

**ACCURACY TEST OF THE WEB-BASED SIMULATION MODEL CROPWATERUSE: COMPARISON OF SIMULATED TO OBSERVED LYSIMETRIC DAILY VALUES DURING THE GROWING SEASON****Carlos J. Fernandez****Texas AgriLife Research and Ext. Ctr.****Corpus Christi, TX****Giovanni Piccinni****Texas AgriLife Research and Ext. Ctr.****Uvalde, TX****Yujin Wen****Department of Soil & Crop Sciences, Texas A&M University****College Station, TX****Abstract**

Computer-assisted decision support systems can be useful tools in agricultural research and commercial crop management as they can help dealing with environmental variability and the complex nature of soil-crop-pest-environment interactions. *CropWaterUse* is an online tool included in the Crop-Weather Program, an evolving Web-based decision support system developed for cotton growers farming in South Texas (<http://cwp.tamu.edu>). *CropWaterUse* was developed using a mechanistic modeling approach to simulate the progression of canopy development (height, leaf area index, and ground cover), crop water use (actual soil evaporation and canopy transpiration), soil moisture storage throughout the soil profile, relative plant-available soil water content and cumulative soil water deficit at root depth. This tool was designed to support management decisions in both rain-fed and irrigated cotton crops. A study was conducted to test the accuracy of *CropWaterUse* by comparing simulated values to continuous actual lysimetric evapotranspiration data and non-destructive plant growth measurements collected at the Texas AgriLife Research Center in Uvalde, TX. Good agreement between simulated and observed values of daily crop water use ( $R^2=0.837$ ), cumulative crop water use ( $R^2=0.9987$ ), main stem nodes ( $R^2=0.9707$ ) and plant height ( $R^2=0.7729$ ) obtained in this study confirm that the *CropWaterUse* model is an accurate tool to simulate extended periods of crop water use in cotton.

**Introduction**

Computer-assisted decision support systems can be important tools in the decision-making process in farming, as they can assist crop-managers deal with environmental variability and the complex nature of soil-crop-pest-environment interactions. The simulation model *CropWaterUse* is a component of the suite of online tools available in the Crop-Weather Program (<http://cwp.tamu.edu>), an evolving Web-based decision support system developed to assist research and crop managers (cotton) in South Texas (Fernandez and Trolinger, 2007). This tool was designed to support management decisions in both rain-fed and irrigated cotton crops.

Unlike other simulation-based irrigation scheduling tools that use potential evapotranspiration (PET) and empirical fixed crop coefficients or fixed crop coefficient curves, the *CropWaterUse* tool was developed using a mechanistic modeling approach to simulate the progression of canopy development, crop water use (actual evapotranspiration or ET), soil moisture storage throughout the soil profile, relative plant-available soil water content and cumulative soil water deficit at root depth.

This poster presents results from a study conducted to confirm (validate) the accuracy of *CropWaterUse* by comparing (a) simulated crop water use values to continuous actual evapotranspiration data collected in a cotton-planted monolithic lysimeter and (b) simulated canopy values (plant height and number of main stem nodes) to observed values measured in an adjacent irrigated cotton field.

**Materials and Methods****Brief Description of Model**

The *CropWaterUse* tool is organized around three main simulation components. The first main component calculates the development of the canopy in terms of height, leaf area index, and ground cover using a series of empirical equations relating main-stem plastochron and internode elongation to air temperature (Reddy et al., 1997) and plant height to leaf area index (Marani and Ephrath, 1985). Algorithms were developed to relate expansive

growth to soil water content available to the plant (Fernandez, unpublished data, 2002). Soil volume occupied by roots is calculated as a function of canopy growth. The second main component calculates water fluxes from the soil and the canopy separately. Soil evaporation is calculated using the Penman-Monteith equation adapted to a bare soil surface and algorithms to simulate the effect of soil drying on the rate of soil evaporation. Rainfall water infiltration is calculated using an algorithm developed to take into account soil infiltration properties, rate of precipitation, and moisture of the upper layers of the soil. Two soil evaporation fluxes are calculated, one for sunlit soil and the other for soil shaded by the canopy. Canopy transpiration is calculated using also the Penman-Monteith method, where canopy height is a variable and the canopy resistance to water flows is a function of plant available soil water content (McCree and Fernandez, 1989). Crop water use is calculated as the sum of sunlit soil evaporation, shaded soil evaporation, and canopy transpiration prorated on ground cover. The third main component calculates two soil water balances at 0.025-m (1-inch) increments, one for non-rooted soil and another for the rooted soil, using a simple “book keeping” method that takes into account current balance, “gains” (rainfall and irrigation), “losses” (soil evaporation), and maximum water holding capacity. This simple “book keeping” method is applied in “cascade” to all layers of the soil profile from top to bottom. These two soil water balances are merged to obtain the overall soil water deficit at rooting depth.

### **Lysimeter Set Up**

Cotton was grown in a monolithic weighing lysimeter (60” x 80” x 108” depth) at the Texas AgriLife Research and Extension Center in Uvalde under full irrigation (Marek et al., 2006). The lysimeter is placed in the middle of a 2.5 ac field beneath a linear LEPA (low energy precision application) irrigation system. Cotton in the lysimeter and surrounding field (cv: Deltapine 555 BR) was re-planted on 19 May 2008, after stand failure from earlier planting, at 40” conventional row spacing and a plant density of 50k plants per acre. The same cultivar was planted also in an adjacent low-pressure center pivot-irrigated field on 15 April 2008. Soil type at experimental site is an Uvalde silty clay loam. The lysimeter was weighed continuously using electronic loadcells and data was collected on 15-minute averages using an automated system (Campbell Scientific datalogger CR23) to measure the amount of water entering (rain and or irrigation) or leaving (evaporation and transpiration) the system. Weather conditions were measured with an automated weather station (Campbell Scientific) located next to the lysimeter. Discrete canopy growth (height and main stem nodes) data were obtained from the center pivot irrigated field.

### **Simulation Runs**

Two simulation runs were performed, one for the lysimeter and the other for the adjacent center pivot irrigated field. Initial soil moisture conditions (relative plant available soil water content) for the top soil (upper 6 inches) was assumed to be 75% at both locations, while the value assumed for the subsoil (below 6 inches) was 90% and 60% were assumed for the lysimeter and the adjacent center pivot irrigated field. Plant and soil parameters used for both runs were identical. Minimum soil and canopy resistances to water vapor flow were set at 30 and 175 s m<sup>-1</sup>, respectively.

### **Results and Discussion**

At the end of the 91-d simulation run to emulate the lysimetric ET, the simulated cumulative crop water use totaled 455 mm, of which 42% was simulated soil evaporation. This simulated value was very close of the total observed lysimetric ET of 449 mm for the same period. End-of-run simulated values for canopy were plant height of 0.81 m, 18.2 main stem nodes, LAI=1.1 m<sup>2</sup>m<sup>-2</sup>, and ground cover of 79.7%.

The progression of daily crop water use values simulated by the model followed closely the observed daily lysimetric ET (Fig. 1). There were some discrepancies between simulated and observed values between simulated and observed values occurred largely between days 30 and 40, where the model underestimated ET, and other few high and low value misalignments. The causes of these discrepancies are being investigated.

The linear regression of simulated on observed daily crop water use values resulted in a highly significant R<sup>2</sup>=0.83 (Fig. 2). Simulated and observed daily cumulative crop water use values along the growing season showed a much better alignment (R<sup>2</sup>=0.9987) than the individual daily values as some of the daily differences cancelled out (Fig. 3).

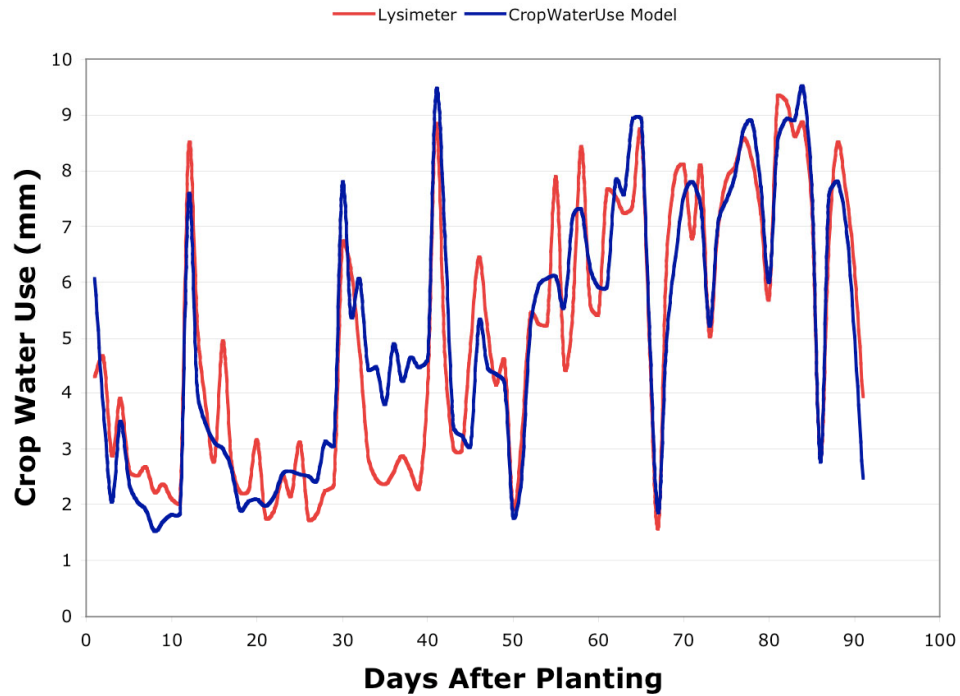


Figure 1. Daily progression of cotton crop water use (ET) values measured with monolithic weighing lysimeter and simulated by the model *CropWaterUse*.

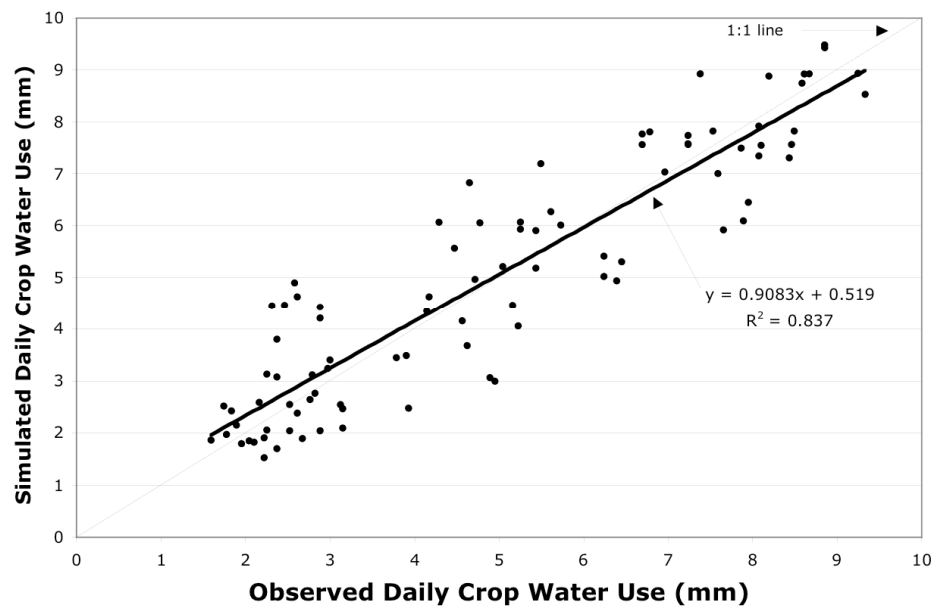


Figure 2. Statistical comparison of daily cotton crop water use (ET) values measured with a monolithic weighing lysimeter and simulated by the model *CropWaterUse*.

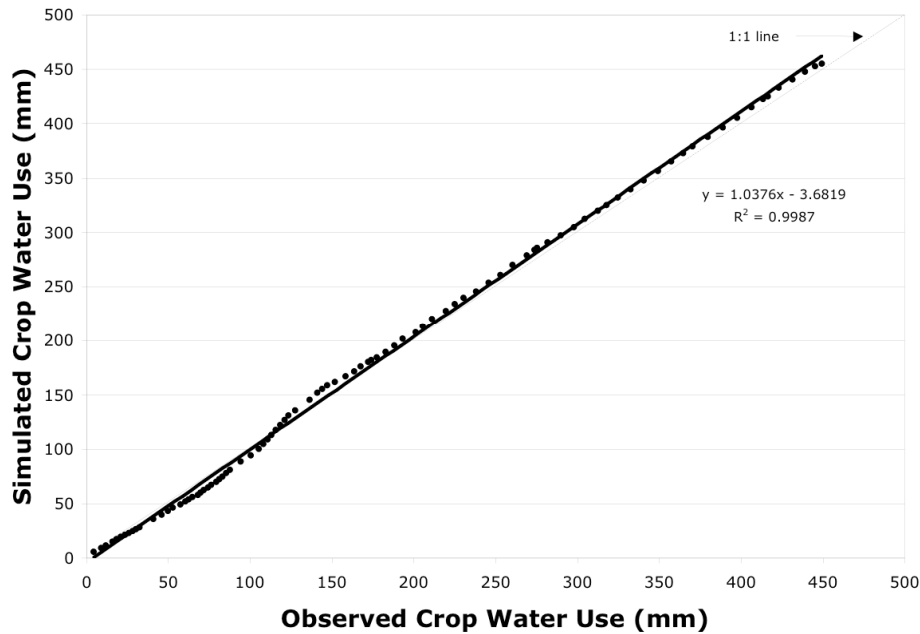


Figure 3. Statistical comparison of cumulative cotton crop water use (ET) values measured throughout the growing season a monolithic weighing lysimeter and simulated by the model *CropWaterUse*.

The accuracy of the model to simulate canopy development was analyzed using plant growth data obtained from the adjacent center pivot irrigated field. The model was run using the same plant and soil parameters used to simulated lysimetric ET, but differing on planting date and initial soil moisture conditions. The ability of the model to simulate the progression of the plant's number of main stem nodes (Fig. 3) and height (Fig. 4) was very good, resulting in  $R^2=0.9707$  and  $R^2=0.7729$ , respectively.

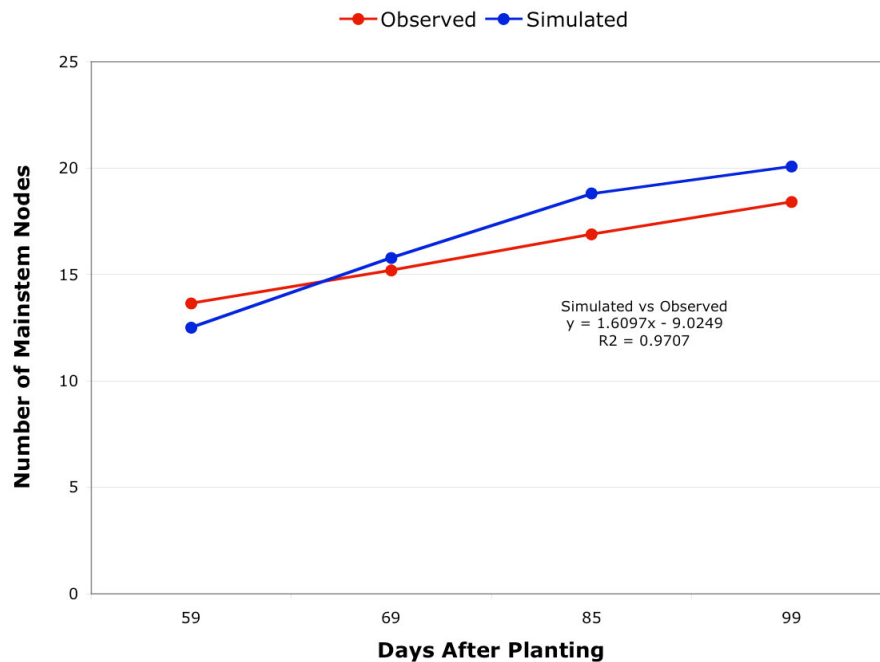


Figure 4. Comparison of number of main stem nodes values measured in an irrigated cotton field and simulated by the model *CropWaterUse*.

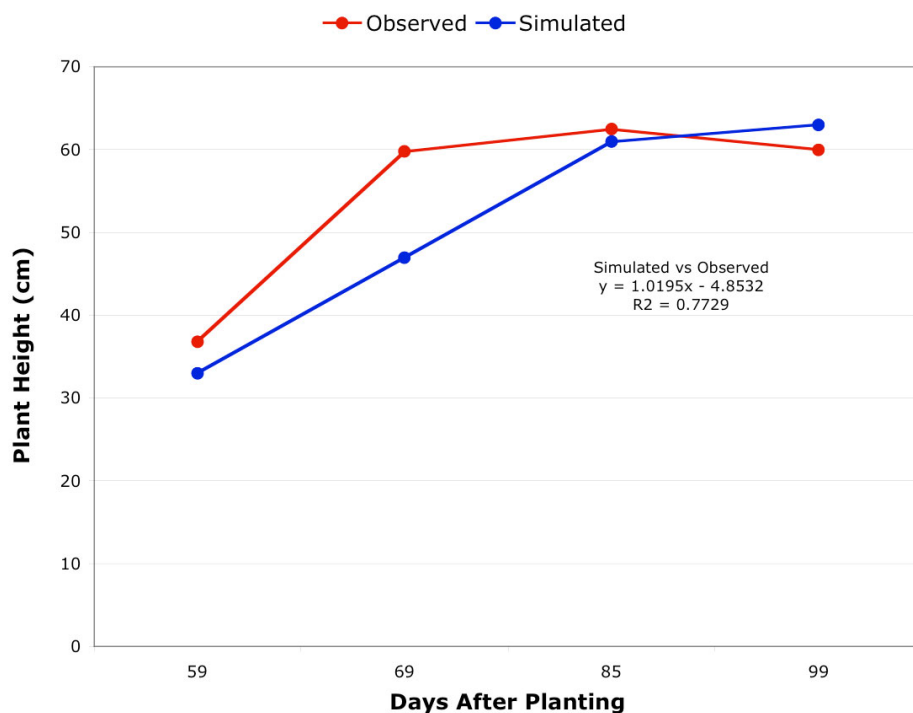


Figure 5. Comparison of cotton plant height values measured in an irrigated field and simulated by the model *CropWaterUse*.

In conclusion, the results obtained in this study, although there are some unexplained discrepancies between simulated and observed values; confirm that the *CropWaterUse* model is an accurate tool to simulate extended periods of crop water use in cotton.

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