Short description of the CROPWAT model

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General

CROPWAT is a decision support system developed by the Land and Water Development Division of FAO for planning and management of irrigation. CROPWAT is meant as a practical tool to carry out standard calculations for reference evapotranspiration, crop water requirements and crop irrigation requirements, and more specifically the design and management of irrigation schemes. It allows the development of recommendations for improved irrigation practices, the planning of irrigation schedules under varying water supply conditions, and the assessment of production under rainfed conditions or deficit irrigation.

Procedures for calculation of the crop water requirements and irrigation requirements are based on methodologies presented in FAO Irrigation and Drainage Papers No. 24 "Crop water requirements" and No. 33 "Yield response to water".

The development of irrigation schedules and evaluation of rainfed and irrigation practices are based on a daily soil-water balance using various options for water supply and irrigation management conditions.

There are two new versions of the CROPWAT: one is CROPWAT v 7.0 that contains a completely version in Pascal, developed with the assistance of the Agricultural College of Velp, Netherlands. It overcomes many of the shortcomings of the original 5.7 version. CROPWAT 7.0 is a DOS-application, but it runs without any problem in all MS-WINDOWS environments. Another one is CropWat for Windows that is written in Visual Basic and operates in the Windows environment. It has been developed with the assistance of the International Irrigation & Development Institute (IIDS) of the University of Southampton, UK.

Both versions use the same FAO (1992) Penman-Montieth method for calculating the reference crop evapotranspiration. These estimates are used in crop water requirements and irrigation scheduling calculations. Some of the interpolation methods used in CropWat for Windows are slightly different (up to 2%) to those used in CROPWAT 7.0. The main differences between the two versions are as the following:

- CropWat for Windows uses graphs and forms to display results;
- CropWat for Windows can deal with multiple crops with up to 30 crops in a cropping pattern; these crops are assumed to be co-existing in the same parcel of land;
- Irrigation Schedules can be calculated for individual blocks of each crop; the time base for results can be daily, weekly, decade or monthly;
- Color and black &white graphs can be printed through the standard Windows Print Manager;
- A “Scheduling scenario file” can be saved and read in quickly at a later date;
- CropWat for Windows uses monthly climatic data only, whereas CROPWAT 7.0 can use decade data as well as monthly data;
- CropWat for Windows allows user-defined irrigation events plus the option to add adjustments to the calculated soil moisture deficit for different reasons (such as: to apply actual rainfall data, to amend soil moisture deficit to bring it in to line with field measurements of soil moisture, etc.). This provides a flexible tool for managing the soil moisture during the growing season.

Input

Calculations of the crop water requirements and irrigation requirements are carried out with inputs of climatic, crop and soil data. For the estimation crop water requirements (CWR) the model requires:

a) ***Reference Crop Evapotranspiration*** (Eto) values measured or calculated using the FAO Penman-Montieth equation based on decade/monthly climatic data: minimum and maximum air temperature, relative humidity, sunshine duration and windspeed;
b) ***Rainfall*** data (daily/decade/monthly data); monthly rainfall is divided into a number of rain storm each month;
c) A ***Cropping Pattern*** consisting of the planting date, crop coefficient data files (including Kc values, stage days, root depth, depletion fraction) and the area planted (0-100% of the total area); a set of typical crop coefficient data files are provided in the program.

In addition, for *Irrigation Scheduling* the model requires information on:

d) ***Soil type*****:** total available soil moisture, maximum rooting depth, initial soil moisture depletion (% of total available moisture);
e) ***Scheduling Criteria*** – several options can be selected regarding the calculation of application timing and application depth (e.g. 80 mm every 14 days, or irrigate to return the soil back to field capacity when all the easily available moisture has been used).

Output

Once all the data is entered, CropWat 4 Windows automatically calculates the results as tables or plotted in graphs. The time step of the results can be any convenient time step: daily, weekly, decade or monthly. The output parameters for each crop in the cropping pattern are:

-reference crop evapotranspiration – Eto (mm/period);
-crop Kc - average values of crop coefficient for each time step;
-effective rain (mm/period) - the amount of water that enters the soil;
-crop water requirements – CWR or Etm (mm/period);
-irrigation requirements – IWR (mm/period);
-total available moisture – TAM (mm);
-readily available moisture – RAM (mm);
-actual crop evapotranspiration – Etc (mm);
-ratio of actual crop evapotranspiration to the maximum crop evapotranspiration - Etc/Etm (%);
-daily soil moisture deficit (mm);
-irrigation interval (days) **&** ***irrigation depth applied*** (mm);
-lost irrigation (mm)– irrigation water that is not stored in the soil (i.e. either surface runoff or percolation);
-estimated yields reduction due to crop stress (when Etc/Etm falls below 100%).

Calculation methods

The values of decade or monthly Reference Crop Evapotranspiration (Eto) are converted into daily values using four distribution models (the default is a polynomial curve fitting).

The model calculates the Crop Water Requirements using the equation: CWR=Eto*Kc*area planted. This means that the peak CWR in mm/day can be less than the peak Eto value when less than 100% of the area is planted in the cropping pattern.

The average values of crop coefficient for each time step are estimated by linear interpolation between the Kc values for each crop development stage. The "Crop Kc" values are calculated as Kc*Crop Area, so if the crop covers only 50% of the area, the "Crop Kc" values will be half of the Kc values in the crop coefficient data file

For crop water requirements and scheduling purposes, the monthly total rainfall has to be distributed into equivalent daily values. CropWat for Windows does this in two steps. First the rainfall from month to month is smoothed into a continuous curve (the default curve is a polynomial curve, but can be selected other smoothing methods available in the program e.g. linear interpolation between monthly values). Next the model assumes that the monthly rain falls in 6 separate rainstorms, one every 5 days (the number of the rainstorms can be changed). The model has available four Effective Rainfall methods (the USDA SCS method is the default).

For the scheduling calculations can be selected two options: *Irrigation Scheduling and /or Daily Soil Moisture Balance.* The Irrigation Scheduling option shows the status of the soil moisture every time new water enters the soil, either by rainfall or a calculated irrigation application. Daily Soil Moisture Balance option shows the status of the soil every day throughout the cropping pattern, how the soil moisture changes in the growing season. User defined irrigation events and other adjustments to the daily soil moisture balance can be made when the Scheduling Criteria are set to "user-defined".

Total Available Moisture (TAM) in the soil for the crop during the growing season is calculated as Field Capacity minus the Wilting Point times the current rooting depth of the crop. Readily Available Moisture (RAM) is calculated as TAM * P, where P is the depletion fraction as defined in the crop coefficient (Kc) file. To avoid crop stress, the calculated soil moisture deficit should not fall bellow the readily available moisture.

The program and the manual developed by Martin Smith, Derek Clarke & Khaled El-Askari can be downloaded from FAO's FTP server:

http://www.fao.org/waicent/faoinfo/agricult/agl/aglw/cropwat.htm