, the reliable results of Y modelling strongly depend on the successful simulation of B. The Y data of the seven different WS showed strong correlation (Figure 2). The minimum difference between the modelled and the measured Y was 0.06 t/ha , which occurred in the C treatment in 2017. The best irrigated Y estimation was in the I100 treatment in 2018. These were overestimations by the model. The largest error was found in the I50 treatment of 2018. It was an underestimation by 1.09 t/ha . The correlation for the seven data points was $r=0.89$ on a $p<0.01$ level. The errors were more or less satisfying for the yields. MAE was 0.45 and RMSE was 0.59 t/ha . Poor simulation results of Y under severe water stress was found by others (Katerji et al., 2013) . Since we modified the maximum canopy cover for the C treatment the results are better, but that is not a good option in modelling. If the points from C treatments are left out, the correlation weakened to $r=0.66$ and the slope of the fitted line reduced, that means large overestimation of yield at the moderately stressed treatments. Rinaldi and coworkers (2011) found better results for simulating canopy cover and total dry B than for dry Y.

In processing tomato production beside fresh weight of Y, the soluble solid content is also very important. AquaCrop simulate dry yields, so the interpretation of the results would be comfortable. According to the results from this experiment there is good potential in the model to model tomato Y, although, useable data resulted only from the I100 treatment. The model must be perfected in the future, but we need more data to calibrate and validate the model for Hungarian conditions.

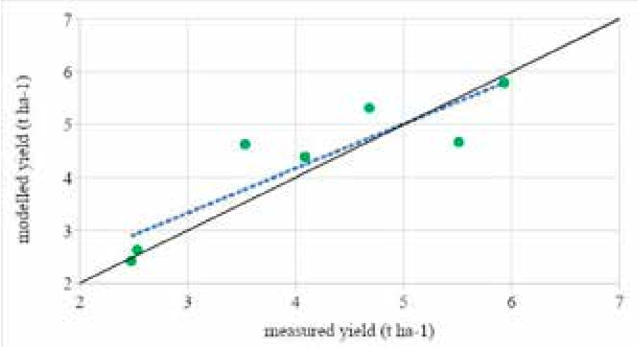


Figure 2.: Correlation between the modelled and the measured yields (n=7). Data points are related to seven different water supplies. The dotted line represents the fitted line to the points. The solid line is the reference for a perfect model.

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