

CropWat for Windows : User Guide

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CropWat 4 Windows Version 4.2

		
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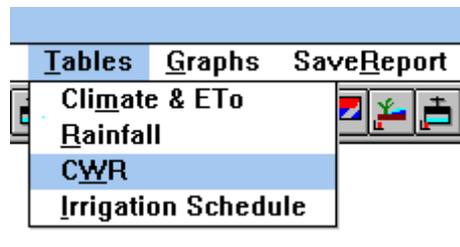
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Conventions used in this manual

1. Menu options which can be selected using the mouse from the main menu at the top of the screen are always printed in **bold** in this manual.

For example, to view a table of crop water requirements, you need to click on **Tables** at the top of the screen then **CWR**. This will be written in this manual as **Tables,CWR**



2. CWR is used as an abbreviation for Crop Water Requirements. (mm/day).

3. SMD is used as an abbreviation for Soil Moisture Deficit (mm).

4. ETo is Reference crop evapotranspiration (mm/day), calculated using the FAO Penman Montieth equation, not the FAO corrected Penman equation. The FAO Penman Montieth equation is described in the following papers :

Allen, Smith, Perrier and Pereira. "An Update for the Definition of Reference Evapotranspiration". ICID Bulletin 1994 Vol 43 No 2 pages 1-34.

Allen, Smith, Pereira and Perrier, "An Update for the Calculation of Reference Evapotranspiration". ICID Bulletin 1994 Vol 43 No 2 pages 35-92.

Additional information can also be found on the FAO Internet web server at [HTTP://WWW.FAO.ORG/AG/AGL/AGLW/WCROP.HTM](http://www.fao.org/ag/agl/aglw/wcrop.htm)

CropWat for Windows user guide

INTRODUCTION

CropWat for Windows is a program that uses the FAO (1992) Penman-Monteith methods for calculating reference crop evapotranspiration. These estimates are used in crop water requirements and irrigation scheduling calculations. The methods supersede the older FAO 24 procedures published in 1977 which are no longer recommended as they over estimate evapotranspiration.

The program uses the same Penman Monteith methodology as used in CROPWAT versions 5.7 and 7.0 and uses the same data such as the CLIMWAT climate and rainfall files.

The program uses a flexible menu system and file handling, and extensive use of graphics. Graphs of the input data (climate, cropping pattern) and results (crop water requirements, soil moisture deficit) can be drawn and printed with ease. Complex cropping patterns can be designed with several crops with staggered planting dates.

The program uses a Windows style “pull-down” menu system, and a “toolbar” at the top of the main screen which takes you to many of the most frequently accessed data entry and results screens. Additionally, the program logic does not have to follow a traditional rigid flow chart. You can choose any menu item or click on any button in the button bar in any order.

CropWat For Windows uses the same equations as in CROPWAT 7.0, but there are some differences between the menu systems and the types of calculation permitted. Some of the interpolation methods used are slightly different to those used in CROPWAT 7.0 and so calculations can occasionally differ by up to 2%. You will get bigger differences if you change the interpolation methods from the defaults.

The main differences between CROPWAT 7.0 and CropWat for Windows are:

- CropWat for Windows uses graphs and forms to display results. You will not see any results until you select a Table or a Graph.
- CropWat for Windows can deal with multiple crops with up to 30 crops in a cropping pattern. However, these crops are assumed to co-exist in the same parcel of land.
- Irrigation Schedules can be calculated for individual blocks of each crop. You can select the time base for results e.g. daily, weekly, monthly.
- Colour and black and white graphs can be printed through the standard Windows Print Manager.
- You can save a “Scheduling scenario file” which remembers the current data files for your project so that they can be read in quickly at a later date.
- CropWat for Windows uses monthly climatic data only, whereas CROPWAT 7.0 can use daily data as well and monthly data.
- CropWat for Windows allows user-defined irrigation events plus the option to add adjustments to the calculated soil moisture deficit. This provides a flexible tool for managing soil moisture during the growing season.
- CropWat for Windows cannot at present calculate crop water requirements for rice.

Installing CropWat for Windows

The program is supplied on two 3.5" disks. CropWat for Windows needs 6Mb free hard disk space to install and occupies 4 Mb of hard disk space once it is installed. Like all new Windows programs we recommend a 486 or faster computer although it will run on a 386 PC with 4Mb of memory. It will run under Windows 3.1, 3.11, 95 and 98. The installation will take about 5 minutes.

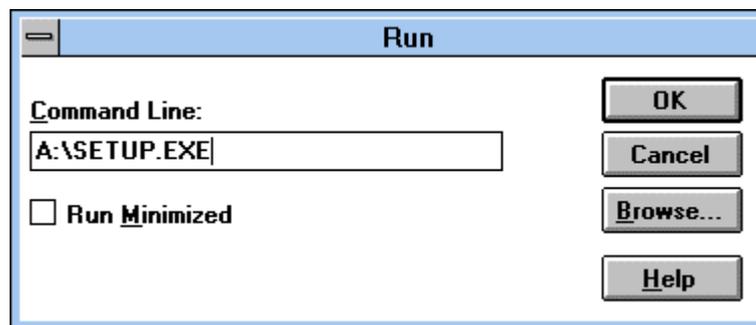
If you see the DOS prompt C:\> you will have to load Windows by typing either **WIN** or **EXIT**

IMPORTANT WARNING: Once Windows is loaded, it is vital that you close down all other active Windows programs to avoid installation problems. For example, Microsoft Office v4, Word 6 and Excel 5 share the same resource files as the installation program SETUP.EXE. If you do not close down Office (including the Office "toolbar") the CROPWAT installation may cause an error which can in some circumstances affect the performance of Office/Word/Excel.

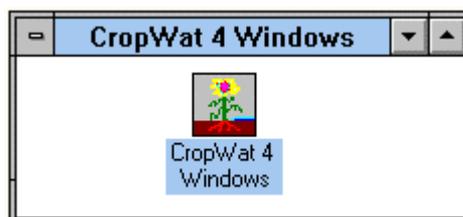
Insert DISK 1 into the disk drive and run file **A:\SETUP**

Windows 3.1 : You can run SETUP.EXE using the File Manager or by selecting File -Run at the top left of the Program Manager screen, and type A:\SETUP.EXE as the Command Line.

Windows 95 : Use the Windows Explorer to point to 3 1/2" disk in drive A and double click on the file SETUP.EXE

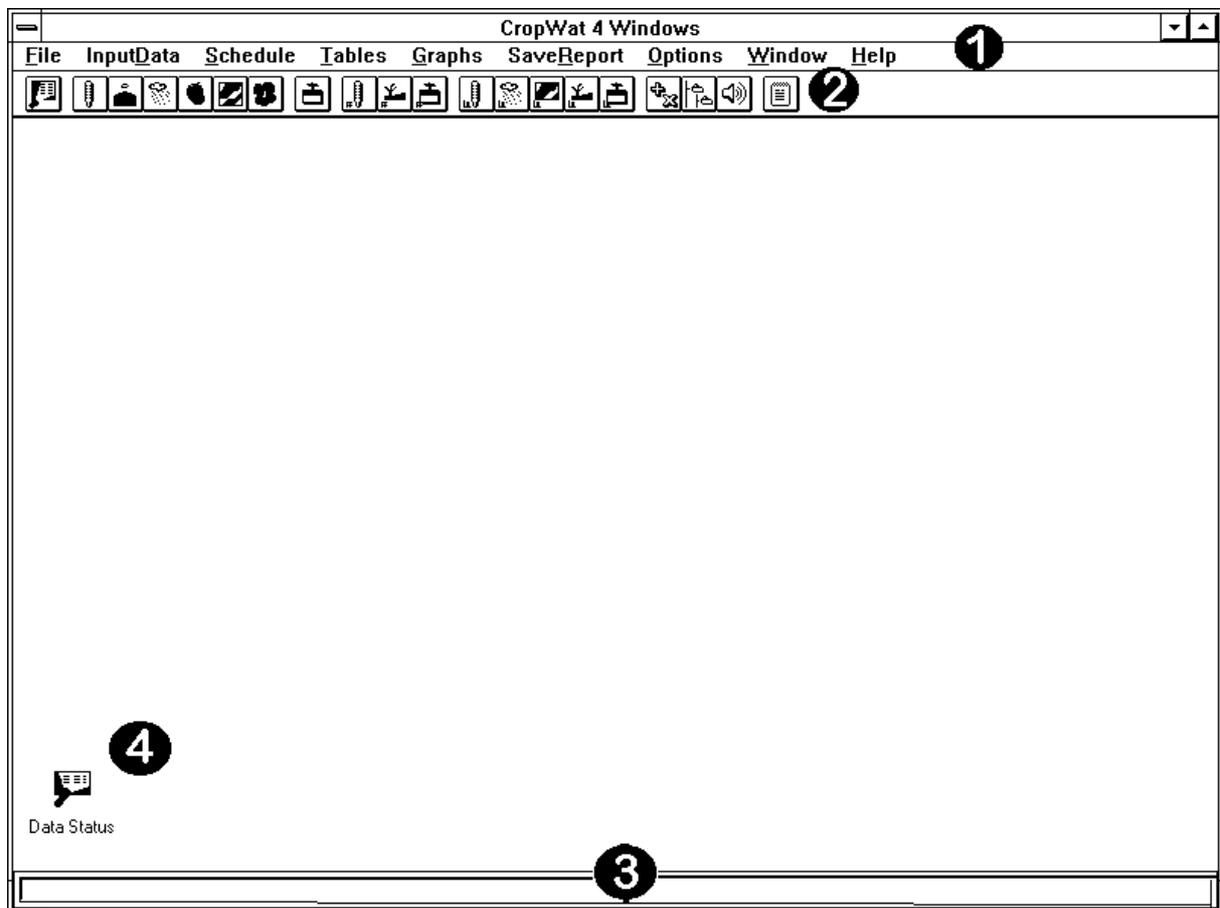


Click on the OK button to start the installation process. Follow the on screen instructions and change DISK 1 for DISK 2 when you are told. By default, the program will be installed to C:\CROPWATW, but you can change this during installation if you prefer. A Windows 3.1 Program Group and icon will also be created if required.



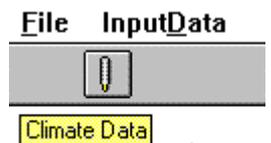
The User Interface and Menu System

The CROPWAT for Windows main menu screen appears like this :



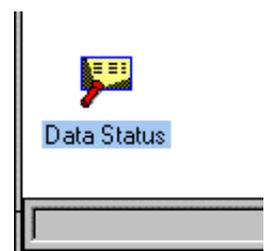
1 : The **Main Menu** bar with pull down menus. The menu system leads to the data entry and results forms. In some cases there are several routes through the menu system to the same results form.

2 : The **Tool Bar**, used to access the most frequently used menu options. Tool Bar icons which take you straight to the data entry windows without using the menu options. Place the mouse pointer on the icon without clicking and you will be told what the icon does.



3 : **Message boxes**, used to inform you about the current calculations

4 : The **Data Status** window. This is used to show the current files in use. Double click to open the window and you will see a summary of the files in use and what additional data is needed to carry out certain calculations.



The main route through the program

Unlike CROPWAT 5.7, the program has an "open" menu system - that is, it is possible to do almost anything in any order. Obviously if you have not entered any climate data then ETo will not be calculated and you cannot calculate crop water requirements.

The Main Menu

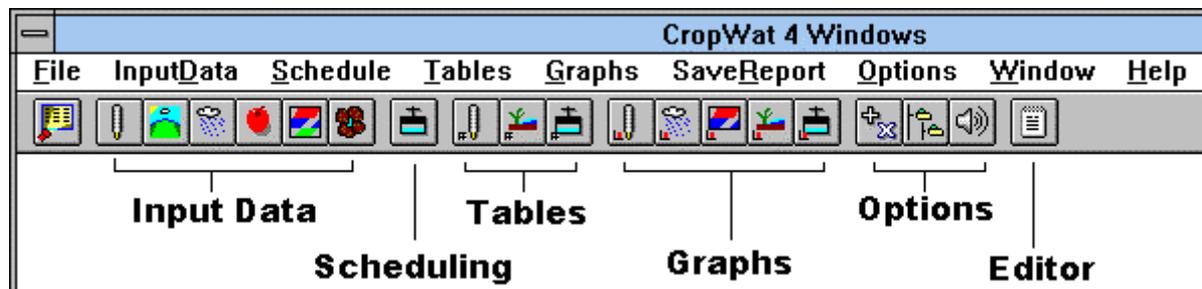
The main "route" through the program follows the menu options along the top of the screen:-



- first you enter data (either using menu option **File** or **Input Data**),
- next you define your scheduling criteria (use menu option **Schedule, Criteria**),
- the results can be seen in tabular or graphical form (menu options **Tables** and **Graphs**)
- you can save the results into ASCII files with **SaveReport**, ready for printing.

The Tool Bar

You can also access the data entry windows using the icons in the Tool Bar. These are grouped into sets of related icons across the top of the screen.



As you work with the program, you will often find that there are several ways of getting to the same menu option. If you do not have a mouse, the menu system can be activated with the keyboard in the usual Windows way: to activate the Main Menu bar, press ALT. The menus can then be used with the cursor and Enter keys, or by pressing the appropriate letter which is underlined.

The DATA STATUS Window



To help you know what data has been entered into the program a "**DATA STATUS WINDOW**" is provided. This is a table summarising the current data in use and also shows if you have entered enough data to calculate crop water requirements or an irrigation schedule.

To open the Data Status Window, click on the Data Status Icon. The icon appears at the lower left corner of the screen when the program starts, and it is also found on the Tool Bar. If you

double click on this icon, you will see a list of what data can be entered into the program and what needs to be entered to carry out some of the calculations. You may want to leave this window open while the program is running.

Watch to see how the Data Status changes every time data is retrieved or entered. This will help you keep track of what is going on. The table below is what you see when the program starts - no data has been entered, so CWR and Schedules cannot be calculated

Data Status			
Data Item	File Name	CWR	Scheduling
Climate	[No Data]	Optional	Optional
ETo	[No Data]	Yes	Yes
Rainfall	[No Data]	Optional	Optional
Crop	[No Data]	Optional	Optional
Cropping Pattern	[No Data]	Yes	Yes
Soil	[No Data]	No	Yes
Scheduling Criteria	[Not Set]	No	Yes
Can Calculate Now?		No	No

Below the Data Status has changed . Several sets of data have been read in from files and a cropping pattern has been entered from the keyboard. Note that the last row of the table (**Can Calculate Now?**) shows that crop water requirements can be calculated, but a schedule cannot be calculated because the scheduling criteria (amount, timing) have not been entered by the user:

Data Status			
Data Item	File Name	CWR	Scheduling
Climate	C:\CROPWAT\CLIMATE\KURNOOL.PEM	Optional	Optional
ETo	C:\CROPWAT\CLIMATE\KURNOOL.PEM	Yes	Yes
Rainfall	C:\CROPWAT\CLIMATE\KURNOOL.CRM	Optional	Optional
Crop	C:\CROPWAT\CROPS\MAIZE.CRO	Optional	Optional
Cropping Pattern	[Keyboard]	Yes	Yes
Soil	C:\CROPWAT\SOILS\MEDIUM.SOI	No	Yes
Scheduling Criteria	[Not Set]	No	Yes
Can Calculate Now?		Yes	No

Note : the file names in the table above are used in the examples in the rest of this manual. You may wish to load these files and follow the examples in this manual, where a crop of maize is planted on 3rd March covering 100% of the area irrigated. The files above are provided - load them using the menu options **File,Retrieve**. ETo will be calculated using the climate data so there is no need to retrieve ETo data. The cropping pattern must be entered manually using **InputData,Crops,CroppingPattern,Enter/Modify**

Data needed for calculations

CropWat for Windows uses monthly data to estimate evapotranspiration This data is smoothed into daily values. Monthly rainfall is divided into a number of rain storms each month. The following table lists data requirements for Crop Water and Scheduling calculations.

WHAT DATA DO I NEED FOR CALCULATIONS ?

For Crop Water Requirements (CWR) , you need

1. Reference Crop Evapotranspiration (ET_o) values calculated from

- either Your own measured values entered directly from the keyboard using **InputData,ET_o**
- or Estimates of ET_o calculated using the Penman-Monteith equation. ET_o is automatically calculated when you enter monthly climatic data (temperatures, humidity, windspeed, sunshine).

The data can be input from the keyboard using **InputData, Climate, Enter/Modify** or from a data file using **InputData, Climate, Retrieve**.

You can use the old *.PEN data files in the CLIMWAT database but to do this you must change the **File Type** from *.PEM to *.PEN when retrieving these files.

2. A Cropping Pattern consisting of

- one or more crop file names and the planting date(s). To do this, use the menu options **InputData,Crops,CroppingPattern**.

Note: the option **InputData,Crops,CropCoefficients** is provided only to enter or edit crop coefficient files (*.CRO). A set of typical crop coefficient data files are provided in C:\CROPWATW\CROPS.

3. Monthly Rainfall data

- rainfall data is not absolutely necessary (e.g. many areas of Egypt have no rain), but it should be used if rain falls in the growing season. Use **InputData,Rainfall** to do this.

You can use the old *.CLI data files in the CLIMWAT database but to do this you must change the **File Type** from *.CRM to *.CLI when retrieving these files.

For Irrigation Scheduling you will need the data listed above and -

4. Soil Type information

- soil data is entered using **InputData, Soil**. A set of typical soil types are provided in C:\CROPWATW\SOILS.

5. Your Scheduling Criteria - the basis on which schedules will be calculated

- you must specify the basis on which the scheduling is to be carried out (e.g. 100mm every 14 days, or irrigate to return the soil back to field capacity when all the easily available moisture has been used). This is done with menu option **Schedule,Criteria**.

Once all the data is entered, CropWat for Windows will carry out the necessary calculations. You do not need to click on a "calculate" or "run" command. If you change any data, the program will automatically recalculate the results.

How do I see the results ?

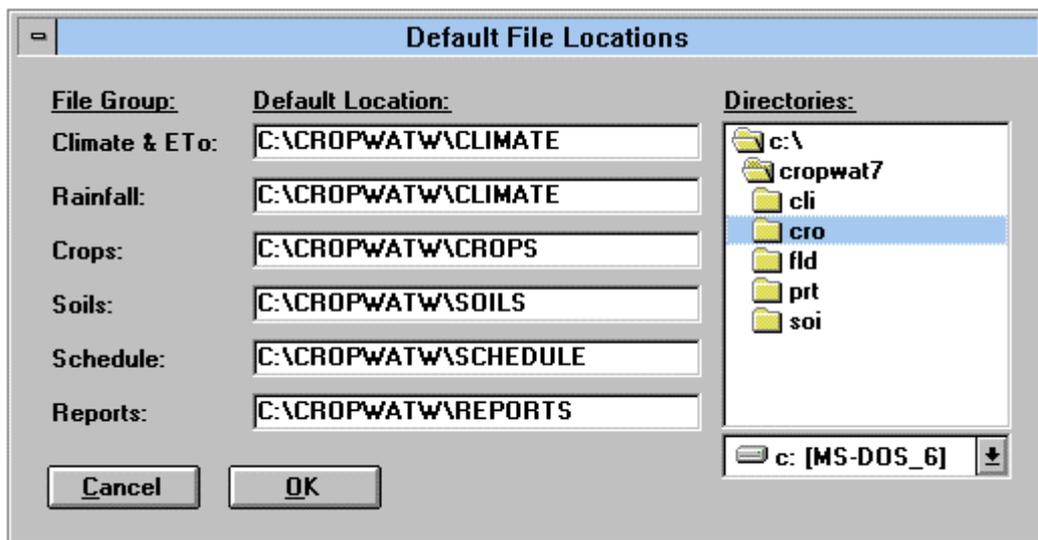
- | | |
|------------|---|
| On screen | - The menu options Tables will show tables of input data and results |
| | - The menu option Graphs allows you to plot data and results |
| To file | - Use the SaveReport option to create ASCII (text) and .CSV (export) files |
| To printer | - Use the Text Editor to print ASCII files created with SaveReport |
| | - Graphs can be rotated to Landscape or Portrait using the Print Manager. |

Data file names and directories

1. The standard installation of CropWat for Windows creates the following directories :

C:\CROPWATW\CLIMATE - climate (*.PEN, *.PEM) and rainfall (*.CLI, *.CRM) files
C:\CROPWATW\CROPS - crop coefficient (*.CRO) and cropping pattern (*.CPT) files
C:\CROPWATW\SOILS - soil data files (*.SOI, *.SOL)
C:\CROPWATW\SCHEDULE - scenarios(*.SNR), irrigations (*.IRR) and UserAdjustments (*.ADJ)
C:\CROPWATW\REPORTS - output files (*.TXT) (analogous to CROPWAT 7 result files *.OUT)

2. When loading/saving files, you can select any directory with the usual Windows dialog box. This allows you to share CLIMWAT or CROPWAT 7.0 data files with CropWat for Windows. You can change the default data directories with the main menu **Options, Default File Locations**.

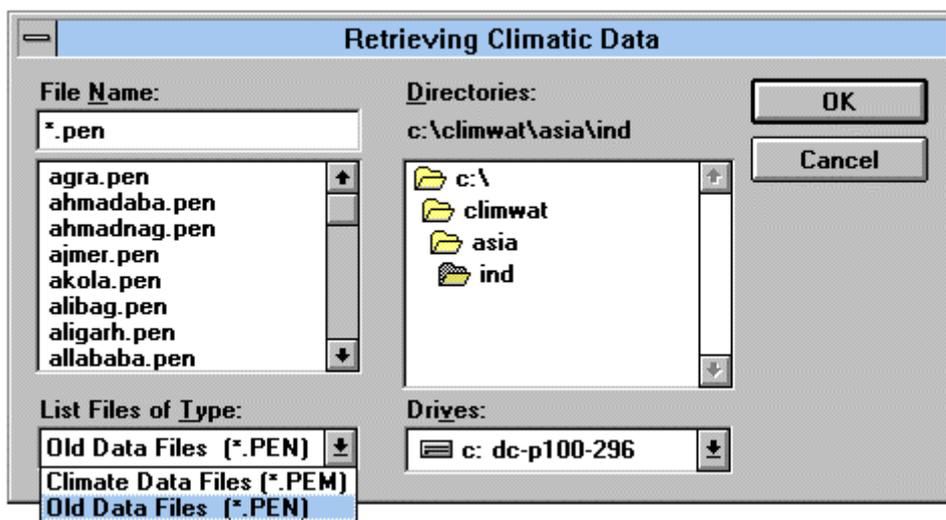


Here the user has changed the data directories from the default to CROPWAT 7 files

3. CropWat for Windows can read the following data file types:

CROPWAT 5.7 and CLIMWAT Monthly Climate files *.CLI
CROPWAT 5.7 and CLIMWAT Monthly Rainfall files *.PEN
CROPWAT 5.7 Soil files *.SOL
CROPWAT 7.0 Monthly Climate files *.PEM, (but not 10 day files *.PEC)
CROPWAT 7.0 Monthly Rainfall files *.CRM, (but not 10 day / 1 day files *.CRC /*.CRD)
CROPWAT 7.0 Soil files *.SOI
It will not read CROPWAT 5.7 Crop Coefficient (*.CRO) files.(See the note below)

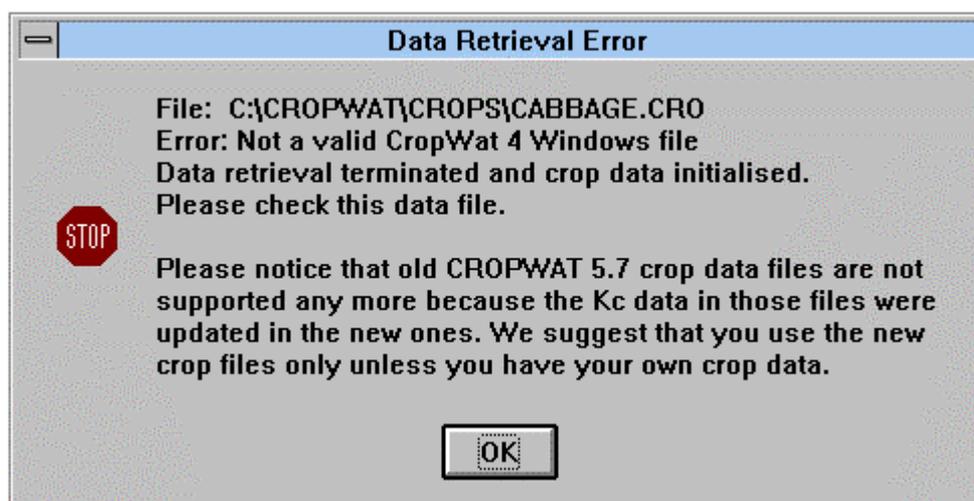
4. Please be careful with file extensions - CropWat for Windows looks for .PEM/.CRM files first! To load an old CROPWAT 5.7/CLIMWAT file, make sure that **File Type** is set to .PEN (climate data) or .CLI (rainfall data) :



See how the user has changed the File Type from .PEM to .PEN when retrieving old CLIMWAT data files for India.

5. Important note about changes to the CROP COEFFICIENT FILES

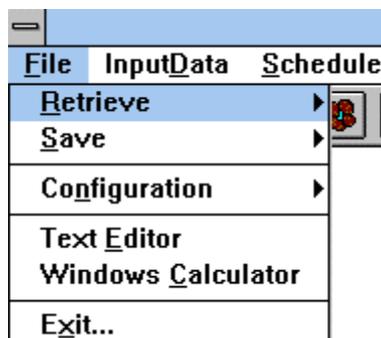
CROPWAT 5.7 Crop Coefficient files *.CRO cannot be read by CropWat for Windows or CROPWAT 7.0 because the Kc and Ky values have been updated by FAO. A new file structure has been used to distinguish between the “old” and “new” crop data files. If you try to retrieve an “old” .CRO file you will see the following message :



6. CropWat for Windows and CROPWAT 7.0 use the same (new) crop coefficient files. If you have your own Crop files created by CROPWAT 5.7, these will have to be re-typed into CROPWAT 7.0 or CropWat for Windows.

The CropWat for Windows main menu options

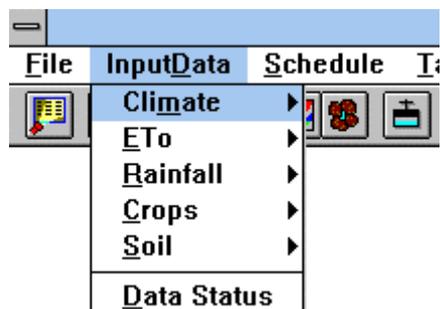
1. The FILE menu



RETRIEVE - load a data file
SAVE - save a data file
CONFIGURATION - allows you to override the default calculation methods or file locations.
TEXT EDITOR - view/print a set of results in an ASCII file
WINDOWS CALCULATOR - check your sums!
EXIT - leave CropWat for Windows

File,Retrieve and **File,Save** allow you to load or save sets of data, for example you could save a set of climatic data that you have just typed in or you could read in some rainfall data from the CLIMWAT database.

2. The INPUT DATA menu



CLIMATE - enter monthly climate data to calculate ETo
ETo - enter your own monthly ETo estimates
RAINFALL - enter monthly rainfall data
CROPS - enter cropping patterns and crop coefficient data
SOIL - enter data for your soil type
DATA STATUS - show or hide the window

These options permit you to enter new data using a “data entry window” or to load/save data to/from files. The load/save options duplicate the **File,Retrieve** and **File,Save** options in the **File** menu. For example, a set of climate data could be read in from a data file using **InputData,Climate,Retrieve** or using **File,Retrieve,Climate Data**.

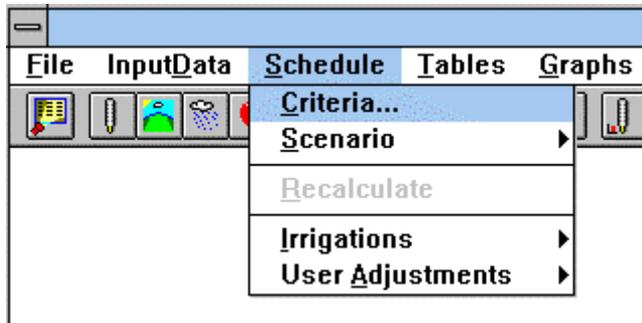
Notes :

1. You can use *.CLI or *.PEN data files in the CLIMWAT database. To do this change the **File Type** from .CRM to .CLI or .PEM to .PEN when retrieving files.
2. Remember that you must define a Cropping Pattern before calculations can be made. To do this use menu options **InputData,Crops,CroppingPattern**. Note that **InputData,Crops,CropCoefficients** should only be used to edit the crop coefficient data files (*.CRO).

Once the data has been entered, you can see it in a table with the **Tables** main menu option or plotted in a graph with the **Graphs** main menu option.

3. The SCHEDULE menu

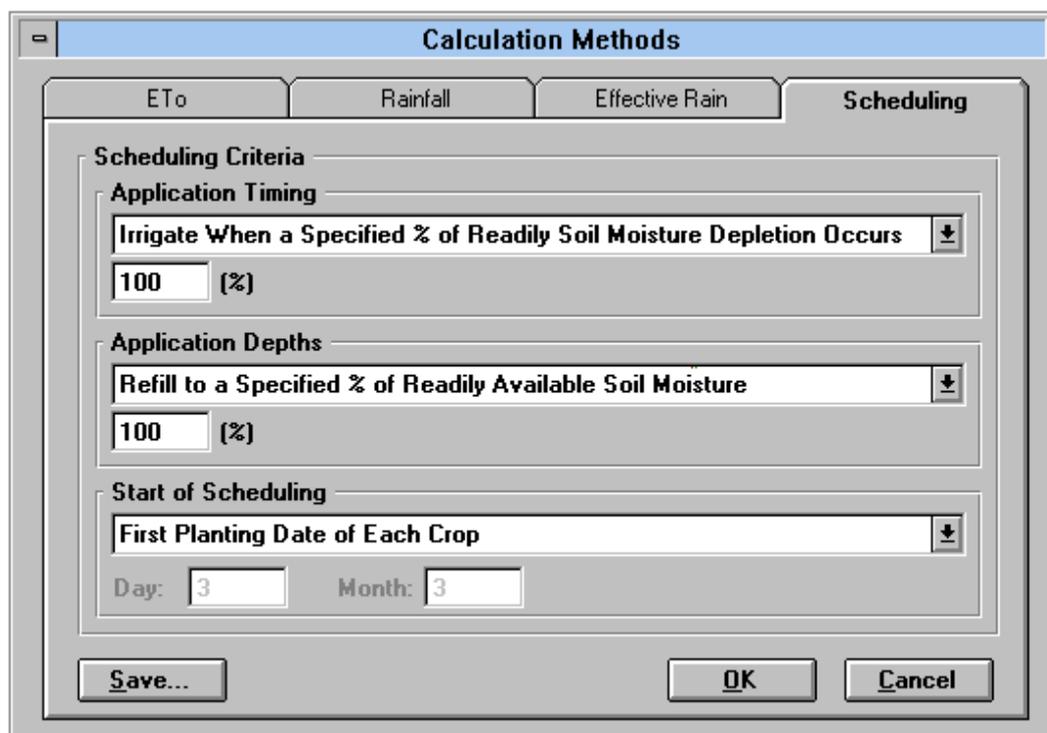
The Schedule Menu lets you define how irrigations are calculated and to manage groups of data files (climate,rain,crop,soil) which are called “irrigation scenarios”. At this stage, all you need to do is to define the method for scheduling using **Schedule, Criteria**.



CRITERIA - irrigation timing and amount
SCENARIO - group a set of data files*
RECALCULATE - if data has changed
IRRIGATIONS - load/save depths/dates*
USER ADJUSTMENTS *

*See the “Advanced” section in this manual for more details

Before any irrigation calculations can be carried out, you must define what kind of schedule you wish to use using **Schedule, Criteria**. If you select **OK** with no other changes, the schedule is calculated for “optimal” irrigation and you can go directly to the tables or graphs of results . Several other options can be selected in the Calculation Methods window.



3.1 Scheduling Criteria Options

CropWat for Windows allows you to select many ways of defining an irrigation schedule. The default options are shown above. These define “optimal” irrigation from the first planting date of the crops, where irrigation is calculated to take place when all of the readily available soil

moisture has been used. The irrigation amount will be equal to the soil moisture deficit, so the soil moisture deficit returns to zero after the irrigation and no water is wasted.

APPLICATION TIMING: The example below says that we will irrigate when all (100%) of the readily available moisture has been used up, so the crop never becomes stressed.

APPLICATION DEPTH : This says that the irrigation amount will be calculated to refill the soil moisture store, i.e. irrigate to return the soil to field capacity (100% of the readily available moisture is replaced).

START OF SCHEDULING : You can start scheduling from any date in the growing season, but the default is to begin from the earliest planting date of each crop.

INITIAL SOIL MOISTURE CONDITIONS : these are defined by the data in the soil file. The example soil files provided are all set to zero soil moisture deficit. You can change this using **InputData,Soils,Enter/Modify**

3.2 Setting your own scheduling options:

CropWat for Windows gives you a wide range of methods to calculate an irrigation schedule.

You can control WHEN the irrigations take place with the APPLICATION TIMING options:

You can say HOW MUCH water is applied with APPLICATION DEPTHS

Once the criteria are defined, the program will calculate the irrigation dates and amounts. These can be seen by selecting **Tables, Irrigation Schedule**, or **Graphs, Irrigation Schedule**.

Scheduling Scenarios

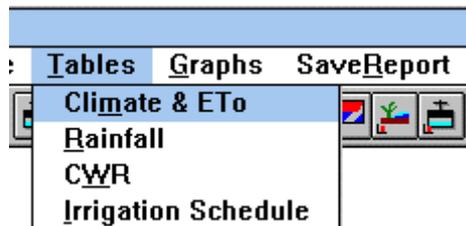
A "Scheduling Scenario" is a "snapshot" of the scheduling data for an irrigated area - it is used to store the names of the data files used in the current irrigation calculation. Once a Scenario is saved it can be re-loaded again rapidly, which allows you to store sets of irrigation conditions - for differing tertiary units for example. See the Advanced section of this manual for more information on Scenarios.

Irrigations and User Adjustments

A useful feature of CropWat for Windows is the ability to enter your own irrigation amounts and timing with the User Defined irrigation options. When these have been typed in, they can be saved using the menu option **Schedule,Irrigations, Save**. This permits you to keep a track of the irrigation events in the growing season. Actual rainfall can also be entered using the **Schedule, User Adjustments** menu option. See the Advanced section of this manual for more details.

4. The TABLES and GRAPHS menu

These menus allow you to see the input data and the results of the calculations for Crop Water Requirements and Scheduling.



Tables menu - examine input data and results

CLIMATE & ETo : Input data & calculated ETo

RAINFALL : Input data & calculated effective rain

CWR : Crop Water Requirements

IRRIGATION SCHEDULE : irrigation & soil moisture

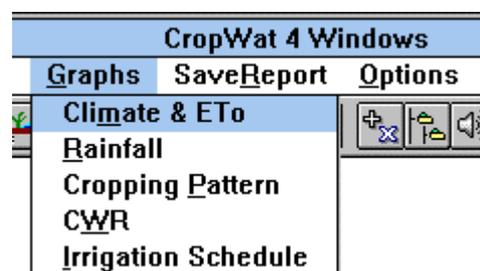
Graphs menu - show graphs of input data and results

CLIMATE & ETo - temperature, wind, humidity, sunshine, rainfall and Penman-Monteith estimates

CROPPING PATTERN - planting dates/areas

CWR - variation during the season, IWR, ETo

IRRIGATION SCHEDULE - soil moisture deficits



Tables and graphs can be shown quickly with the Toolbar icons:



- Icons for Tables of Climate, CWR and Scheduling



- Icons for Graphs of Climate, Rain, Crop Pattern, CWR and Scheduling

4.1 Example CLIMATE Table

The table below was read in from file KURNOOL.PEM. It can be displayed by selecting **Tables,Climate**. It summarises the monthly climate data for the station (i.e. temperature, humidity, windspeed and sunshine hours).

The calculated values of Reference Crop Evapotranspiration (ET_o) using the 1992 FAO recommended Penman Monteith equation are shown in the right hand column together with the calculated solar radiation. The units of ET_o are millimetres of water per day.

These results will be different to the values calculated using the 1977 edition of FAO24 Irrigation and Drainage Paper “Crop Water Requirements”. The old FAO 24 equations have been found to over estimate ET_o and are no longer recommended. The results should however be very close to those produced by CROPWAT 5.7 and CROPWAT 7.0 except some differences in the last decimal place of the calculated ET_o values.

Climate Data Table							
Country	India	Station	KURNOOL	Altitude	281	(m)	
Month	Max Temp. (C)	Min Temp. (C)	Humidity (%)	WindSpeed (km/d)	SunShine (hours)	Solar Radiation (MJ/m2/d)	ET _o (mm/d)
January	31.3	17.0	55.0	104.0	9.7	20.0	4.2
February	34.3	19.3	44.0	112.0	10.3	22.6	5.2
March	37.5	22.5	37.0	121.0	10.7	25.0	6.2
April	39.3	26.0	39.0	138.0	10.1	25.1	6.9
May	40.0	27.2	42.0	225.0	9.2	23.6	8.1
June	35.6	25.0	58.0	354.0	6.5	19.3	7.2
July	32.5	23.8	67.0	363.0	4.9	16.9	5.8
August	32.1	23.5	67.0	302.0	5.4	17.7	5.5
September	31.9	23.3	69.0	207.0	6.0	18.2	4.9
October	32.4	22.4	66.0	95.0	9.5	21.9	4.7
November	31.0	19.2	63.0	78.0	8.4	18.6	3.8
December	30.3	16.6	60.0	69.0	9.3	18.8	3.5
Average	34.0	22.1	55.6	180.7	8.3	20.6	5.5

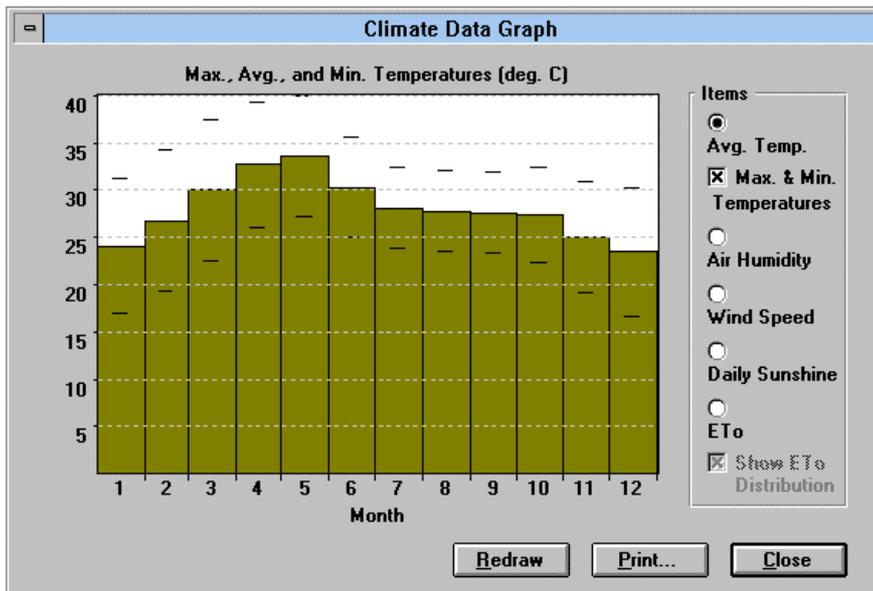
Report... Close

A copy of this table can be saved to an ASCII file on disk with the **Report** button. The file can be viewed or printed using the built in editor by selecting **File,TextEditor**, or alternatively, read directly into any text editor such or a word processor.

4.2 Example Climate Graphs

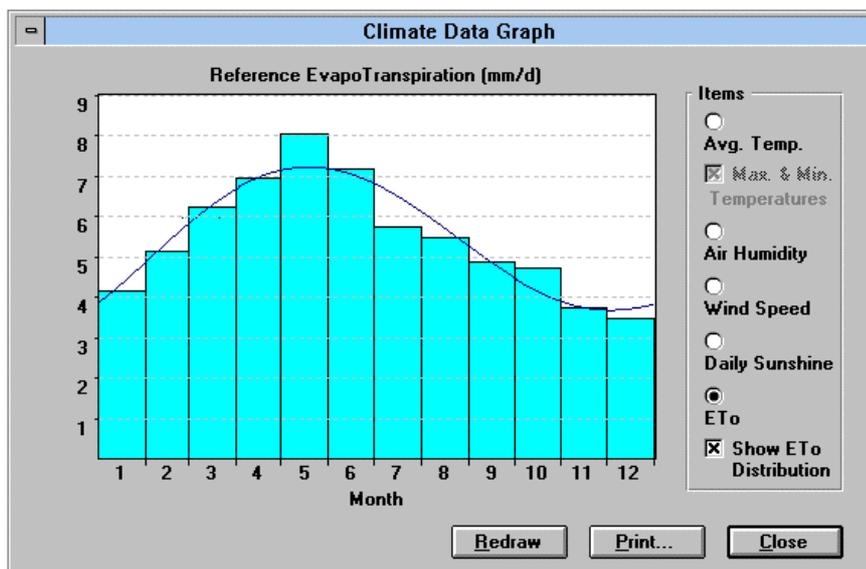


Graphs of the climatic data and calculated ETo can be shown with menu option **Graphs,Climate** or the climate graph icon in the Toolbar. The data to be plotted is selected by clicking in the “Items” selection box on the right of the graph. A printout of the graph can be made by clicking on the **Print** button on the graph.

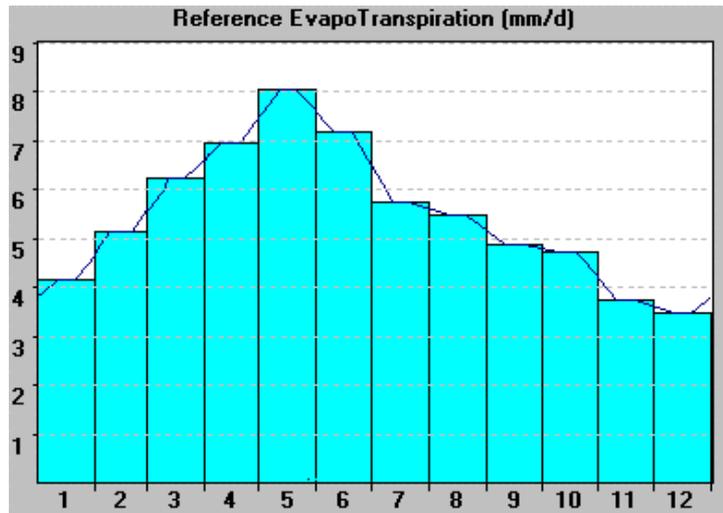


The Temperature graph above shows the mean temperature for each month. The ticks above and below the mean show the maximum and minimum values.

The ETo graph below shows how the curve fitting is used to distribute the monthly estimates into daily values. The method of curve fitting can be changed with **Options, CalculationMethods, ETo Distribution Model**. The fitted curve can be turned off by de-selecting the check box labelled “Show ETo Distribution” on the right of the graph.



In this graph, the user has selected to smooth monthly ETo into daily values using the option “Linear Distribution at ends of the month”. NB This will produce different results in crop water and irrigation scheduling compared with the smooth curve used above. You should select the most appropriate distribution to suit your own data.



4.3 Printing Graphs

The graphs can be printed in either portrait (vertical) or landscape (horizontal) layout. When you click on the **Print** button, you will see a preview of the graph. The following options are available when printing:

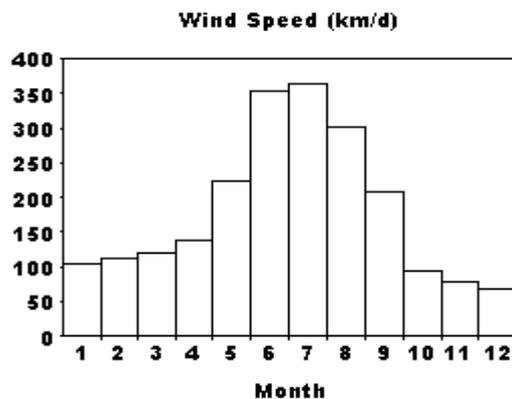
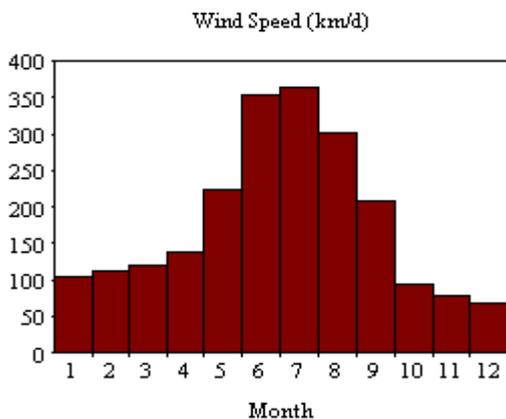


PRINTER - use the Windows Print Manager to select which printer to use, the paper size and layout (Portrait/Landscape)

PREVIEW - see the page layout before printing

FONT- select the typeface used in labelling the graph

COLOUR PRINT - an “x” will send shading information to the printer. This is fine for colour printing but it can waste a lot of ink if you have a black and white printer.



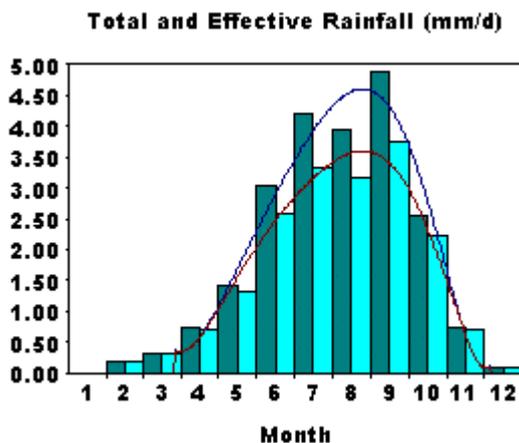
Graphs of wind speed plotted in colour with “Times” font and in Black and White with “Arial” font

Note : All printing is controlled by the Windows Print Manager and if you select Landscape printing, you should remember to re-set the paper to Portrait when finished, otherwise your next word processed printout will also come out in Landscape mode!

4.4 Example RAINFALL Table

This table is shown by selecting **Tables,Rainfall**. It lists the monthly total rainfall and the calculated effective rainfall. It is the same as the data entry form used to input the raw data.

	<u>T</u> otal	<u>E</u> ffective		
January	0.0	0.0	(mm/month)	OK
February	5.0	5.0	(mm/month)	Cancel
March	10.0	9.8	(mm/month)	Retrieve...
April	22.0	21.2	(mm/month)	Save...
May	44.0	40.9	(mm/month)	Report...
June	91.0	77.8	(mm/month)	Clear
July	130.0	103.0	(mm/month)	Clear All...
August	122.0	98.2	(mm/month)	Effective
September	147.0	112.4	(mm/month)	
October	79.0	69.0	(mm/month)	
November	22.0	21.2	(mm/month)	
December	3.0	3.0	(mm/month)	
Total	675.00	561.50		



A graph of total and effective rainfall can be produced with **Graphs,Rainfall**.

The method used for calculating Effective Rainfall can be changed by clicking on the **Effective** button in the rainfall table. This will call up the **Options, Calculation Methods, Effective Rainfall** menu.

Note that 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

i) First the rainfall from month to month is smoothed into a continuous curve. The default curve is a polynomial curve. In some cases a smooth curve is difficult to fit, for example where there is a sudden change from a dry season to a very wet season. Other smoothing methods are available e.g. linear interpolation between monthly values (see **Options, Calculation Methods, Rainfall** and **Graphs,Rainfall**).

ii) Next we have to assume that there are a given number of individual rainstorms in month. This is because it is unlikely that the rain will fall at a continuous uniform intensity throughout each month. CropWat for Windows assumes that the monthly rain falls in 6 separate rainstorms, one every 5 days. You can change the number of rain storms with **Options, Calculation Methods, Rainfall, RainfallAggregation**.

4.5 Example CROP WATER REQUIREMENTS TABLE

This table lists information about the ETo, rainfall and crop coefficient data for each crop in the cropping pattern. To show it select **Tables,CWR..** You can change the time step and the assumed in field Irrigation Efficiency, which affects the calculated the Field Water Supply in litres per second per hectare (FWS l/s/ha).

Crop Water Requirements Table								
MAIZE (Grain) ↓		Time Step (Days): 10		Update		Report...		
[All Blocks] ↓		Irrigation Efficiency (%): 70		Close				
Date	ETo (mm/period)	Crop Area (%)	Crop Kc	CWR (ETm) (mm/period)	Total Rain (mm/period)	Effect. Rain (mm/period)	Irrig. Req. (mm/period)	FWS (l/s/ha)
23/3	66.05	100.00	0.33	22.07	2.45	2.40	19.67	0.33
2/4	68.20	100.00	0.54	36.61	4.05	4.05	32.56	0.54
12/4	69.92	100.00	0.76	53.25	6.25	6.18	47.07	0.78
22/4	71.19	100.00	0.99	70.23	9.51	9.15	61.08	1.01
2/5	71.99	100.00	1.18	84.77	13.31	12.46	72.31	1.20
12/5	72.31	100.00	1.20	86.77	17.33	15.82	70.95	1.17
22/5	72.16	100.00	1.20	86.59	21.38	19.04	67.55	1.12
1/6	71.55	100.00	1.20	85.86	25.34	22.04	63.82	1.06
11/6	70.50	100.00	1.16	82.15	29.17	24.79	57.36	0.95
21/6	69.05	100.00	0.96	65.97	32.80	27.30	38.67	0.64
1/7	67.23	100.00	0.72	48.55	36.20	29.56	18.99	0.31
11/7	32.83	100.00	0.55	17.95	19.28	15.55	2.40	0.08
Total	927.14			778.02	217.06	188.34	589.69	[0.72]

At the top of the form you can specify :

- Which crop in the cropping pattern you want the CWR results for
- The block of the crop (assuming the crop has been planted in staggered blocks)
- The Time Step of the CWR results - this can be any convenient time step, including 1 day steps. This is set to 10 days by default
- The field Irrigation Efficiency. This is used to calculate the Field Water Supply. The default is 70% but you can enter your own values.

Meaning of the data in each column

Date : the start of each time step (defined by Time Step at the top of the table)

ET_o : reference crop evapotranspiration in millimetres per time step

Crop Area : the proportion of the area planted with the specified crop in the current cropping pattern. In this example there is only one crop and it covers 100% of the planted area.

Crop K_c : average values of crop coefficient for each time step. This is calculated by linear interpolation between the K_c values for each crop stage. Note that the “Crop K_c” values in this case are calculated as K_c*Crop Area, so if the crop covers only 50% of the area, the “Crop K_c” values will be half of the K_c values in the crop coefficient data file.

CWR : Crop Water Requirements for this crop. Calculated as ET_o*CropK_c

Total and Effective Rainfall : These are the values obtained by smoothing between the monthly totals.

Irrig.Req. : Irrigation Requirements for this crop in millimetres for the current time step.

FWS : Field Water Supply in litres per second per hectare assuming continuous supply and the Irrigation Efficiency shown at the top of the table. The value in square brackets at the bottom of this column [0.72] is the average field water supply for this crop during the growing season.

Explaining the calculations : row 9 of the table (time step starting 22/5, 22nd May):

Average ETo is calculated as 7.216 mm/day, or 72.16 mm per 10 day time step

The Crop is Maize and covers 100% of the planted area

The "Crop Kc" = average crop coefficient for this time step *100% = 1.20

The Crop Water Requirement (CWR) is therefore 72.16*1.20 = 86.59 mm per 10 days

Effective rain = 19.04mm, so the Irrigation Requirement is 86.59-19.4 = 67.55mm per 10 days

The Field Water Supply for one hectare is calculated using

1 hectare * 67.55 mm * (100/Irrigation Efficiency)

FWS = 100m * 100m * 67.55/1000m * (100/70) m³ per 10 days

= 675.5 m³ * (1/0.7) = 965 m³ per 10 days or 96.5 m³/day

= 0.0011169 m³/second

= 1.1169 litres per second per hectare or **1.12** as shown in the last column of the table.

A copy of the results can be saved to file ready for printing with the "Report" button. Below is a table of results produced in this example which has been stored in file C:\CROPWATW\REPORTS\EXAMPLE1.TXT

```

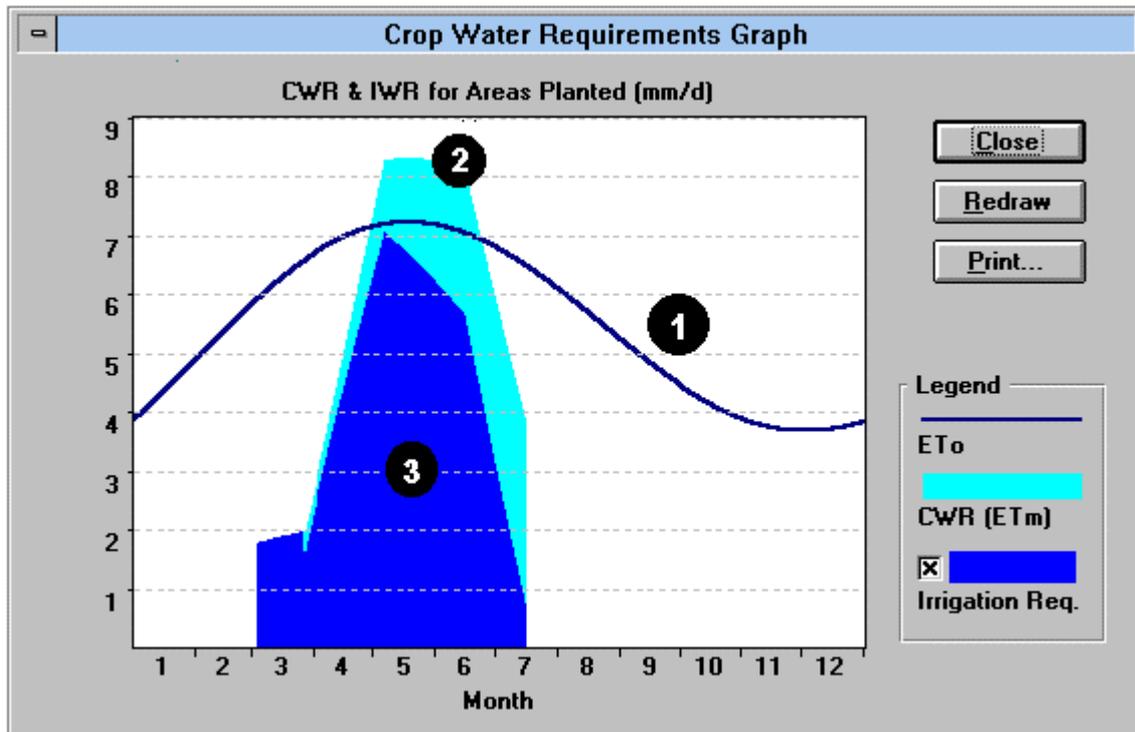
*****
                          Crop Water Requirements Report
*****
-- Crop # 1                : MAIZE (Grain)
- Block #                  : [All blocks]
- Planting date           : 3/3
- Calculation time step = 10 Day(s)
- Irrigation Efficiency = 70%
-----
Date      ETo      Planted  Crop      CWR      Total  Effect.  Irr.      FWS
(mm/period) (%)      Area      Kc      (ETm)    Rain    Rain    Req.      (l/s/ha)
----- (mm/period) -----
3/3      60.66      100.00  0.30      18.20    0.00    0.00    18.20    0.30
13/3     63.52      100.00  0.30      19.06    0.00    0.00    19.06    0.32
23/3     66.05      100.00  0.33      22.07    2.45    2.40    19.67    0.33
2/4      68.20      100.00  0.54      36.61    4.05    4.05    32.56    0.54
12/4     69.92      100.00  0.76      53.25    6.25    6.18    47.07    0.78
22/4     71.19      100.00  0.99      70.23    9.51    9.15    61.08    1.01
2/5      71.99      100.00  1.18      84.77    13.31   12.46   72.31    1.20
12/5     72.31      100.00  1.20      86.77    17.33   15.82   70.95    1.17
22/5     72.16      100.00  1.20      86.59    21.38   19.04   67.55    1.12<----- example
1/6      71.55      100.00  1.20      85.86    25.34   22.04   63.82    1.06
11/6     70.50      100.00  1.16      82.15    29.17   24.79   57.36    0.95
21/6     69.05      100.00  0.96      65.97    32.80   27.30   38.67    0.64
1/7      67.23      100.00  0.72      48.55    36.20   29.56   18.99    0.31
11/7     32.83      100.00  0.55      17.95    19.28   15.55    2.40    0.08
-----
Total    927.14                                778.02  217.06  188.34  589.69  [0.72]
-----
* ETo data is distributed using polynomial curve fitting.
* Rainfall data is distributed using polynomial curve fitting.
C:\CROPWATW\REPORTS\EXAMPLE1.TXT

```

4.6 Crop Water Requirements Graphs



A graph of ETo, Crop Water Requirements and Irrigation Requirements can be shown with the menu option **Graph,CWR** or the CWR graph icon in the Toolbar.



1 : The curve is the Reference Crop Evapotranspiration in mm/day, smoothed between the months with a polynomial curve

2 : The tall shaded area is the Crop Water Requirement (CWR) for the cropped area in mm/day. This follows the shape of a typical Kc curve, and it rises above the ETo curve when the crop coefficient is greater than 1.0. NB: if the area planted in the cropping pattern is less than 100%, CWR will be reduced proportionally.

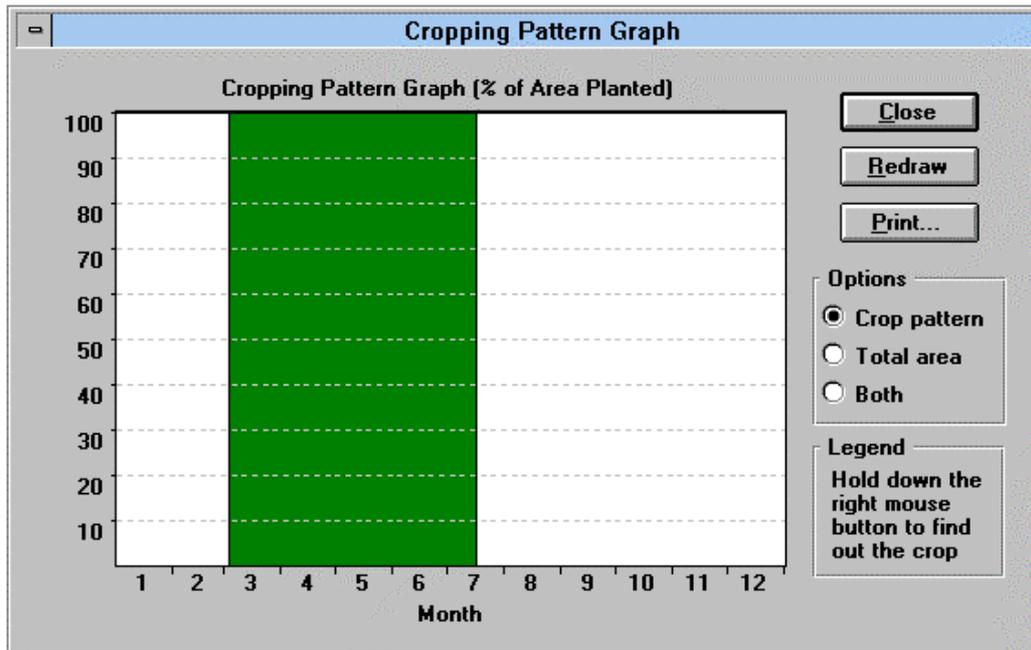
3 : The lower shaded area is the Irrigation Water Requirement (IWR) in mm/day. The difference between CWR and IWR is made up by the effective rainfall

4.7 Cropping Patterns

CropWat for Windows can calculate crop water requirements or irrigation schedules with up to 30 crops. Each crop in the pattern is defined by the crop coefficient file name, the date of planting and the area planted (0-100% of the total area).

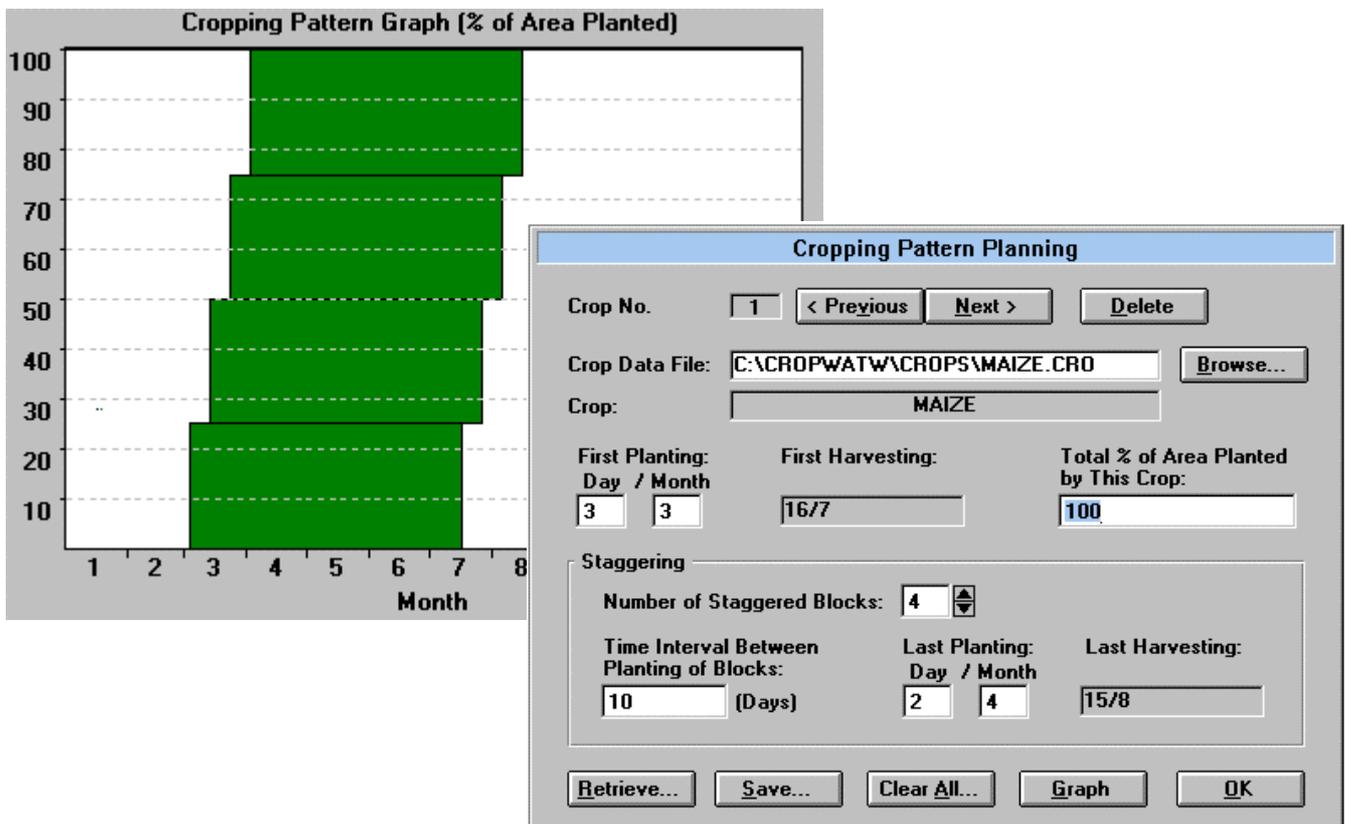


Each crop may be planted in a set of blocks staggered in time. The current cropping pattern can be shown with **Graphs,CroppingPattern** or the Cropping Pattern icon in the Toolbar.



Here a crop of maize is planted on 3rd March. The crop is assumed to be planted all at the same time and covers 100% of the project area. The **Options** box on the right of the screen allows you to plot the % of area cropped, which is useful if there are multiple crops in the crop pattern.

A crop can be staggered into several blocks each planted on differing dates. For example, the maize crop shown above can be divided into 4 blocks planted at 10 day intervals using **InputData,CroppingPattern,Enter/Modify** :



Options

Crop pattern

Total area

Both

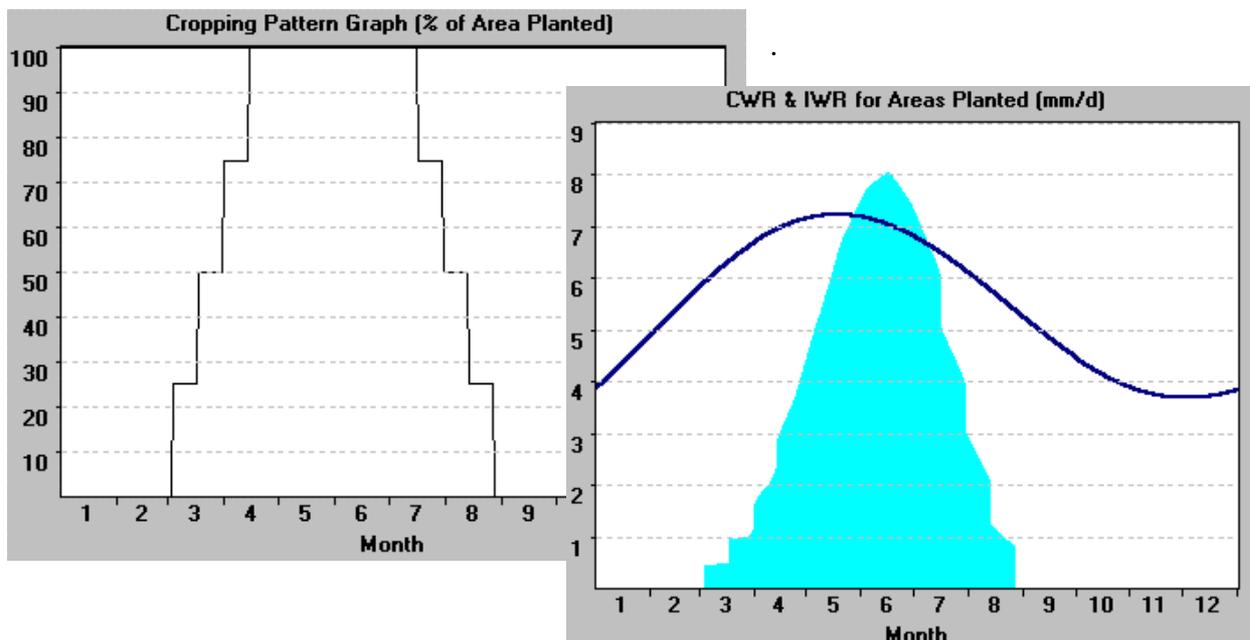
Legend

Hold down the right mouse button to find out the crop

Next to the graph is an Options box. This allows you to plot the area planted (see graph below).

You can identify each crop name by clicking on the cropping pattern graph with the right mouse button.

The effect of staggering the planting date can be seen in the steps on the Crop Water Requirements graph below



Note that CropWat for Windows calculates crop water requirements using the equation

$$\text{CWR} = (\text{ETo} * \text{Kc} * \text{area planted})$$

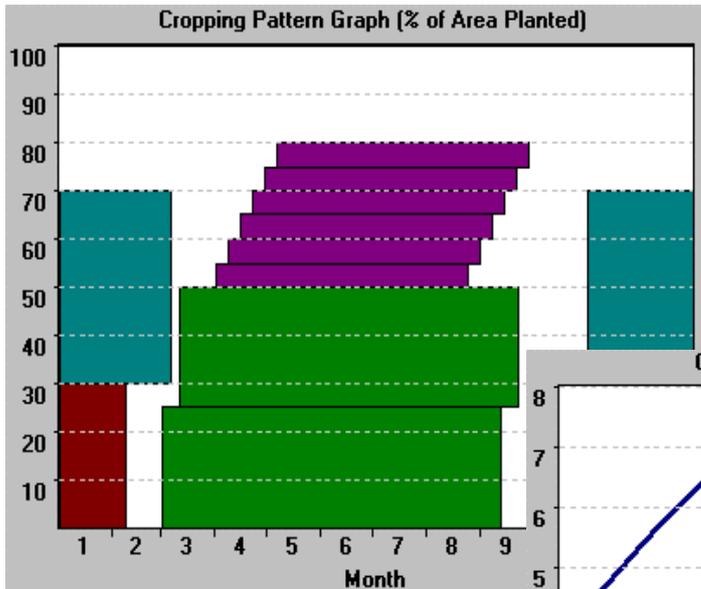
and not

$$(\text{ETo} * \text{Kc})$$

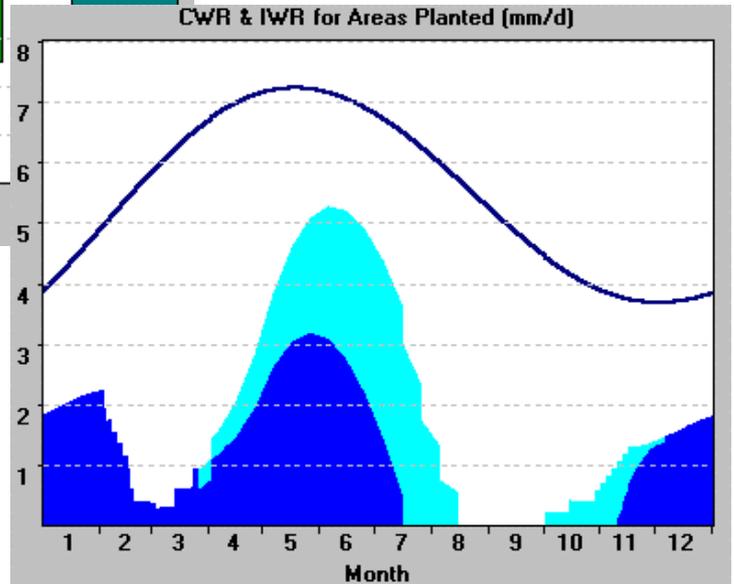
This means that the peak CWR in mm/day can be less than the peak ETo value when less than 100% of the area is planted in the cropping pattern.

More complex cropping patterns can be built. CropWat for Windows will always check to see if the total area planted is less than 100% and will not allow calculations to proceed until the total area is less than 100%.

Below, a cropping pattern with four crops is defined. The maximum cropped area is 80% in this case. Note how the peak CWR is shown as less than the peak ETo because the area is used in the calculation.



A complex cropping pattern produces varying crop and irrigation water requirements throughout the year.



Note that although the graphs show the total crop water requirements, the table of crop water requirements can be used to examine CWR for either all crops or just one crop using the pull down list at the top of the table.

Similarly the CWR either for all blocks or each individual block of a crop can be shown :

Crop Water Requirements Table								
MAIZE		Time Step (Days): 10		Update		Report...		
[All Crops]		Irrigation Efficiency (%): 70		Close				
MAIZE		Area	Crop Kc	CWR (ETm)	Total Rain	Effect. Rain	Irrig. Req.	FWS
Date	(mm/period)	(%)		(mm/period)	(mm/period)	(mm/period)	(mm/period)	(l/s/ha)
3/3	60.66	16.00	0.05	2.91	0.00	0.00	2.91	0.05
13/3	63.52	32.00	0.10	6.10	0.00	0.00	6.10	0.10
23/3	66.05	48.00	0.15	8.95	0.00	0.00	8.95	0.15

Above : Selecting which crop to show in the CWR table

Right : Selecting which block of maize to show in the CWR table.

Crop Water Requirements Table			
MAIZE		Time Step (Days): 10	
Block # 2		Irrigation Efficiency (%): 70	
[All Blocks]		Area	Crop Kc
Date	(mm/period)	(%)	
3/3	60.66	16.00	0.05
13/3	63.52	32.00	0.10
23/3	66.05	48.00	0.15

4.8 Example IRRIGATION SCHEDULING Table

An Irrigation Scheduling table can only be shown if sufficient data has been entered and the scheduling criteria have been set (see the Data Status Window for more information).

It is possible that you have forgotten to input or define some data. CropWat for Windows will inform you of what extra data is needed. The example message below is hopefully self-explanatory:

**This table is empty because:
No scheduling criteria defined**

Once the data has been entered, you can calculate an optimal irrigation schedule by selecting **Schedule, Criteria, OK**. You can then use **Tables, Irrigation Schedule** to see the scheduling calculations:

Irrigation Scheduling Table													
MAIZE (Grain)		Options		Yield Reduction:		Close							
Block # 1		<input checked="" type="radio"/> Irrigation Schedule <input type="radio"/> Daily Soil Moisture Balance		0.0%		Report...							
Date	Day No.	TAM (mm)	RAM (mm)	Rainfall (mm)	Efct. Rain (mm)	ETc (mm)	ETc/ETm (%)	SMD (mm)	Irr. Interval (Days)	Net Irr. (mm)	Lost Irr. (mm)	User Adjust. (mm)	
21/3	19	69.1	34.6	0.0	0.0	1.9	100.0%	35.3	18	35.3	0.0		
26/3	24	76.7	38.3	1.8	1.8	2.0	100.0%	8.0					
31/3	29	84.2	42.1	1.8	1.8	2.6	100.0%	17.7					
5/4	34	91.8	45.9	2.0	2.0	3.4	100.0%	31.1					
10/4	39	99.3	49.6	2.5	2.5	4.2	100.0%	48.1					
11/4	40	100.8	50.4	0.0	0.0	4.4	100.0%	52.5	21	52.5	0.0		
15/4	44	106.8	53.4	3.2	3.2	5.1	100.0%	16.1					
20/4	49	114.4	57.2	4.0	4.0	5.9	100.0%	40.0					
24/4	53	120.4	60.2	0.0	0.0	6.6	100.0%	65.4	13	65.4	0.0		
25/4	54	121.9	61.0	4.8	0.0	6.8	100.0%	6.8					
30/4	59	129.4	64.7	5.8	5.8	7.6	100.0%	37.4					
4/5	63	135.5	67.7	0.0	0.0	8.3	100.0%	69.6	10	69.6	0.0		
5/5	64	137.0	68.5	6.8	0.0	8.5	100.0%	8.5					

Double Click Any Cell in the 'User Adjust.' Column to Adjust the Soil Moisture Balance

Irrigation scheduling for a maize crop planted as a single block on 3rd March in Kurnool.

The Table can appear in two ways, either **Irrigation Schedule** or **Daily Soil Moisture Balance**. These are selected in the **Options** box at the top of the form. Also be sure to select the correct crop/staggered block if you have multiple crops or staggered planting dates in your cropping pattern.

a) Irrigation Scheduling option

This table shows the status of the soil moisture every time new water enters the soil, either by rainfall or a calculated irrigation application. Calculated irrigation events are shown in the right hand side of the table (Net Irrigation/Irrigation Interval); the other lines in the table are where rainfall events occur as defined in the Options menu (e.g. a rain event every 5 days).

b) Daily Soil Moisture Balance option

This shows the status of the soil every day throughout the cropping pattern. It is useful in seeing how the soil moisture changes in the growing season, but the table is much longer and contains possibly too much information for most users. Graphs can be used to show these changes more clearly.

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”. This provides a flexible system to simulate actual changes in water use during the growing season. See the Advanced section of this manual for more details.

Key to the column headings in the Irrigation Schedule Table:

Date : either the date of a rainfall/calculated irrigation event or the date in the season

TAM : Total Available Moisture in the soil for the crop at this date (mm). This is calculated as Field Capacity minus the Wilting Point times the current rooting depth of the crop.

RAM : Readily Available Moisture in the soil for the crop at this date (mm). It is calculated as $RAM = TAM * P$ where P is the depletion fraction for this crop at the current date as defined in the crop coefficient (Kc) file e.g. MAIZE.CRO.

Rain: rainfall amount calculated for this date (assuming 5 rain events per month)

Efct. Rain: Effective rainfall - the amount of rainfall that enters the soil

ETc : Actual crop evapotranspiration

ETc/ETm : Ratio of actual crop ET to the maximum crop ET. This is useful developing user defined irrigation schedules It should be 100% for an unstressed crop.

SMD : Soil Moisture Deficit on this date (mm).

Irr Interv: The interval in days since the last irrigation took place

Net Irr : The irrigation depth applied (mm)

Lost Irr : Irrigation water that is not stored in the soil - i.e either surface runoff or percolation.

User Adjust : Adjustments you make to the SMD (see the Advanced section of this manual).

Totals are shown at the bottom of the table (rainfall, evapotranspiration, net irrigation, lost irrigation).

The estimated yield reduction due to crop stress (when Etc/ETm falls below 100%) is shown at the top of the table. The reduction is estimated based on the methods described in FAO Irrigation and Drainage paper no 33 “Yield Reduction to Water”. The values calculated should be used only as a guide to the likely effect of water shortage on crop yield. You are recommended to develop your own crop yield data (Ky) based on in field experience.

4.9 Saving and Printing the Irrigation Schedule Table

A full summary of the irrigation schedule, together with information on  the crop, planting date, scheduling criteria etc can be saved to an ASCII file by clicking on the **Report** button at the top of the Irrigation Scheduling Table. The file will be stored as a text (.TXT) file in C:\CROPWATW\REPORTS which can be viewed by any convenient text editor or read into a word processor.

CropWat for Windows has a simple text editor which can be accessed from the **File,TextEditor** menu option or by clicking on the text editor toolbar icon. This permits you to view or print the file.



Below is a sample scheduling report printed using the Text Editor :

```

03/09/98                                     CropWat 4 Windows Ver 4.2
*****
                                Irrigation Scheduling Report
*****
* Crop Data:
-----
- Crop # 1      : MAIZE  (Grain)
- Block #      : 1
- Planting date: 3/3
* Soil Data:
-----
- Soil description           : Medium
- Initial soil moisture depletion: 0%
* Irrigation Scheduling Criteria:
-----
- Application Timing:
  Irrigate when 100% of readily soil moisture depletion occurs.
- Applications Depths:
  Refill to 100% of readily available soil moisture.
- Start of Scheduling: 3/3
-----

```

Date	TAM (mm)	RAM (mm)	Total Rain (mm)	Efct. Rain (mm)	ETc (mm)	ETc/ETm (%)	SMD (mm)	Interv. (Days)	Net Irr. (mm)	Lost Irr. (mm)	User Adj. (mm)
21/3	69.1	34.6	0.0	0.0	1.9	100.0%	35.3	18	35.3	0.0	
26/3	76.7	38.3	1.8	1.8	2.0	100.0%	8.0				
31/3	84.2	42.1	1.8	1.8	2.6	100.0%	17.7				
5/4	91.8	45.9	2.0	2.0	3.4	100.0%	31.1				
10/4	99.3	49.6	2.5	2.5	4.2	100.0%	48.1				
11/4	100.8	50.4	0.0	0.0	4.4	100.0%	52.5	21	52.5	0.0	
15/4	106.8	53.4	3.2	3.2	5.1	100.0%	16.1				
20/4	114.4	57.2	4.0	4.0	5.9	100.0%	40.0				
24/4	120.4	60.2	0.0	0.0	6.6	100.0%	65.4	13	65.4	0.0	
25/4	121.9	61.0	4.8	0.0	6.8	100.0%	6.8				
30/4	129.4	64.7	5.8	5.8	7.6	100.0%	37.4				
4/5	135.5	67.7	0.0	0.0	8.3	100.0%	69.6	10	69.6	0.0	
5/5	137.0	68.5	6.8	0.0	8.5	100.0%	8.5				
10/5	140.0	70.0	7.8	7.8	8.7	100.0%	44.0				
14/5	140.0	70.0	0.0	0.0	8.7	100.0%	78.6	10	78.6	0.0	
15/5	140.0	70.0	8.8	0.0	8.7	100.0%	8.7				
20/5	140.0	70.0	9.8	9.8	8.7	100.0%	42.3				
24/5	140.0	70.0	0.0	0.0	8.7	100.0%	77.0	10	77.0	0.0	
25/5	140.0	70.0	10.8	0.0	8.7	100.0%	8.7				
30/5	140.0	70.0	11.8	11.8	8.6	100.0%	40.1				
3/6	140.0	70.0	0.0	0.0	8.6	100.0%	74.6	10	74.6	0.0	
4/6	140.0	70.0	12.8	0.0	8.6	100.0%	8.6				
9/6	140.0	70.0	13.7	13.7	8.5	100.0%	37.7				
13/6	140.0	70.0	0.0	0.0	8.5	100.0%	71.8	10	71.8	0.0	
14/6	140.0	70.0	14.7	0.0	8.5	100.0%	8.5				
19/6	140.0	75.6	15.6	15.6	7.8	100.0%	33.4				
24/6	140.0	82.6	16.5	16.5	6.9	100.0%	53.0				
29/6	140.0	89.6	17.4	17.4	6.0	100.0%	67.3				
4/7	140.0	96.6	18.2	18.2	5.1	100.0%	76.4				
9/7	140.0	103.6	19.0	19.0	4.3	100.0%	80.4				
14/7	140.0	110.6	19.7	19.7	3.4	100.0%	79.5				
Total			229.0	170.4	778.0	100.0%			524.9	0.0	0.0

continued....

```

* Yield Reduction:
-----
- Estimated yield reduction in growth stage # 1 = 0.0%
- Estimated yield reduction in growth stage # 2 = 0.0%
- Estimated yield reduction in growth stage # 3 = 0.0%
- Estimated yield reduction in growth stage # 4 = 0.0%
-----
- Estimated total yield reduction                = 0.0%
* These estimates may be used as guidelines and not as actual figures.
-----

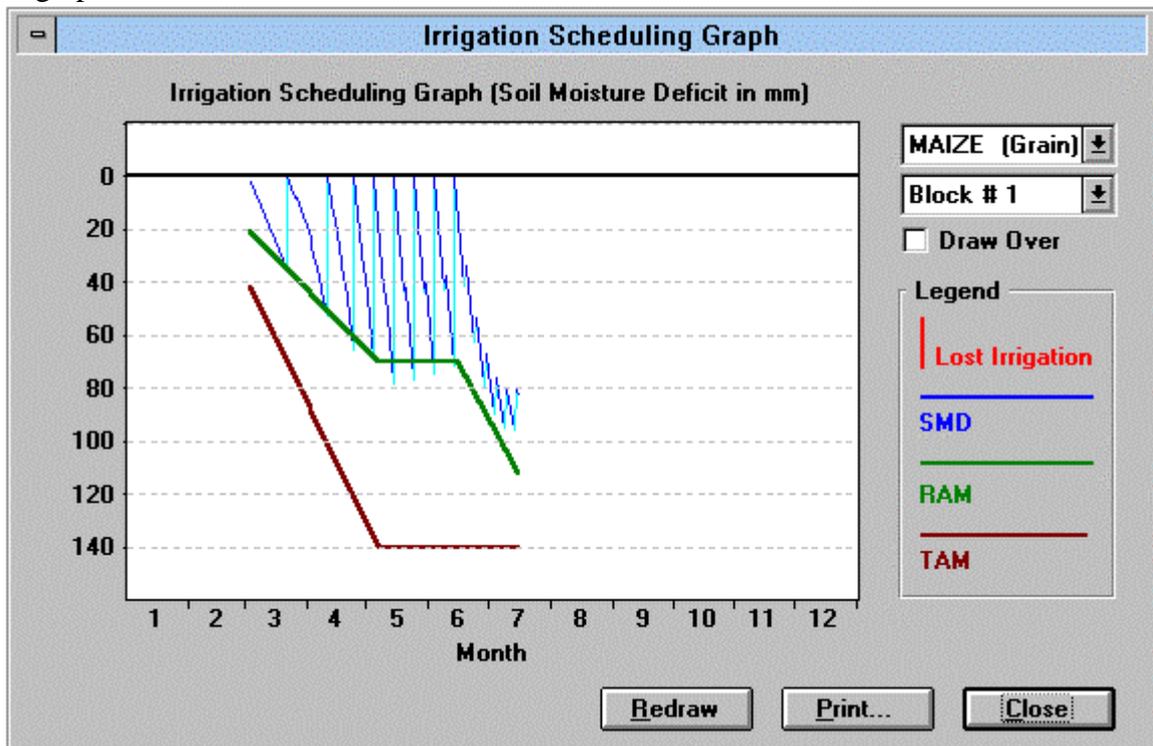
* Legend:
-----
TAM = Total Available Moisture = (FC% - WP%)* Root Depth [mm].
RAM = Readily Available Moisture = TAM * P [mm].
SMD = Soil Moisture Deficit [mm].
* Notes:
-----
Monthly ETo is distributed using polynomial curve fitting.
Monthly Rainfall is distributed using polynomial curve fitting.
To generate rainfall events, each 5 days of distributed rainfall are
accumulated as one storm.
Only NET irrigation requirements are given here. No any kind of losses
was taken into account in the calculations.
*****
C:\CROPWATW\REPORTS\EXAMPLE1.TXT

```

4.10 Irrigation Scheduling Graphs



A graph of the calculated soil moisture deficit can be plotted for one or several crops with the menu option **Graphs,IrrigationSchedule** or by clicking on the schedule graph icon in the toolbar.



The graph plots calculated soil moisture deficit for the crop/block selected at the top right of the form. The lower line on the graph is the total available moisture in the soil (TAM), which increases as the roots of the plant grow deeper at the start of the season. The middle line is readily available moisture (RAM) defined in the crop coefficient file.

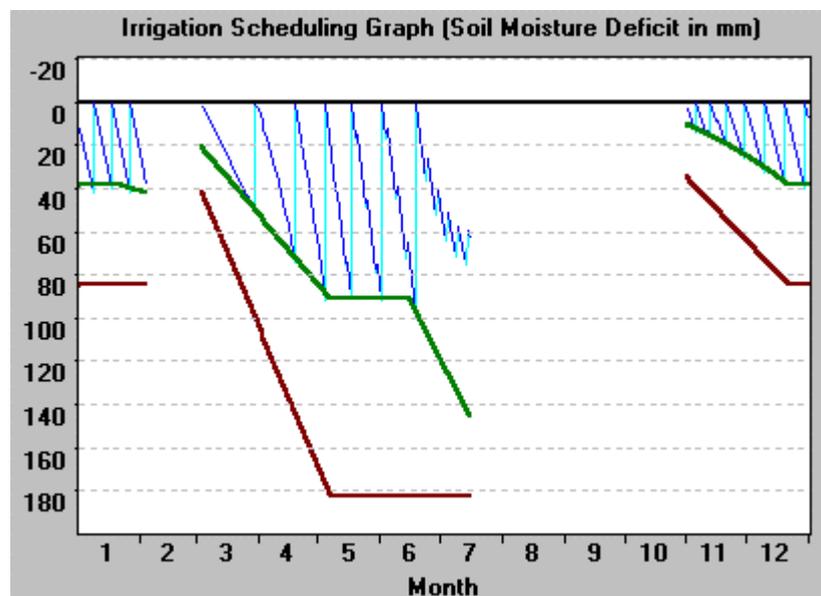
4.12 User Defined Irrigations

You can define your own irrigation amounts and dates by selecting the menu options **Schedule, Criteria, Variable Intervals** and **Variable depths**. The graph will initially reset to no irrigations. You then enter the irrigation depths in the Scheduling Table by double clicking on the **‘Nett Irr’** column. As each irrigation is entered, the table is re-calculated and the graph is also updated. See the Advanced section of this manual for more details.

4.13 Schedule Graph Options

You can draw the soil moisture profile/schedule for several crops on the cropping pattern graph. These can be shown individually by changing the crop/block name on the right of the form, or can be drawn on the same graph by clicking on the **‘Draw over’** check box:

The screenshot shows two identical control panels. The top panel has a dropdown menu with 'Small Vegetabl' selected, and a list of options: 'MAIZE', 'Small Vegetables', and 'CABBAGE'. The bottom panel has a dropdown menu with 'Small Vegetabl' selected, a 'Block # 1' dropdown, and a checked checkbox labeled 'Draw Over'.



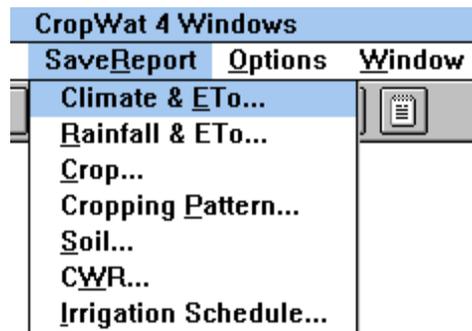
The y-axis (soil moisture deficit) is automatically scaled by the first crop selected. When using the **Draw over** option, a second crop may not fit on the graph. To re-scale the y-axis, turn off the Draw Over option then click on the **Redraw** button.

The graph can be printed by clicking on the **Print** button, but as the graph has to be re-built for the printer, only the last crop/block selected can be printed out -i.e. the Draw over option does not work when printing the graph.

5. The SAVE REPORT menu option

This option is used to save/print a summary of the input data and results. It is not the same as saving the raw input data with the File or InputData menu.

The aim is to create files with the summary data which than can be either printed or imported into another program such as a word processor or spreadsheet. This menu is also reached by clicking on the “Report” button on some results screens as shown in the CWR and Scheduling sections above. The files will be stored in C:\CROPWATW\REPORTS .



The reports (on Climate, Rainfall, Crop, CropPattern, Soil) are saved in .TXT (ASCII) files only. The results of calculations (CWR and irrigation schedule) can be either saved in an ASCII file or in a . CSV (“comma separated variable”) file ready for importing into a spreadsheet. See the Advanced section of this manual for more details.

Using the Text Editor to view/print results

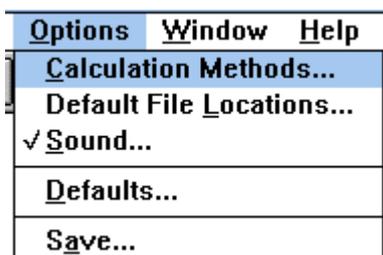
ASCII files can be viewed by any convenient text editor or read into a word processor. CropWat for Windows has a simple text editor which can be accessed from the **File,TextEditor** menu option or by clicking on the editor Toolbar icon. This permits you to view or print the file.



Once the Text Editor is loaded, it fills the screen. You can see the ASCII files by selecting **File,Retrieve** and then print the file using **File,Print**. To return to CropWat for Windows select **File, Close and return to CropWat**

6. The OPTIONS menu -changing calculation methods, directories, sounds

CropWat for Windows is set up with a default set of calculation methods which produce results as close as possible to CROPWAT 7.0. Using **Options** the from the main menu, you can change **Calculation Methods** and the **Default File Locations** .



Toolbar Icons for setting Calculation Methods, Default File Locations, and Sound On/Off

It is suggested that you do not change any of the default Options until you have gained some experience in using the program. If, after a while, you want to change the default Options, you can use **Options,Save** to force CropWat for Windows to start up with your own defaults.

Default File Locations can be set and “remembered” using **Options,Default File Locations** then **Options,Save**. This is useful if you want to share your CROPWAT 7.0 data files with CropWat for Windows - just set the default file locations to C:\CROPWAT7\CLI, C:\CROPWAT7\SOI etc.

The Calculation Methods are selected from the “tabs” at the top of the form . This form is shown by selecting **Options,Calculation Methods** .

The screenshot shows the 'Calculation Methods' dialog box with the 'ETo' tab selected. The 'ETo Equation' section has the 'Penman-Monteith' option selected. The 'Angstrom's Coefficients' section shows 'a = 0.25' and 'b = 0.50'. The 'ETo Distribution Model' section has 'Fit a Curve to Monthly Averages' selected. The 'Save...', 'OK', and 'Cancel' buttons are visible at the bottom.

A summary of the calculation methods available

Options, CalculationMethods, ETo

- lets you change the “a” and “b” Angstrom coefficients in the Penman Monteith equation
- lets you select how the monthly ETo is converted into Daily values

Options, CalculationMethods, Rainfall

- smoothing rain totals between months
- setting the number of rain events per month.

Options, CalculationMethods, Effective Rainfall

- choice of four Effective Rainfall models (the USDA SCS method is the default)

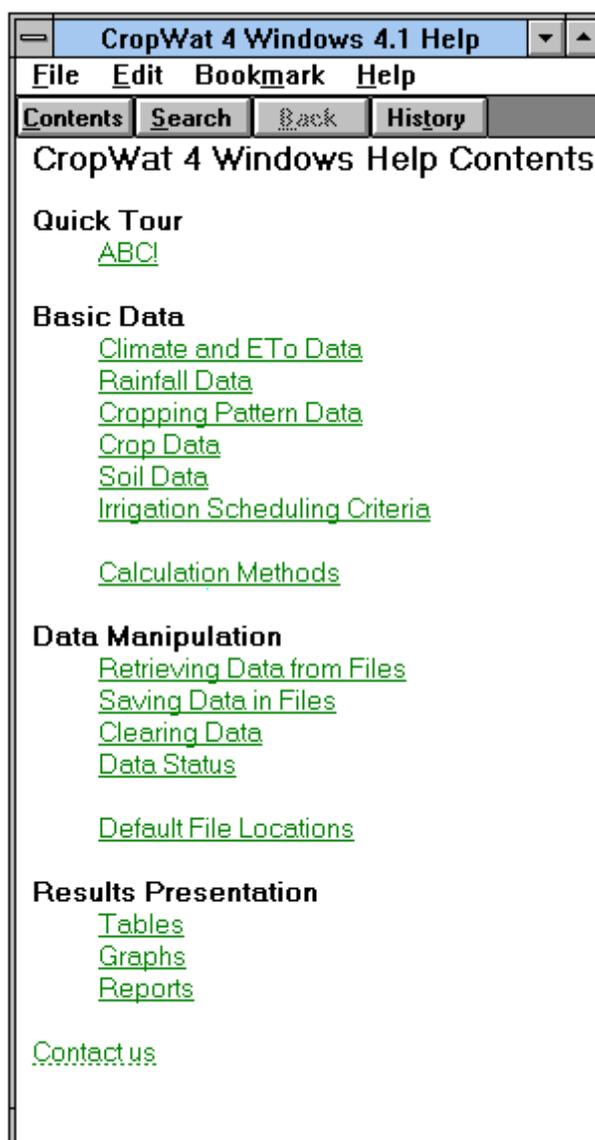
Options, CalculationMethods, Scheduling

- This is the same as selecting **Schedule,Criteria**. It offers a wide range of options for when irrigations occur and the amount of water applied.

7. The HELP menu

The help system contains on line information to help you use the program.

However we recommend that you read the manual and the following Advanced Section to enable you to get the best out of CropWat for Windows.



Help,About will introduce you to the team responsible for writing CropWat for Windows. We hope that you are able to make good use of the program. Please email us if you have any problems:

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ADVANCED SECTION

A. Scheduling Scenarios

B. User Defined Irrigations

C. User Adjustments

D. Exporting Results files to spreadsheets

A. SCHEDULING SCENARIOS

Once you have calculated an irrigation schedule, the list of files you have used can be stored as a group in a Scenario file (*.SNR) . A “Scenario” is a snapshot of the scheduling data you are currently using. A Scenario file can be created with the menu option **Schedule, Scenario, Save**. This will store the names of the data files currently in use in CropWat for Windows : climate data, rainfall data , cropping pattern and soil type.

You can read in the same set of data files and carry on with **Schedule, Scenario, Retrieve** and carry on with your calculations for the same area on another day. This will allow you to store sets of crop, soil and climate data for different irrigated areas.

Notes about Scenario files:

1 Scenario files have the extension *.SNR and are stored in the directory C:\CROPWATW\SCHEDULE

2 You cannot save a Scenario until all the input data is stored in a data file . If you have more than one crop, you must store the cropping pattern using **InputData, CroppingPattern, Save**.

3 The Scenario file does not store your Scheduling Criteria. You will have to set the criteria again the next time you retrieve the scenario with **Schedule, Criteria**.

B. USER DEFINED IRRIGATIONS

To model what actually takes place in a growing season it is necessary to enter specific irrigation gifts on given dates. A wide range of options are available in the Scheduling Criteria, but these may not describe what actually happened (e.g. a broken or damaged gate may deliver more water than planned.)

The impact of non-standard irrigation schedules can be examined by setting the Schedule Criteria to “**User Defined**” -i.e. scheduling with variable dates and amounts of irrigation. To select User Defined irrigations, select **Schedule, Criteria** and set the Application Timing to “**Irrigate at Variable Intervals**” and the Application depths to “**Variable Depths**” :

Scheduling Criteria

Application Timing

Irrigate at Variable Intervals (User-Defined) (Days) [v]

100 (Days)

Application Depths

Variable Depths (User-Defined) (mm) [v]

100 (mm)

Setting Scheduling Criteria to “User Defined”

You can now enter the non-standard irrigations into the Irrigation Schedule Table. We recommend that you display the Irrigation scheduling table with the **Daily Soil Moisture Balance** option. Note that selecting User Defined irrigations will remove any existing irrigations and the SMD graph will show calculated soil moisture deficit with rainfall only until you add your own irrigation events.

Irrigation Scheduling Table

MAIZE (Grain) [v] Block # 1 [v]

Options: Irrigation Schedule **Daily Soil Moisture Balance**

Yield Reduction: 71.2%

Date	Day No.	TAM (mm)	RAM (mm)	Rainfall (mm)	Efct. Rain (mm)	ETc (mm)	ETc/ETm (%)	SMD (mm)	Irr. Interval (Days)	Net Irr. (mm)	Lost Irr. (mm)	User Adjust. (mm)
3/3	1	42.0	21.0	0.0	0.0	1.8	100.0%	1.8				
4/3	2	43.5	21.8	0.0	0.0	1.8	100.0%	3.6				
5/3	3	45.0	22.5	0.0	0.0	1.8	100.0%	5.4				
6/3	4	46.5	23.3	0.0	0.0	1.8	100.0%	7.2				
7/3	5	48.0	24.0	0.0	0.0	1.8	100.0%	9.0				
8/3	6	49.5	24.8	0.0	0.0	1.8	100.0%	10.8				
9/3	7	51.0	25.5	0.0	0.0	1.8	100.0%	12.6				
10/3	8	52.6	26.3	0.0	0.0	1.8	100.0%	14.5				
11/3	9	54.1	27.0	0.0	0.0	1.9	100.0%	16.3				
12/3	10	55.6	27.8	0.0	0.0	1.9	100.0%	18.2				
13/3	11	57.1	28.5	0.0	0.0	1.9	100.0%	20.1				
14/3	12	58.6	29.3	0.0	0.0	1.9	100.0%	21.9				
15/3	13	60.1	30.0	0.0	0.0	1.9	100.0%	23.8				

Double Click Any Cell in the 'User Adjust.' Column to Adjust the Soil Moisture Balance

Irrigation Schedule Table shown using the Daily Soil Moisture Balance option (arrow). User Defined irrigation events can be entered by double clicking on the appropriate date in the “Net Irr” column (arrow).

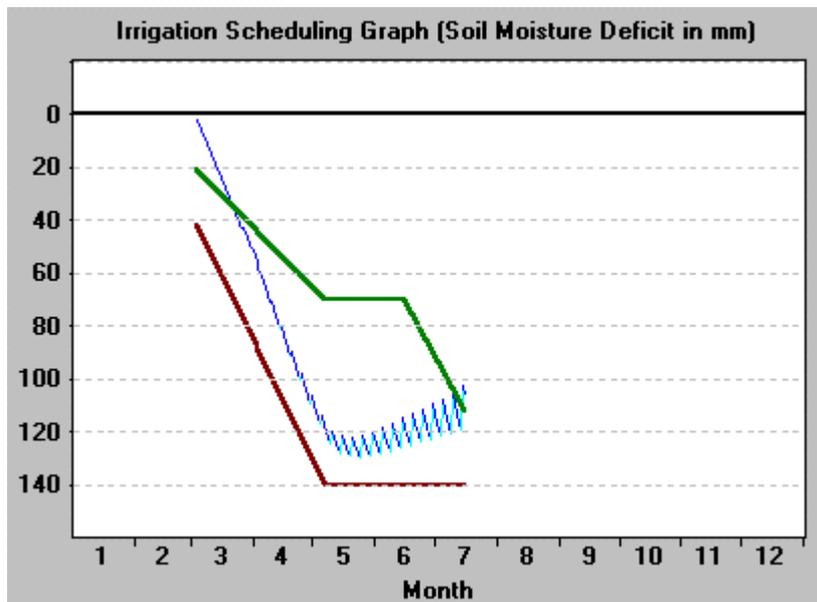
Example of adding user defined irrigations

In this example we will use the maize crop in Kurnool planed on 3rd March with the following restrictions to water supply :

1. Irrigation water delivery commences on 1st April
2. Each irrigation is fixed to 75mm net application
3. Each irrigation turn is every 14 days

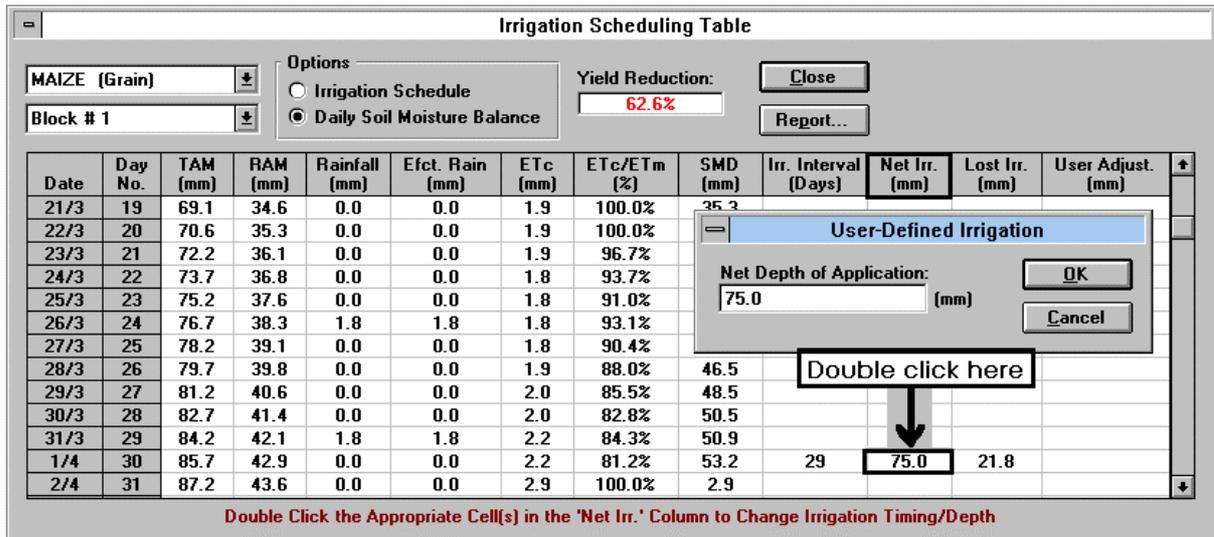
Follow these steps to enter the user defined irrigations

1. Select **Schedule, Criteria** and set the Amount and Timing to **User Defined** (see above).
2. Display the Irrigation Scheduling Table (**Tables, Schedule**) and select the **Daily Soil Moisture Balance** option at the top of the table.
3. You may also want to display the scheduling graph as this will change every time a new irrigation is typed in. (**Graphs, Irrigation Schedule**).



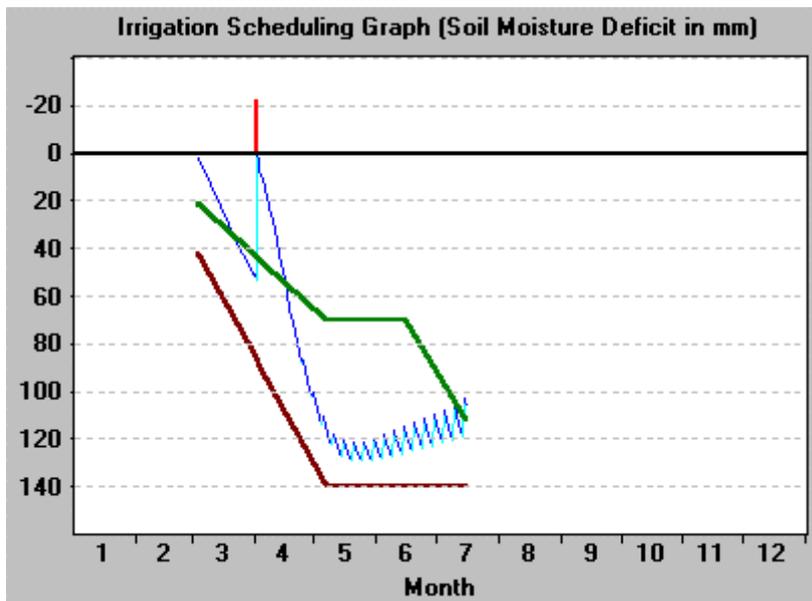
User defined irrigation with no irrigations . The calculated soil moisture deficit shows the effect of rainfall only. The graph shows that the soil moisture deficit reaches the limit of the easily available moisture in the middle of month 3. This crop will have a low yield - the yield reduction is estimated to be 71.2% in the table below.

4. Double click in the **Net Irr** column on 1st April in the Irrigation Scheduling Table. This will show a dialog box requesting how much water is to be applied (**Net Depth of Application**).
5. To apply 75mm of irrigation (net), enter **75** into the dialog box and click on the **OK** button. CropWat for Windows will now re-calculate the soil moisture balance for the rest of the season and update the Irrigation Scheduling Table.



Irrigation Scheduling Table with the first User Defined Irrigation applied on April 1st

6. CropWat for Windows will now calculate the first irrigation interval (29 days since planting), lost or over-irrigation (21.8mm), update the scheduling table, re-calculate the total yield reduction (62.6%) and then re-draw the scheduling graph.

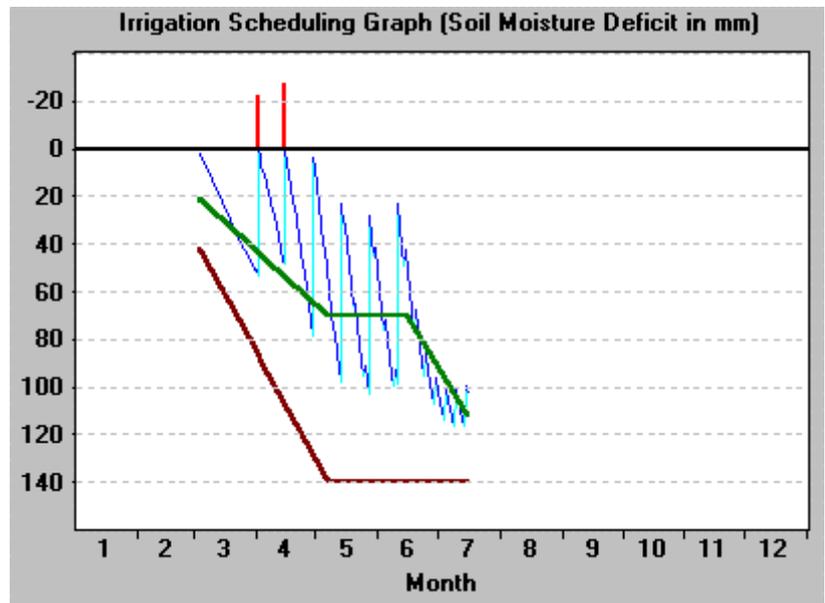


Scheduling graph after applying 75mm net irrigation on 1st April. Note the over irrigation and the fact that the crop will now become stressed later in April.

7. You can add additional irrigations later in the season by entering more User Defined Irrigations into the Scheduling Table. In the graph below, five other 75mm irrigations were applied with a 14 day interval. The predicted crop stress was kept small and the yield reduction was not high (7%). Note that some over irrigation took place at the start of the season. The total amount of water used (and wasted) is shown at the bottom of the table.

It is important to remember that these calculations do not take into account any leaching requirements or groundwater contribution to the soil moisture zone

Scheduling graph with five other irrigations of 75mm applied later in the season. The calculated soil moisture deficits indicate over irrigation at the start of the season and some crop stress in mid-season.



8. . You can save the irrigation dates and amounts in an .IRR file with the menu option **Schedule, Irrigations, Save**. These .IRR files can be re-loaded into the computer at a later date using **Schedule, Irrigations, Retrieve**. This provides a useful system of recording actual and planned irrigations, or investigate the effect of applying last year's irrigation schedules to a new cropping pattern.

9. If you go back and change the scheduling criteria, the user defined irrigations are re-set to zero.

C. CAPILLARY RISE AND PERCOLATION : USER ADJUSTMENTS

You can make adjustments to the soil moisture balance by **double clicking in the User Adjust column** in the irrigation schedule table. Reasons for doing this might be

- to apply actual rainfall data
- to allow for capillary rise contributing to the soil moisture
- to allow for deep percolation out of the soil profile
- to amend the SMD to bring it in to line with field measurements of soil moisture.

To enter an adjustment, **double click on the “User Adjust” column** in the irrigation scheduling table on the date you want to make the adjustment. A dialog box will appear asking you to enter the desired adjustment to the SMD .

Date	Day No.	TAM (mm)	RAM (mm)	Rainfall (mm)	Efect. Rain (mm)	ETc (mm)	ETc/ETm (%)	SMD (mm)	Irr. Interval (Days)	Net Irr. (mm)	Lost Irr. (mm)	User Adjust. (mm)
3/3	1	42.0	21.0	0.0	0.0	1.8	100.0%	1.8				
4/3	2	43.5	21.8	0.0	0.0							
5/3	3	45.0	22.5	0.0	0.0							
6/3	4	46.5	23.3	0.0	0.0							
7/3	5	48.0	24.0	0.0	0.0							
8/3	6	49.5	24.8	0.0	0.0							
9/3	7	51.0	25.5	0.0	0.0							
10/3	8	52.6	26.3	0.0	0.0	1.8	100.0%	14.5				
11/3	9	54.1	27.0	0.0	0.0	1.9	100.0%	16.3				
12/3	10	55.6	27.8	0.0	0.0	1.9	100.0%	10.0				
13/3	11	57.1	28.5	0.0	0.0	1.9	100.0%	11.9				
14/3	12	58.6	29.3	0.0	0.0	1.9	100.0%	13.7				
15/3	13	60.1	30.0	0.0	0.0	1.9	100.0%	15.6				

Example user adjustment: entering an actual rainfall event of 8.2mm on March 11.

The soil moisture deficit (SMD) is re calculated by taking $SMD + ET_{crop} - UserAdjustment$. In the example above the SMD is 16.3 on March 11, ET_{crop} is 1.9mm, so the SMD will become 18.2mm if there is no adjustment. The adjustment entered (8.2mm) reduces the deficit from 18.2mm to 10.0mm on the following day. (User Adjustments are shown as a green vertical line in the Irrigation Scheduling Graphs.)

You can repeat this to enter actual rainfall data for the whole season. However, if you wish to use the adjustments to simulate actual rainfall, you should be sure to delete any existing rainfall before adding the adjustments (**InputData,Rainfall,Clear**).

Saving User Adjustments into a file (*.ADJ)

Each adjustment is similar to a user defined irrigation. You can save the adjustments (which might represent a season of actual rainfall data) using the menu options **Schedule, UserAdjustments, Save**. These files are stored in directory C:\CROPWATW\SCHEDULE and the files are given the extension .ADJ. Using this method,

it is possible to store a set of known daily rainfalls from previous seasons and use the data to see the effect on alternate cropping patterns or planting dates.

Groundwater Contribution and Leaching Requirements

CropWat for Windows does not include estimates for leaching requirements or the effect of shallow water tables, which may be significant in the control of salts. If you have your own values or estimates for these factors, you can model their effect by applying an adjustment for each day in the growing season. For example, applying an adjustment of minus 2.5mm/day would have the effect of removing 2.5mm/day from the soil, which can be equivalent to a vertical downward movement of water through the soil profile (percolation, or leaching). A positive daily adjustment would equate to an upward movement of water from a shallow water table into the root zone. An easy way to apply these kinds of adjustments is to edit an existing .ADJ file with the text editor. The .ADJ files consist of two values per line - the day in the year (1-365) followed by the user adjustment in mm. To add in your own adjustments, enter the day number followed by the adjustment. Remember that each individual day needs its own adjustment so a season with minus 2mm/day percolation will require that each day in the growing season will have to be entered into the .ADJ file.

Notes about User Adjustments and User Defined Irrigations

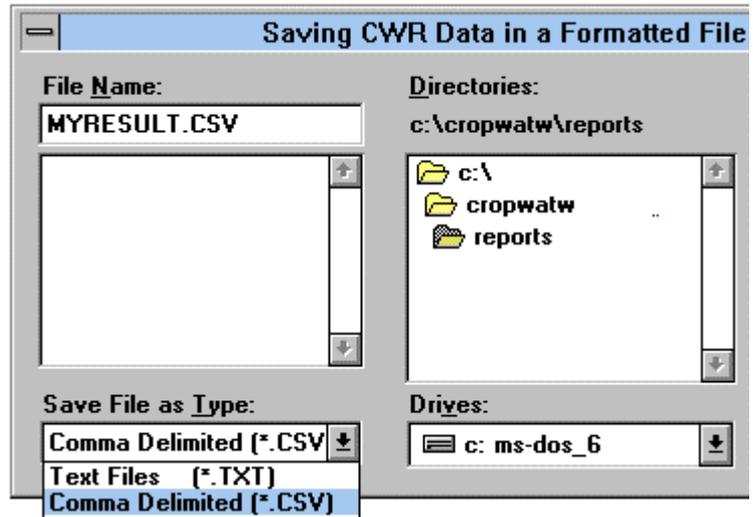
1. When you retrieve irrigation events from a file with **Irrigation, Retrieve**, the program sets the scheduling criteria to "user-defined". This causes a slight problem if the scheduling criteria had not been set before retrieving the irrigation events. You will have to retrieve it twice in this particular case. Notice also that retrieving irrigation events will NOT erase any user adjustments in memory so they can be combined together.
2. On the other hand, retrieving user adjustments with **Schedule, UserAdjustments, Retrieve** from files ERASES any irrigations in memory. So if you want to retrieve both irrigation applications and user adjustments, retrieve the adjustments before the irrigations. User adjustments in irrigation schedules are assumed to be applied to ALL the crops in a cropping pattern.
3. So the most straightforward way to retrieve irrigation events and user adjustments is to activate the Schedule Table or Schedule Graph on the screen and choose the crop to which you want to apply the data. Then retrieve the user adjustments BEFORE the irrigation events. The program should apply the new data to the current crop and update the irrigation schedule automatically.
4. Once you choose another crop or block in the cropping pattern list in the Schedule Table or Graph, the program will erase all irrigation events but it will not erase the user adjustments (assuming that user adjustments could be rainfall events or capillary rise, it makes sense that they are applied to all the crops).
5. To erase user adjustments from memory, choose the Recalculate command by selecting **Schedule, Recalculate**.

C .EXPORTING RESULTS FILES TO A SPREADSHEET

The results of CWR and scheduling calculations can be sent into export files type .CSV - Comma Separated (or comma delimited) Variables.

To do this select **File Type, Comma Delimited** in the **SaveReport** menu.

These .CSV files can be imported into a spreadsheet, or sometimes they can be read in directly, depending on which spreadsheet you use.



Note : CropWat for Windows operates as a full-screen Windows application. You can “shrink” the program to an icon using the “minimise” button at the top right of the program and then load your spreadsheet. Alternatively, you can swap between CropWat for Windows and the spreadsheet using the usual Windows method of pressing ALT-TAB.

	A	B	C	D	E	F	G
14							
15							
16	Date	ETo	Area	Crop Kc	ETm	Total Rain	Effect. Rai N
17		(mm/period	(%)		(mm/period	(mm/period	(mm/period (n
18							
19	03-Mar	60.66	16	0.05	2.91	0	0
20	13-Mar	63.52	32	0.1	6.1	0	0
21	23-Mar	66.05	48	0.15	9.85	2.45	2.4
22	02-Apr	68.2	64	0.23	15.88	4.05	4.05
23	12-Apr	69.92	64	0.3	21.16	6.25	6.18
24	22-Apr	71.19	64	0.41	28.93	9.51	9.15
25	02-May	71.99	64	0.53	38.43	13.31	12.46
26	12-May	72.31	64	0.63	45.85	17.33	15.82
27	22-May	72.16	64	0.7	50.53	21.38	19.04
28	01-Jun	71.55	64	0.73	52.42	25.34	22.04
29	11-Jun	70.5	64	0.73	51.58	29.17	24.79