EXAMPLE OF THE USE OF CROPWAT 8.0

1. INTRODUCTION

This document shows in a practical way the use of CROPWAT 8.0 for design and management of irrigation schemes, taking the user, with the help of an actual data set, through the different steps required to calculate evapotranspiration, crop water requirements, scheme water supply and irrigation scheduling.

To learn about how the software works and the main calculation procedures, users are invited to read the context-specific Help available in the software.

The example set used is taken from the Rajolibanda Diversion Scheme in Andhra Pradesh, India.

2. CALCULATION OF REFERENCE EVAPOTRANSPIRATION

2.1 Introduction

The Reference Evapotranspiration (ETo) represents the potential evaporation of a well-watered grass crop. The water needs of other crops are directly linked to this climatic parameter.

Although several methods exist to determine ETo, the Penman-Monteith Method has been recommended as the appropriate combination method[1] to determine ETo from climatic data on:

- temperature
- humidity
- sunshine
- windspeed.

2.2 Climate Data Collection

In order to calculate ETo, the respective climatic data should be collected from the nearest and most representative meteorological station. Several institutes and agencies may keep climatic records such as the Irrigation Department, the Meteorological Service or nearby Agricultural Research Stations and may provide information on climatic stations inside or in the vicinity of our irrigation scheme which should be considered for crop water requirement (CWR) calculations.

In some cases, when the scheme is large, more than one station may be available, but often no suitable stations with sufficient climatic data are located in the scheme. In such a case a careful selection should be made of the data.

In our example, the data for the Rajolibanda Scheme have been obtained from the following sources:

Temperature:	IMS Station, Kurnool (1930-1960)
Humidity:	IMS Station, Kurnool
Wind:	IMS Station, Kurnool
Sunshine hours:	Airport, Hyderabad

2.3 Climate Data Conversion

In general, climate data by the National Meteorological Service are standardized. Normally some conversions are required in order to adjust the data into the format accepted by CROPWAT 8.0. In particular, attention should be given to the units in which the climatic records are given.

As an example, the following notes for conversion of the climatic data provided by the IMS to the units required for CROPWAT 8.0 are given.

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[1] For further reference see FAO Irrigation and Drainage Paper No. 56, 1998. *Crop Evapotranspiration – guidelines for computing crop water requirements*,.

Temperature data

IMS: Mean Daily Maximum and Minimum Temperature, [º C]
CROPWAT: Maximum and Minimum Temperature, [º C]
Conversion: No conversion needed

Humidity data

IMS: Relative Humidity [in percentage] as well as the Vapour Pressure [kPa] both for morning and afternoon
CROPWAT: Average daily Relative Humidity [in percentage] or Vapour Pressure [kPa]
Conversion: Average of morning and afternoon values of vapour pressure
Comments: Vapour pressure rather than Relative Humidity values are taken, as the latter relate to temperature values at sunrise and noon

Sunshine data

IMS: Cloudiness in Oktas of sky of All and Low Clouds for morning and noon
CROPWAT: Sunshine hours (heliograph) or sunshine percentage
Conversion: According to the following relationship:

$$SSP = 0.95 - \frac{LC1 + LC2}{2} + \alpha * \frac{AC1 + AC2}{2}$$

where: SSP = sunshine rate (fraction)
LC1 = low clouds at sunrise (oktas)
LC2 = low clouds at noon (oktas)
AC1 = high clouds at sunrise (oktas)
AC2 = low clouds at noon (oktas)
α = empirical parameter (≈ 0.3)

Windspeed data

IMS: Average Daily Windrun in km/hour
CROPWAT: Average Daily Windspeed in km/day or m/sec
Conversion: WS km/day = 24 x WS km/hour

2.4 Climate/ETo Data Input and Output

The Climate module can be selected by clicking on the "Climate/ETo" icon in the module bar located on the left of the main CROPWAT window. The data window will open with the default data type (Monthly / Decade / Daily values); it is possible to quickly change to another data type by using the drop down menu from the "New" button on the toolbar. In alternative, use the "New" button in the "File" drop down menu.

The module is primary for data input, requiring information on the meteorological station (country, name, altitude, latitude and longitude) together with climatic data. CROPWAT 8.0 can calculate reference ETo using only temperature, but humidity,

wind speed and sunshine should be entered if available.

For the benefit of CROPWAT 8.0 users a climatic database called CLIMWAT has been developed to provide the basic climatic information needed by the programme. CLIMWAT Version 2.0 contains monthly climatic data that can be exported in the appropriate format required by CROPWAT 8.0.

The Climate/ETo module includes calculations, producing Radiation and ETo data using the FAO Penman-Monteith approach. A printout of climatic data inserted and of calculated Radiation and ETo is shown in Table 1.

2.5 Climate/ETo Data Saving

After checking the data for possible errors, Climate/ETo data can be saved selecting the "Save" button on the Toolbar or the "File" > "Save" menu item. It is important to give an appropriate name to the data set which can easily be recognized later. In our example, the name KURNOOL, referring to the climate station from which the data has been taken, was used.

MONTHLY ETO PENMAN-MONTEITH DATA
(File: KURNOOL.pen)

Country: Location 9529 Station: KURNOOL
Altitude: 281 m. Latitude: 15.80 °N Longitude: 78.06 °E

Month	Min Temp °C	Max Temp °C	Humidity %	Wind m/s	Sunshine hours	Radiation MJ/m²/day	ETo mm/day
January	17.0	31.3	47	1.2	8.8	18.7	3.79
February	19.3	34.3	37	1.3	9.3	21.2	4.66
March	22.5	37.5	30	1.4	9.7	23.5	5.67
April	26.0	39.3	34	1.6	9.2	23.6	6.42
May	27.2	40.0	37	2.6	8.3	22.2	7.60
June	25.0	35.6	54	4.1	5.8	18.3	6.85
July	23.8	32.5	64	4.2	4.4	16.2	5.52
August	23.5	32.1	63	3.5	4.9	16.9	5.28
September	23.3	31.9	65	2.4	5.5	17.3	4.69
October	22.4	32.4	61	1.1	8.7	20.7	4.49
November	19.2	31.0	56	0.9	7.7	17.6	3.62
December	16.6	30.3	51	0.8	8.4	17.7	3.27
Average	22.1	34.0	50	2.1	7.5	19.5	5.15

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Table 1 Printout – Climate/ETo Data Kurnool

3. PROCESSING OF RAINFALL DATA

3.1 Introduction

The rainfall contributes to a greater or lesser extent in satisfying CWR, depending on the location. During the rainy season in tropical and some semi-tropical regions, a great part of the crop's water needs are covered by rainfall, while during the dry season, the major supply of water should come from irrigation. How much water is coming from rainfall and how much water should be covered by irrigation is, unfortunately, difficult to predict as rainfall varies greatly from season to season.

In order to estimate the rainfall deficit for irrigation water requirements, a statistical analysis needs to be made from long-term rainfall records.

In addition to the variability of rainfall from year to year, not all rain which falls is used by the crop. The intensity of rain may be such that part of the rainfall is lost due to surface runoff or due to deep percolation below the root zone. In order to determine that part of the rainfall which effectively contributes to cover CWR, a number of definitions are first given, while subsequently it is explained how the different rainfall values can be calculated and how they are incorporated in the CWR calculations.

3.2 Rainfall Definitions

Average monthly rainfall:

Mathematically determined average for a series of rainfall records, most commonly available. To be used for CWR calculation to represent average climatic conditions.

Dependable rainfall:

The amount of rainfall which can be depended upon in 1 out of 4 or 5 years corresponding to a 75 or 80% probability of exceedance and representing a dry year. The dependable rainfall (80%) is used for the design of the irrigation system capacity.

Rainfall in wet, normal and dry years:

Defined as the rainfall with a respectively 20, 50 and 80% probability of exceedance, representing a wet, normal and dry year. The three values are useful for the programming of irrigation supply and simulation of irrigation management conditions. The rainfall in normal years (50% probability) is, in general, well approached by the average rainfall.

Historical or actual rainfall data:

The actual recorded rainfall used for evaluation purposes.

Effective rainfall:

Defined as that part of the rainfall which is effectively used by the crop after rainfall losses due to surface run off and deep percolation have been accounted for. The

effective rainfall is the rainfall ultimately used to determine the crop irrigation requirements.

3.3 Rainfall Data Collection

The precipitation data required for CROPWAT 8.0 can be daily, decade or monthly rainfall, commonly available from many climatic stations. In addition, substations may be found with single rainfall records. For larger schemes, records of several rainfall stations may be available, allowing an analysis of the spatial variability.

To allow a calculation of rainfall probabilities, rainfall records from a range of years (15-30) are to be collected.

Rainfall records of the Rajalibanda Scheme are taken from Uppal Camp and are presented in Table 2.

Month	'74	'75	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85	Average
Jan	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb	0	0	0	0	13	45	0	0	0	0	0	0	5
Mar	0	0	0	0	0	0	0	13	0	0	0	13	2
Apr	0	0	8	13	38	0	20	20	0	0	15	14	11
May	69	8	33	70	87	197	0	0	18	0	0	106	49
Jun	44	89	48	140	103	118	74	56	180	0	66	29	79
Jul	15	201	121	176	144	111	76	112	72	0	128	120	106
Aug	121	110	98	160	266	13	96	101	0	257	14	73	109
Sep	69	139	119	20	272	267	66	290	8	171	42	72	128
Oct	175	384	0	101	0	104	13	43	107	64	77	117	99
Nov	15	23	20	76	29	36	0	18	76	0	8	10	26
Dec	0	0	0	0	13	0	0	0	0	0	8	6	2
Total	508	954	448	759	964	891	345	654	460	492	362	556	616

Table 2 Monthly rainfall data (1974-1985) Raingauge: Uppal Camp

3.4 Rainfall Data Processing

For programming of irrigation water supply and management, rainfall data of normal, wet and dry years are used.

An estimate of the respective rainfall data can be obtained by computing and plotting probabilities from the rainfall records. The different steps involved are:

i. Tabulate yearly rainfall totals for a given period.

ii. Arrange data in descending order of magnitude.

iii. Tabulate plotting position according to:

$$Fa = 100 * m / (N + 1)$$

where: N = number of records

m = rank number
Fa = plotting position

Year		'74	'75	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85
Rain	mm/year	508	954	448	759	964	891	345	654	460	493	363	558
Rank No		7	2	10	4	1	3	12	5	9	8	11	6
Rank No		1	2	3	4	5	6	7	8	9	10	11	12
Rain	mm/year	964	954	891	759	654	558	508	493	460	448	363	345
Fa	%	8	15	23	31	38	46	54	62	69	77	85	92

Table 3 Processing rainfall records (Uppal Camp)

iv. Plot values on log-normal scale and obtain the logarithmic regression equation, as shown in Figure 2.

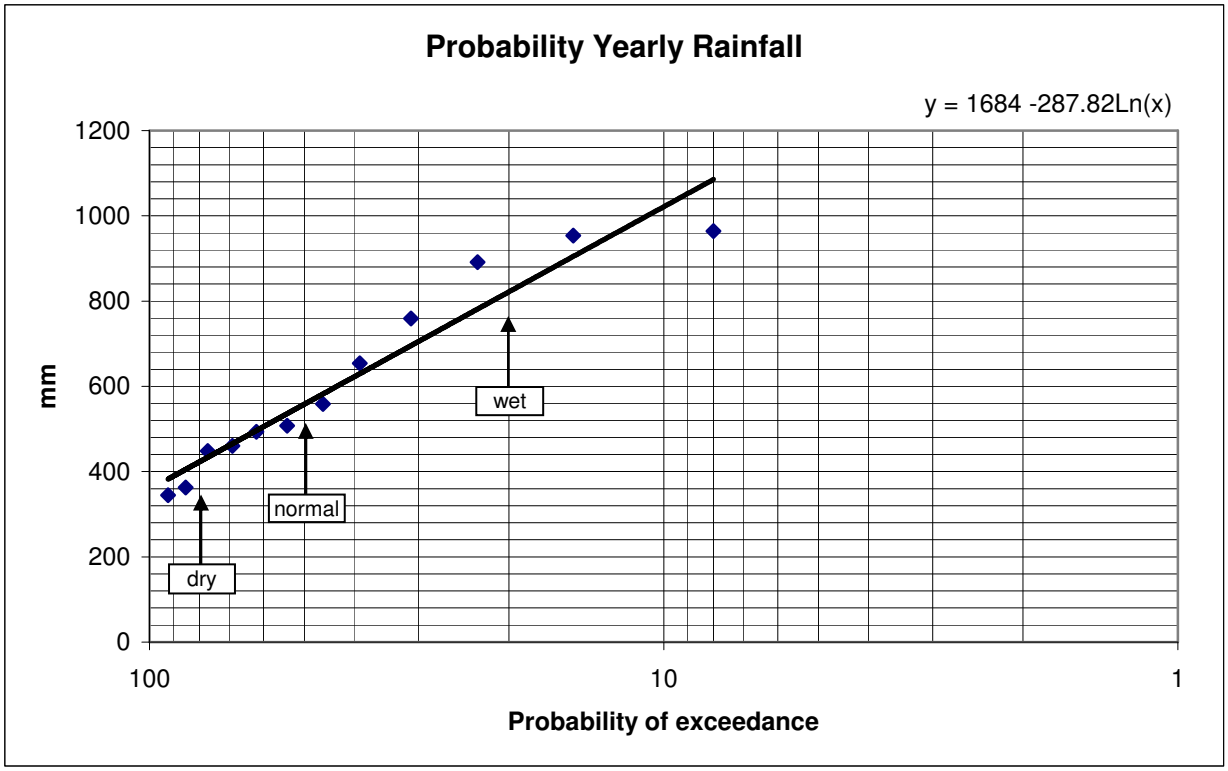

Figure 1 Dependable Rain

v. Calculate year values at 20, 50 and 80% probability: P80 = 423 mm
P50 = 558 mm
P20 = 822 mm

vi. Determine monthly values for the dry year according to the following relationship:

$$P_{i_{dry}} = P_{i_{av}} * \frac{P_{dry}}{P_{av}}$$

where: $P_{i\,av}$ = average monthly rainfall for month i
$P_{i\,dry}$ = monthly rainfall dry year for month i

P_{av} = average yearly rainfall
P_{dry} = yearly rainfall at 80% probability of exceedance

Similarly values for normal and wet years can be determined. Results are given in the following table.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average	0	5	2	11	49	79	106	109	128	99	26	2	616
Dry	0	3	1	8	34	54	73	75	88	68	18	1	423
Wet	0	7	3	15	65	105	141	145	171	132	35	3	822

Table 4 Processing rainfall records (Uppal Camp)

3.5 Effective Rainfall Method

To account for the losses due to runoff or percolation, a choice can be made of one of the four methods given in CROPWAT 8.0 (Fixed percentage, Dependable rain, Empirical formula, USDA Soil Conservation Service).

In general, the efficiency of rainfall will decrease with increasing rainfall. For most rainfall values below 100 mm/month, the efficiency will be approximately 80%. Unless more detailed information is available for local conditions, it is suggested to select the Option "Fixed percentage" and give 80% as requested value.

In the water balance calculations included in the irrigation scheduling part of CROPWAT, a possibility exists to evaluate actual Efficiency values for different crops and soil conditions.

3.6 Rainfall Data Input and Output

The Rain module can be selected by clicking on the "Rain" icon in the module bar located on the left of the main CROPWAT window. The data window will open with the default data type (Daily / Decade / Monthly values); it is possible to quickly change to another data type by using the drop down menu from the "New" button on the toolbar. In alternative, use the "New" button in the "File" drop down menu.

Once the window is open with the suitable data type, type rainfall data and check the input.

The Rain module also include calculations, producing Effective rainfall data using one of the approaches available, which can be selected by clicking on "Options" on the toolbar while the Rain module is the active window.

Table 5 shows a printout of the average rainfall data file of KURNOOL.

3.7 Saving Rainfall Data

Rainfall data should be saved after input of one set of data is completed. To do so, select the "Save" button on the Toolbar or the "File" > "Save" menu item.

The naming of the file should adequately reflect the type of rainfall data. In our case,

the following files are saved:

KURN-AV: for average ETo from Kurnool and average rainfall data
KURN-NOR: for average ETo data from Kurnool and rainfall data in a normal year (50%)
KURN-WET: for average ETo data and precipitation data of a year with rainfall of 20% probability of exceedance
KURN-DRY: for average ETo data and precipitation data of a year with rainfall of 80% probability of exceedance

The files are included in Appendix 1.

MONTHLY RAIN DATA
(File: C:\Documents and Settings\All Users\Application Data\CROPWAT\data\rain\KURN-AV.CRM)

Station: KURNOOL

Eff. rain method: Effective rain is 80 % of actual rain

	Rain mm	Eff rain mm
January	0.0	0.0
February	5.0	4.0
March	2.0	1.6
April	11.0	8.8
May	49.0	39.2
June	79.0	63.2
July	106.0	84.8
August	109.0	87.2
September	128.0	102.4
October	99.0	79.2
November	26.0	20.8
December	2.0	1.6
Total	616.0	492.8

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Table 5 Printout - Average rainfall data of Kurnool

4. CROP AND CROPPING PATTERN INFORMATION

4.1 Introduction

To determine the irrigation requirements of the Rajolibanda Diversion Scheme, an assessment should be made of the different crops grown under irrigation presently and possibly in the future. Furthermore, information on the various crop characteristics such as length of the growth cycle, crop factors, rooting depth, etc., should be collected.

CROPWAT 8.0 has crop data for several common crops taken from selected FAO publications. However, the most reliable crop data remain the data obtained from local agricultural research stations.

4.2 Crop and Cropping Pattern Data Collection

A local survey should be carried out in the irrigation scheme to assess the crops grown rainfed as well as under irrigation. Through field observations, interviews with extension agents and farmers and additional information from other agencies, for instance a revenue department, an assessment can be made of the present cropping pattern.

Essential information collected from the field should include:

1. Crop and crop variety
2. First and last planting date
3. First and last harvesting date

Additional information may include:

4. Indicative yield level
5. Indicative irrigation practices:
    - field irrigation methods
    - irrigation frequencies and interval
    - irrigation application depths

From the Agricultural Research Stations, more accurate information may be collected on:

6. Crop characteristics:
    - length of individual growth stages
    - crop factors, relating crop evapotranspiration to reference evapotranspiration
    - rooting depth
    - allowable depletion levels
    - yield response factors.

4.3 Crop and Cropping Pattern Data Processing

The collected information on the planting and harvest dates should be systematically arranged in a cropping pattern.

The planting date of crops, in particular those which cover substantial areas or are high in water demands such as rice, may be spread over a period of 3-6 weeks. In such cases the crop may be subdivided into different crop units with planting date intervals of 10-15 days.

Figure 3 illustrates a possible distribution of crops over the year and over the irrigated area.

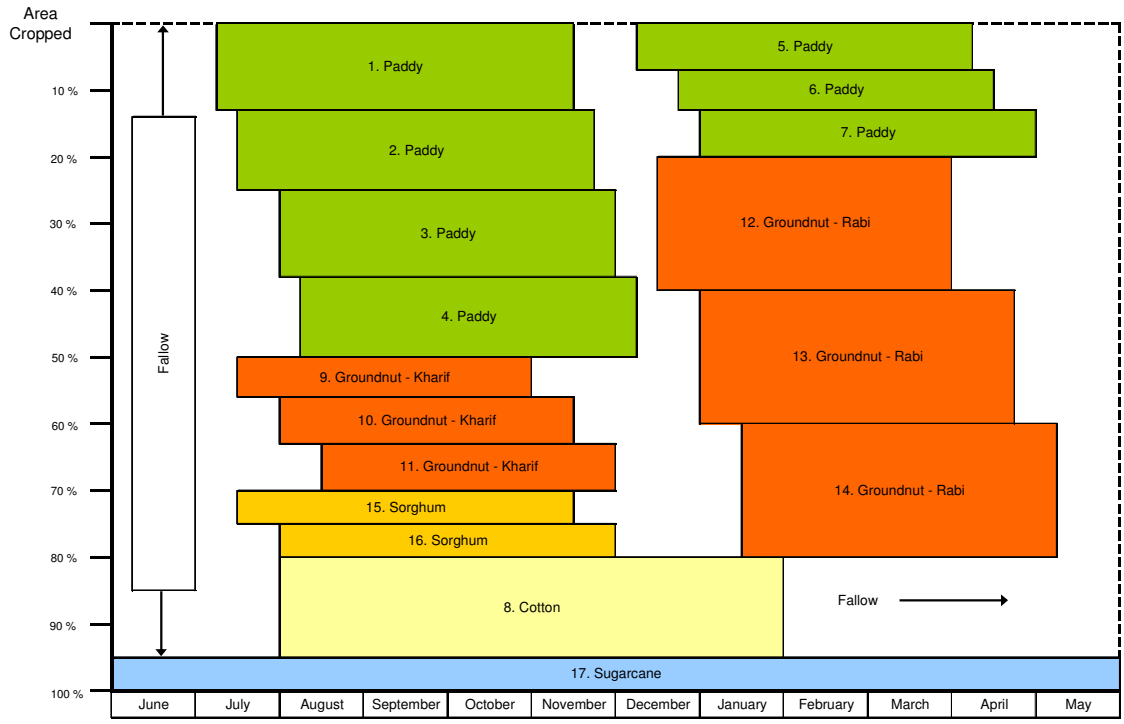

Figure 3. Cropping Pattern for Rajolibanda

4.4 Crop and Cropping Pattern Data Input and Output

The Crop module can be selected by clicking on the "Crop" icon in the module bar located on the left of the main CROPWAT window. The data window will open with the default data type (Non-rice / Rice crop); it is possible to quickly change to the other data type by using the drop down menu from the "New" button on the toolbar. In alternative, use the "New" button in the "File" drop down menu.

The Crop module requires crop data over the different development stages, defined as follow:

- Initial stage: it starts from planting date to approximately 10% ground cover.
- Development stage: it runs from 10% ground cover to effective full cover. Effective full cover for many crops occurs at the initiation of flowering.
- Mid-season stage: it runs from effective full cover to the start of maturity. The start of maturity is often indicated by the beginning of the ageing, yellowing or senescence of leaves, leaf drop, or the browning of fruit to the degree that the crop evapotranspiration is reduced relative to the ETo.
- Late season stage: it runs from the start of maturity to harvest or full senescence.

Data required differ in case of a non-rice or a rice crop. In case of non-rice crop, the following information is necessary:

- Crop name
- Planting date
- Crop coefficient (Kc)
- Stages length
- Rooting depth
- Critical depletion fraction (p)
- Yield response factor (Ky)

If available, maximum crop height should be provided.

Table 6 shows a printout of the Crop module in case of groundnut in winter time.

DRY CROP DATA
(File: C:\Documents and Settings\All Users\Application Data\CROPWAT\data\crops\KURN-GRONDNUT RABI.CRO)

Crop Name: Groudnut Rabi Planting date: 06/12 Harvest: 24/03

Stage	initial	develop	mid	late	total
Length (days)	20	30	35	25	110
Kc Values	0.40	-->	1.15	0.60	
Rooting depth (m)	0.30	-->	0.80	0.80	
Critical depletion	0.45	-->	0.45	0.50	
Yield response f.	0.20	0.80	0.60	0.20	0.70
Cropheight (m)			0.40		

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Table 6 Printout - Crop data Groundnut (Rabi)

The rice crop module requires the following additional information in comparison to non-rice crops:

- Planting date in case of direct sowing, or transplanting date in case of sowing in a nursery area
- Duration of nursery and land preparation (including puddling) stages
- Dry and Wet Crop coefficients (Kc)
- Puddling depth

Table 7 shows a printout containing the information of a rice.

RICE DATA
(File: C:\Documents and Settings\All Users\Application Data\CROPWAT\data\crops\KURN-RICE.CRO)

Crop Name: Rice Transplanting date: 0612/20/07 Harvest: 03/04/2008

Stage	nursery	landprep		growth stage				total
		total	puddling	initial	develop	mid	late	
Length (days)	30	20	5	20	30	40	30	150
Kc dry	0.70		0.30	0.50	-->	1.05	0.70	
Kc wet	1.20		1.05	1.10	-->	1.20	1.05	
Rooting depth (m)				0.10	-->	0.60	0.60	
Puddling depth (m)			0.40					
Nursery area (%)	10							
Critical depletion	0.20			0.20	-->	0.20	0.20	
Yield response f.				1.00	1.09	1.09	1.09	1.09
Cropheight (m)						1.00		

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Table 7 Printout - Crop data Paddy

The files of the crops in the scheme under analysis are included in Appendix 2.

The Cropping pattern module can be selected by clicking on the "Crop Pattern" icon in the module bar located on the left of the main CROPWAT window. In alternative, it is possible to use the drop down menu from the "New" button on the toolbar or the "New" button in the "File" drop down menu.

The cropping pattern module is primary data input, requiring information on the crops (Up to 20) being part of the scheme. With reference to each crop, the following data should be provided:

- Crop file
- Planting date
- Area: extension of the area dedicated to each crop, as a percentage of the total cropped area. Care should be taken that at any given moment the sum of the individual crops does not exceed 100 % of total scheme area.

Table 8 provides a printout for Rajolibanda scheme.

CROPPING PATTERN DATA
(File: C:\Documents and Settings\All Users\Application Data\CROPWAT\data\sessions\Rajolibanda.PAT)

Cropping pattern name: Rajolibanda

No.	Crop file	Crop name	Planting date	Harvest date	Area %
1	KURN-RICE.CRO	Rice	10/07	06/11	13
2	KURN-RICE.CRO	Rice	20/07	16/11	12
3	KURN-RICE.CRO	Rice	01/08	28/11	13
4	KURN-RICE.CRO	Rice	10/08	07/12	12
5	KURN-RICE.CRO	Rice	10/12	08/04	7
6	KURN-RICE.CRO	Rice	20/12	18/04	6
7	KURN-RICE.CRO	Rice	01/01	30/04	7
8	KURN-COTTON.CRO	COTTON	01/08	27/01	15
9	KURN-GRONDNUT KHARIF	Groudnut Kharif	15/07	01/11	6
10	KURN-GRONDNUT KHARIF	Groudnut Kharif	01/08	18/11	7
11	KURN-GRONDNUT KHARIF	Groudnut Kharif	15/08	02/12	7
12	KURN-GRONDNUT RABI.C	Groudnut Rabi	15/12	03/04	20
13	KURN-GRONDNUT RABI.C	Groudnut Rabi	01/01	20/04	20
14	KURN-GRONDNUT RABI.C	Groudnut Rabi	15/01	04/05	20
15	KURN-SORGHUM.CRO	SORGHUM (Grain)	15/07	11/11	5
16	KURN-SORGHUM.CRO	SORGHUM (Grain)	01/08	28/11	5
17	KURN-SUGARCAN.CRO	Sugarcane (Ratoon)	01/01	31/12	5

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Table 8 Printout - Cropping pattern

4.5 Crop and Cropping Pattern Data Saving

Crop and Cropping Pattern data should be saved after input of one set of data is completed. To do so, select the "Save" button on the Toolbar or the "File" > "Save" menu item. Remember that the naming of the file should adequately reflect the type of crop and cropping pattern data.

5. CROP WATER REQUIREMENT CALCULATIONS

5.1 Introduction

Calculation of the CWR can be carried out by calling up successively the appropriate climate and rainfall data sets, together with the crop files and the corresponding planting dates.

In case of CWR calculation of rice, soil data are also required.

5.2 Soil Data Collection

Information from the soil surveys carried out in the Rajolibanda area show two distinct soil categories:

- Red Sandy Loams, Red Loamy and Red Sandy, covering 23% of the command area, relatively shallow and free-draining, particularly suitable for upland crops;
- Black Clay Soils, covering 77%, deep but poorly drained, suitable mainly for paddy and deep rooting crops like cotton.

5.3 Soil Data Input and Output

The Soil module is selected by clicking on the "Soil" icon in the module bar located on the left of the main CROPWAT window. In alternative, it can be opened by using the drop down menu from the "New" button on the toolbar or using the "New" button in the "File" drop down menu.

The Soil module is essentially data input, requiring the following general soil data:

- Total Available Water (TAW)
- Maximum infiltration rate
- Maximum rooting depth
- Initial soil moisture depletion

In case of rice calculation, the following additional soil data are required:

- Drainable porosity
- Critical depletion for puddle cracking
- Water availability at planting
- Maximum water depth

The module also includes calculations, providing the initial available soil moisture and, in case of rice, the maximum percolation rate after puddling.

The Printout of the Black Clay Soil, required for CWR rice calculation, is provided in Table 9. The files of the soils in the scheme under analysis are included in Appendix 3.

SOIL DATA
(File: C:\Documents and Settings\All Users\Application Data\CROPWAT\data\soils\BLACK CLAY SOIL.SOI)

Soil name: BLACK CLAY SOIL

General soil data:

Total available soil moisture (FC - WP)	200.0	mm/meter
Maximum rain infiltration rate	30	mm/day
Maximum rooting depth	900	centimeters
Initial soil moisture depletion (% TAM)	50	%
Initial available soil moisture	100.0	mm/meter

Additional soil data for rice calculations:

Drainable porosity (SAT - FC)	10	%
Critical depletion for puddle cracking	0.60	mm/day
Water availability at planting	5	mm WD
Maximum waterdepth	120	mm

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Table 9 Printout – Black Clay Soil

5.4 Soil Data Saving

Soil data should be saved after input of one set of data is completed. To do so, select the "Save" button on the Toolbar or the "File" > "Save" menu item. Remember that the naming of the file should adequately reflect the type of soil data.

5.5 CWR Data Input and Output

The CWR module can be selected by clicking on the "CWR" icon in the module bar located on the left of the main CROPWAT window. Data on Climate/ETo, Rainfall (average), Crop and Soil (in case of rice) are required. If not all data are available, CROPWAT will produce a warning and close the CWR module.

The CWR module includes calculations, producing the irrigation water requirement of the crop on a decadal basis and over the total growing season, as the difference between the crop evapotranspiration under standard conditions (ETc) and the Effective rainfall.

Examples of CWR printouts are shown in Tables 10 and 11.

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL (KURN-AV)

Crop: Rice
Planting date: 20/07

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Jun	2	Nurs	1.20	0.82	0.8	2.1	0.8
Jun	3	Nurs/LPr	1.19	1.37	13.7	23.5	90.8
Jul	1	Nurs/LPr	1.06	6.28	62.8	26.4	36.4
Jul	2	Init	1.07	5.79	57.9	29.1	171.3
Jul	3	Init	1.10	5.91	65.0	29.1	35.9
Aug	1	Deve	1.10	5.90	59.0	28.4	30.5
Aug	2	Deve	1.11	5.88	58.8	28.5	30.3
Aug	3	Deve	1.13	5.76	63.4	30.4	33.0
Sep	1	Mid	1.15	5.63	56.3	33.6	22.6
Sep	2	Mid	1.16	5.42	54.2	35.9	18.3
Sep	3	Mid	1.16	5.34	53.4	32.8	20.7
Oct	1	Mid	1.16	5.27	52.7	30.1	22.6
Oct	2	Late	1.15	5.18	51.8	28.1	23.7
Oct	3	Late	1.11	4.66	51.3	21.0	30.3
Nov	1	Late	1.05	4.12	41.2	12.2	29.0
Nov	2	Late	1.01	3.67	22.0	3.1	19.5
					764.3	394.3	615.7

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Table 10 Printout - Crop water requirements paddy (Black clay soil)

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL

Crop: Groudnut Rabi
Planting date: 15/12

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Dec	2	Init	0.20	0.65	3.9	0.0	3.9
Dec	3	Init	0.20	0.69	7.6	0.0	7.6
Jan	1	Deve	0.29	1.04	10.4	0.0	10.4
Jan	2	Deve	0.59	2.25	22.5	0.0	22.5
Jan	3	Deve	0.92	3.77	41.4	0.1	41.3
Feb	1	Mid	1.14	4.98	49.8	1.1	48.8
Feb	2	Mid	1.14	5.33	53.3	1.6	51.7
Feb	3	Mid	1.14	5.71	45.7	1.2	44.5
Mar	1	Late	1.14	6.08	60.8	0.5	60.3
Mar	2	Late	1.00	5.67	56.7	0.1	56.5
Mar	3	Late	0.77	4.55	50.0	1.1	49.0
Apr	1	Late	0.61	3.79	11.4	0.4	10.6
					413.5	6.2	407.1

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Table 11 Printout - Crop water requirements Groundnut Rabi (Red sandy loam soil)

A summary of the results of the different CWR calculation for our cropping pattern is given in the following table. Results of the individual calculations are given in Appendix 4.

No.	CROP	Plant. date	Harvest date	Area %	ETc mm	Eff Rain mm	Irr req mm
1	PADDY	10-Jul	6-Nov	13	797.0	407.3	637.3
2	PADDY	20-Jul	16-Nov	12	764.3	394.3	615.7
3	PADDY	1-Aug	28-Nov	13	730.4	370.9	612.9
4	PADDY	10-Aug	7-Dec	12	708.9	349.0	617.1
5	PADDY	10-Dec	8-Apr	7	704.9	18.4	927.5
6	PADDY	20-Dec	18-Apr	6	737.8	14.4	955.0
7	PADDY	1-Jan	30-Apr	7	783.5	16.2	1000.5
8	COTTON	1-Aug	27-Jan	15	604.4	291.4	362.0
9	GROUNDNUT-KHARIF	15-Jul	1-Nov	6	425.7	316.6	123.6
10	GROUNDNUT-KHARIF	1-Aug	18-Nov	7	400.9	285.1	129.3
11	GROUNDNUT-KHARIF	15-Aug	2-Dec	7	378.9	250.1	155.9
12	GROUNDNUT-RABI	15-Dec	3-Apr	20	413.5	6.2	407.1
13	GROUNDNUT-RABI	1-Jan	20-Apr	20	455.9	9.0	446.8
14	GROUNDNUT-RABI	15-Jan	4-May	20	492.4	18.6	472.9
15	SORGHUM	15-Jul	11-Nov	5	382.0	328.1	85.4
16	SORGHUM	1-Aug	28-Nov	5	356.2	288.9	108.1
17	SUGARCANE	1-Jan	31-Dec	5	2024.1	492.9	1549.2

Table 12 Crop Water Requirements

6. SCHEME AND CANAL WATER REQUIREMENTS

6.1 Introduction

The irrigation supply to any irrigation scheme or canal command area can be calculated by adding up the requirements of each cropped area. Any changes in cropping pattern can be conveniently calculated by modifying area size of the different crops. Similarly, the irrigation supply for each canal unit can be determined through CROPWAT 8.0.

6.2 Scheme Supply Data Input and Output

The Scheme Supply module can be selected by clicking on the "Scheme" icon in the module bar located on the left of the main CROPWAT window. Data on climate/ETo, rainfall, soil (in case of rice) and cropping pattern are required. If not all data are available, CROPWAT will produce a warning and close the scheme module.

The scheme module includes calculations, producing:

- Irrigation requirement for each crop of the scheme
- Net scheme irrigation requirement
- Irrigated area as a percentage of the total area
- Irrigation requirement for the actual area

A printout of the Scheme Water Requirements (SWR) is shown in Table 13.

SCHEME SUPPLY

ETo station: KURNOOL Cropping pattern: Rajolibanda
Rain station: KURNOOL

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
1 Rice	0.0	0.0	0.0	0.0	0.0	85.4	250.3	96.8	62.2	72.4	17.6	0.0
2 Rice	0.0	0.0	0.0	0.0	0.0	40.6	243.5	93.9	62.0	76.9	48.5	0.0
3 Rice	0.0	0.0	0.0	0.0	0.0	0.0	241.7	91.8	60.6	79.3	90.0	0.0
4 Rice	0.0	0.0	0.0	0.0	0.0	0.0	73.6	232.3	58.6	79.3	101.8	22.3
5 Rice	135.0	147.3	193.4	48.7	0.0	0.0	0.0	0.0	0.0	0.0	76.7	252.4
6 Rice	132.9	147.2	199.0	114.6	0.0	0.0	0.0	0.0	0.0	0.0	44.2	254.9
7 Rice	131.2	145.8	201.4	199.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	297.5
8 Cotton	74.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	64.9	105.4	110.3
9 Groudnut Kharif	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.6	56.7	33.2	2.2	0.0
10 Groudnut Kharif	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	37.3	64.1	30.3	0.0
11 Groudnut Kharif	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.8	73.8	70.9	3.8
12 Groudnut Rabi	86.1	142.2	161.3	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.0
13 Groudnut Rabi	53.9	124.1	192.7	93.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14 Groudnut Rabi	27.0	85.9	193.4	173.7	12.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15 Sorghum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	27.5	38.5	12.1	0.0
16 Sorghum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	50.7	51.9	0.0
17 Sugarcane	47.5	76.4	176.2	226.7	244.6	184.1	124.5	109.7	69.8	74.7	87.5	85.6
Net scheme irr.req.												
in mm/day	2.4	3.7	5.1	3.0	0.5	0.8	3.5	2.3	1.4	2.2	2.4	2.7
in mm/month	73.6	103.6	157.9	91.0	14.7	25.2	108.2	71.4	42.9	68.1	70.6	82.2
in l/s/h	0.27	0.43	0.59	0.35	0.05	0.10	0.40	0.27	0.17	0.25	0.27	0.31
Irrigated area (% of total area)	100.0	85.0	85.0	85.0	25.0	30.0	55.0	73.0	100.0	100.0	100.0	79.0
Irr.req.act.area (l/s/h)	0.27	0.50	0.69	0.41	0.22	0.32	0.73	0.37	0.17	0.25	0.24	0.39

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Table 13 Printout - Scheme Water Requirements (SWR) Rajolibanda

6.3 Evaluation of Scheme Water Requirements Results

The results of the SWR for the given cropping pattern can now be compared with the available supply from the diversion at the anicut or reservoir.

Average monthly discharge of the Rajolibanda main canal (average over 1975-1985 period) is shown in the following table and compared with the calculated scheme requirements based on our schematic cropping pattern, and taking into account a 50% efficiency.

	Jun	Jul	Aug	Sep	Oct	Nov	Total
Actual Supply (Mm3)	5.8	26.3	35.4	36.2	39.6	38.5	181.8
Net scheme irr.req. (mm/month)	25.2	108.2	71.4	42.9	68.1	70.6	386.4
Irrigation efficiency (%)	50%	50%	50%	50%	50%	50%	
Gross scheme irr.req. (mm/month)	50.4	216.4	142.8	85.8	136.2	141.2	772.8
Irrigated area (ha)	10000	10000	10000	10000	10000	10000	
Gross scheme irr.req. (Mm3/month)	5.0	21.6	14.3	8.6	13.6	14.1	77.3
Requirement/Supply	87%	82%	40%	24%	34%	37%	43%

Table 14 Evaluation scheme water supply Kharif season

	Dec	Jan	Feb	Mar	Apr	May	Total
Actual Supply (Mm3)	35.4	34.9	31.2	35.8	30.0	1.1	168.4
Net scheme irr.req. (mm/month)	82.2	73.6	103.6	157.9	91.0	14.7	523.0
Irrigation efficiency (%)	50%	50%	50%	50%	50%	50%	
Gross scheme irr.req. (mm/month)	164.4	147.2	207.2	315.8	182.0	29.4	1046.0
Irrigated area (ha)	10000	10000	10000	10000	10000	10000	
Gross scheme irr.req. (Mm3/month)	16.4	14.7	20.7	31.6	18.2	2.9	104.6
Requirement/Supply	46%	42%	66%	88%	61%	267%	62%

Table 15 Evaluation scheme water supply Rabi season

The ratio estimated SWR and actual supply (average of 10 years) gives some interesting information on efficiency of supply and may provide indications for further adjustments in the cropping pattern and scheme water supply.

7. IRRIGATION SCHEDULING

7.1 Introduction

An important element of CROPWAT 8.0 is the irrigation scheduling module, which has several application possibilities:

- to develop indicative irrigation schedules:
  - for the agricultural extension service to promote better irrigation practices
  - for the irrigation service to establish improved rotational delivery schedules;
- to evaluate existing irrigation practices on water use efficiency and water stress conditions;
- to evaluate crop production under rainfed conditions, to assess feasibility of supplementary irrigation and to develop appropriate irrigation schedules;
- to develop alternative water delivery schedules under restricted water supply conditions.

The calculations of the scheduling module are based on a soil water budget, where, on a daily basis, the soil moisture status is determined, accounting for incoming and outgoing water in the root zone.

We will see using our example from the Rajolibanda scheme how the different applications are worked out.

7.2 Schedule Data Input and Output

The Schedule module can be selected clicking on the "Schedule" icon in the module bar located on the left of the main CROPWAT window. Data on climate/ETo, rainfall, crop and soil are required. If not all data are available, CROPWAT will produce a warning and close the schedule module.

The schedule module essentially includes calculations, producing a soil water balance on a daily step. The following parameters are used:

- Effective rainfall, over dry, normal and/or wet years
- Water stress coefficient (Ks)
- Crop evapotranspiration under non-standard conditions (ETc adj)
- Root zone depletion
- Net irrigation
- Deficit
- Irrigation losses
- Gross irrigation
- Flow

The calculations for scheduling of rice are somewhat different. For lowland rice, a water layer is maintained in the field for most of the growing season and therefore, extra irrigation water is required not only to cover evaporation losses but also to compensate for the percolation losses in the inundated fields. Furthermore, prior to transplanting, substantial irrigation water is required for the land preparation and the nursery. The additional following parameters are displayed in case of rice calculation:

- Puddling state
- Deep Percolation
- Depletion of soil moisture
- Depletion of saturation

7.3 Irrigation Scheduling Applications

To illustrate the different applications of the scheduling program, we will work out some examples.

7.3.1 Development of indicative irrigation schedule

Objective:

To determine the irrigation water supply for a given crop in terms of frequency and irrigation depth, assuring optimal crop growth and efficient water use.

Conditions:

The irrigation schedule should meet the requirements of the field irrigation method practised and the operational criteria of the irrigation system (Warabandi). Furthermore, the validity of the schedule for different soil types and for variable rainfall conditions should be assessed.

***Required data and information*:**

The essential information required for the development of an indicative schedule is given below for two crops:

1.	Crop:	Groundnut Rabi
	Planting date:	15 December
	Climate:	Kurnool Normal Years
	Soil:	Red Sandy Loam, Red Sandy and Red Loamy
	Irrigation method:	Furrow irrigation
	Net application:	40-50 mm
	Irrigation supply:	Warabandi system with fixed rotational interval period
2.	Crop:	Cotton
	Planting date:	1 August
	Climate:	Kurnool Normal, Wet and Dry Years
	Soil:	Black Clay Soil, Red Sandy Loam and Red Sandy
	Irrigation method:	Basin irrigation
	Net application:	70-80 mm
	Irrigation supply:	Warabandi system with fixed rotational interval period

***Scheduling procedures*:**

In order to develop the irrigation schedule which would fit our requirements, an interactive procedure is followed in which several runs are made with different timing and application options.

The results of each run will be evaluated providing the information for the next option. A printout of each run is given in Appendix 5.1 with summarized results given in Table 17. An example of the printout of an irrigation schedule developed for groundnut is given in Table 16. The different runs provide an indication of the criteria which are evaluated and used for the next run.

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: Groudnut Rabi Planting date: 15/12
Rain station: KURNOOL Soil: RED SANDY LOAM Harvest date: 03/04

Yield red.: 3.2 %

Crop scheduling options
Timing: Irrigate at user defined intervals
Application: Fixed application depth of 45 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
23 Jan	40	Dev	0.0	0.86	98	56	45.0	9.7	0.0	64.3	0.19
2 Feb	50	Dev	0.0	1.00	100	44	45.0	4.7	0.0	64.3	0.74
12 Feb	60	Mid	0.0	1.00	100	48	45.0	9.0	0.0	64.3	0.74
22 Feb	70	Mid	0.0	0.92	99	54	45.0	15.8	0.0	64.3	0.74
4 Mar	80	Mid	0.0	0.76	95	62	45.0	24.9	0.0	64.3	0.74
14 Mar	90	End	0.0	0.63	89	69	45.0	32.3	0.0	64.3	0.74
24 Mar	100	End	0.0	0.64	88	69	45.0	32.7	0.0	64.3	0.74
3 Apr	End	End	0.0	0.80	0	62					

Totals:

Total gross irrigation	450.0	mm	Total rainfall	7.2 mm
Total net irrigation	315.0	mm	Effective rainfall	7.2 mm
Total irrigation losses	0.0	mm	Total rain loss	0.0 mm
Actual water use by crop	391.2	mm	Moist deficit at harvest	69.1 mm
Potential water use by crop	409.8	mm	Actual irrigation requirement	402.6 mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	100.0 %
Deficiency irrigation schedule	4.5	%		

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	1.2	1.7	11.8	4.5	%
Yield response factor	0.20	0.80	0.60	0.20	0.70	
Yield reduction	0.0	0.9	1.0	2.4	3.2	%
Cumulative yield reduction	0.0	0.9	2.0	4.3		%

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Table 16 Printout - Selected irrigation schedule for groundnut

For groundnut, the following sequence of runs is made:

Run 1

Timing Option:	Irrigation at critical depletion
Application Option:	Refill soil to field capacity
Evaluation Criteria:	- Interval variance (9 to 14 days)
	- Application variance (42 to 57 mm)

Run 2

Timing Option:	Irrigation at fixed depletion (40 mm)
Application Option:	Fixed application depth (40 mm)
Evaluation Criteria:	- Interval variance (7 to 11 days)

Run 3-5

Timing Option:	Irrigation at fixed intervals per stage (7 to 10 days)
Application Option:	Fixed application depth (40 to 45 mm)
Evaluation Criteria:	- Irrigation efficiency (65 to 74%)
	- Eventual yield reduction (0 to 5%)

Run 6

Timing Option:	Irrigate at user defined intervals (40/50/60/70/80/90/100 days)
Application Option:	Fixed application depth (45 mm)
Evaluation Criteria:	- Irrigation efficiency (100%)
	- Yield reduction (3%)

Run 7-8

The effect of the selected irrigation schedule on irrigation and rain efficiency and yield reduction is evaluated for varying soil type:

Timing Option:	Irrigate at user defined intervals (40/50/60/70/80/90/100 days)
Application Option:	Fixed application depth (45 mm)
Evaluation Criteria:	- Irrigation efficiency (100%)
	- Yield reduction (1 to 6%)

Run	Net irr. (mm)	Irrig. Turns	Tot net irr. (mm)	Sched. Effic.	Yield Reduc.	Rain Effic.
Red Sandy Loam (140 mm/m)						
1	variable	7	365	100%	-	92%
2	variable	10	400	100%	-	100%
3	40	15	600	65%	-	82%
4	40	10	400	74%	5%	92%
5	45	10	450	71%	2%	92%
6	45	7	315	100%	3%	100%
Red Sandy (100 mm/m)						
7	45	7	315	100%	7%	92%
Red Loamy (180 mm/m)						
8	45	7	315	100%	1%	100%

Table 17 Summarized results scheduling runs for groundnut

The results of a similar procedure followed for a cotton crop are shown in Table 18.

As rainfall is more substantial than for the previous crop, the effect of precipitation for wet and dry years is evaluated in separate runs, as well as the effect of medium and light texture soils.

Run	Net irr. (mm)	Irrig. Turns	Tot net irr. (mm)	Sched. Effic.	Yield Reduc.	Rain Effic.
Black Clay Soil (200 mm/m), Average year						
1	183	1	183	100%	-	100%
2	80	5	400	100%	-	98%
3	80	5	400	91%	-	100%
4	70	5	350	100%	-	100%
5	70	4	280	100%	-	100%
Red Sand Loam (140 mm/m), Average year						
6	70	4	280	100%	-	74%
Red Sandy (100 mm/m), Average year						
7	70	4	280	100%	-	74%
Black Clay Soil (200 mm/m), Dry year						
8	70	4	280	100%	3%	100%
Black Clay Soil (200 mm/m), Wet year						
9	70	4	280	93%	-	88%
10	70	1	70	100%	-	88%

Table 18 Summarized results scheduling runs for cotton

7.3.2 Evaluation of irrigation practices

***Objective*:**

To assess adequacy of existing irrigation practices in terms of efficient water use and production level as a base to develop and promote better irrigation practices.

***Required data and information*:**

In order to evaluate existing practices, actual data should be collected through field surveys and interviews with farmers. Although a detailed survey would provide more accurate information, a rapid survey on certain parameters would provide already useful indications, as shown in our example.

The minimum data information should include, apart from general information on climate, crops and soils:

- Crop information: Variety, planting date, harvest date;
- Climate: Data on actual rainfall over the growing season, as far as available;
- Irrigation frequency: Actual dates of irrigation, or average irrigation interval practised, or number of irrigations over the growing season;
- Irrigation application: Estimate of average irrigation depth per irrigation according to irrigation method practised;
- Soil: Estimate soil texture.

Example: **Sorghum**

During a field visit to Rajolibanda, the following information was obtained from discussions with farmers and from field observations:

Crop:	HYV sorghum, grown for certified seed production
Planting date:	13 September
Harvest date:	17 January (estimated)
1st irrigation:	23 November
Interval period:	20-25 days
Irrigation method:	Basin irrigation, size 10 x 25 m
Application depth:	70-80 mm (estimated)
Soil type:	Red Loamy (180 mm/m) (estimated)
Rainfall data:	Kurnool 1986 (see Appendix 1)
ETo	Climate data Kurnool

CWR Calculation

The CWR calculated for the sorghum crop yields:

Total ETcrop	= 412 mm
Effective Rainfall	= 142 mm
Irrigation Requirement	= 276 mm

Scheduling Procedures

After processing of CWR calculations and soil data input the following options are selected on the base of the information previously collected:

- Timing Option: Irrigate at user defined interval (72/93/114)
- Application Option: Fixed application depth (70 mm)

A printout of the results is given.

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: SORGHUM (Grain) Planting date: 13/09
Rain station: KURNOOL Soil: RED LOAMY Harvest date: 17/01

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at user defined intervals
Application: Fixed application depth of 70 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
23 Nov	72	Mid	7.9	1.00	100	29	70.0	0.0	16.9	100.0	0.16
14 Dec	93	Mid	0.0	1.00	100	41	70.0	4.1	0.0	100.0	0.55
4 Jan	114	End	0.0	1.00	100	42	70.0	6.2	0.0	100.0	0.55
17 Jan	End	End	0.0	1.00	100	22					

Totals:

Total gross irrigation	300.0	mm	Total rainfall	178.2	mm
Total net irrigation	210.0	mm	Effective rainfall	178.2	mm
Total irrigation losses	16.9	mm	Total rain loss	0.0	mm
Actual water use by crop	410.0	mm	Moist deficit at harvest	38.7	mm
Potential water use by crop	410.0	mm	Actual irrigation requirement	231.8	mm
Efficiency irrigation schedule	91.9	%	Efficiency rain	100.0	%
Deficiency irrigation schedule	0.0	%			

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.60	0.60	1.20	0.80	1.00	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

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Table 19 Printout – Irrigation scheduling practiced by the farmer

The example shows that farmers' practice matches fairly well the calculated irrigation requirements.

7.3.3 Rainfed production and supplementary irrigation

***Objective*:**

- To assess the adequacy of rainfall for crop growth.
- To determine yield reductions due to rainfall deficits.
- To determine feasibility of supplementary irrigation.
- To develop supplementary irrigation schedules.

***Required data*:**

Climate: The rainfall data used will concern in general statistically processed values with assigned probability values (80, 50 or 20), but also historical rainfall data may be used. In our example, climatic data of an average year are used.

Crop: Crops and crop varieties normally grown under rainfall should be used. An adjustment of the crop file may be necessary as rainfed crops will in general be better adapted to stress conditions than higher yielding irrigated crops; consequently length of growing stages, rooting depth, allowable depletion levels and yield response factor will need to be adjusted. In our example, cotton has been used as a crop to show the procedures.

Soil: Predominant soils for rainfed crops should be taken. In our example, the deep Black Clay Soils have been used to assess suitability of rainfed cotton.

CWR Calculations

The crop water requirements of cotton calculated earlier (see Appendix 4) show for cotton planted on 1 August the following summarized results:

Total ET cotton	= 604 mm
Effective rainfall	= 291 mm
Irrigation Requirements	= 362 mm

Scheduling Procedures

To assess the effect of rainfall deficits on crop growth, the following option should be selected:

- Timing Option: No irrigation (Rainfed)
- Application Option: -

A printout of the results is shown in Table 20.

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: COTTON Planting date: 01/08
Rain station: KURNOOL Soil: BLACK CLAY SOIL Harvest date: 27/01

Yield red.: 14.5 %

Crop scheduling options
Timing: No predefined irrigation
Application: Fixed application depth of 70 mm
Field eff. 70 %

Table format: Daily soil moisture balance

Date	Day	Stage	Rain mm	Ks fract.	ETa mm/day	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
1 Aug	1	Init	0.0	1.00	1.9	53	0.0	33.3	0.0	0.0	0.00
10 Aug	10	Init	0.0	1.00	1.9	31	0.0	27.1	38.3	0.0	0.00
20 Aug	20	Init	0.0	1.00	1.8	21	0.0	23.9	37.1	0.0	0.00
30 Aug	30	Init	0.0	1.00	1.8	12	0.0	17.7	31.0	0.0	0.00
9 Sep	40	Dev	0.0	1.00	2.2	7	0.0	11.3	0.0	0.0	0.00
19 Sep	50	Dev	0.0	1.00	2.9	6	0.0	12.4	22.7	0.0	0.00
29 Sep	60	Dev	0.0	1.00	3.6	9	0.0	19.1	34.3	0.0	0.00
9 Oct	70	Dev	0.0	1.00	4.3	14	0.0	36.1	32.2	0.0	0.00
19 Oct	80	Dev	0.0	1.00	4.9	22	0.0	60.8	26.5	0.0	0.00
29 Oct	90	Mid	0.0	1.00	4.8	30	0.0	83.0	20.3	0.0	0.00
8 Nov	100	Mid	0.0	1.00	4.5	41	0.0	113.5	16.5	0.0	0.00
18 Nov	110	Mid	0.0	1.00	4.2	53	0.0	149.5	0.0	0.0	0.00
28 Nov	120	Mid	0.0	1.00	4.0	66	0.0	185.7	0.0	0.0	0.00
8 Dec	130	Mid	0.0	0.68	2.7	77	0.0	215.6	0.0	0.0	0.00
18 Dec	140	End	0.0	0.50	1.8	84	0.0	236.6	0.0	0.0	0.00
28 Dec	150	End	0.0	0.40	1.3	90	0.0	251.8	0.0	0.0	0.00
7 Jan	160	End	0.0	0.31	0.9	94	0.0	262.7	0.0	0.0	0.00
17 Jan	170	End	0.0	0.24	0.6	97	0.0	270.3	0.0	0.0	0.00
27 Jan	End	End	0.0	0.18	0.0	98					

Totals:

Total gross irrigation	0.0	mm	Total rainfall	364.3 mm
Total net irrigation	0.0	mm	Effective rainfall	364.3 mm
Total irrigation losses	0.0	mm	Total rain loss	0.0 mm
Actual water use by crop	499.3	mm	Moist deficit at harvest	275.0 mm
Potential water use by crop	601.9	mm	Actual irrigation requirement	237.6 mm
Efficiency irrigation schedule	-	%	Efficiency rain	100.0 %
Deficiency irrigation schedule	17.0	%		

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	6.2	64.6	17.0	%
Yield response factor	0.20	0.50	0.50	0.25	0.85	
Yield reduction	0.0	0.0	3.1	16.1	14.5	%
Cumulative yield reduction	0.0	0.0	3.1	18.8		%

Cropwat 8.0 Bèta

Table 20 Printout - Rainfed production level of cotton

Results show clearly that the yield of cotton is substantially affected by stress in the latter part of its growing stage, which will no doubt cause a premature senescence of the crop.

Supplementary irrigation will result in an increase in crop yields. A single supplementary supply of irrigation when considering data for a wet year would

guarantee an optimal cotton production, as determined earlier (Appendix 5.1).

7.3.4 Deficit irrigation

Objective

- To assess the effect of limited water supply on crop growth for conditions of restricted water availability.
- To develop an alternative irrigation schedule optimizing crop production under limited water supply conditions.

Required Data

A similar data set as used under option 7.3.1 can be used. We have taken groundnuts planted in Rabi on 15 December with an average climatic data set, grown on a Red Sandy Loam.

CWR Calculations

CWR of groundnuts have been calculated:

Total ETc	:	438 mm
Effective rainfall	:	6 mm
Irrigation Requirements	:	432 mm

Scheduling Procedures

Timing options available in CROPWAT 8.0 for Deficit irrigation are the following:

- Irrigate at given Yield reduction
- Irrigate at given ETc reduction per stage

As our aim is to optimize crop production under restricted water supply, we will choose the first option.
An initial value of 10% may be given, in later runs possibly increased or decreased.

A fixed irrigation depth of 40 mm is typically used for groundnut irrigated on furrows.

Scheduling Results

In Table 21 the results of the schedule are shown. The total irrigation supply is 360 mm, compared to a previous irrigation supply requirement of 400 mm (see section 7.3.1).

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: Groudnut Planting date: 15/12
Rain station: KURNOOL (KURN-AV) Soil: RED SANDY LOAM Harvest date: 23/04

Yield red.: 18.0 %

Crop scheduling options
Timing: Irrigate at 10 % yield reduction
Application: Fixed application depth of 40 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
24 Jan	41	Dev	0.0	0.60	87	69	40.0	22.2	0.0	57.1	0.16
9 Feb	57	Dev	0.0	0.62	86	69	40.0	34.3	0.0	57.1	0.41
20 Feb	68	Mid	0.0	0.56	83	72	40.0	40.3	0.0	57.1	0.60
1 Mar	77	Mid	0.0	0.56	81	72	40.0	40.7	0.0	57.1	0.73
9 Mar	85	Mid	0.0	0.58	82	71	40.0	40.0	0.0	57.1	0.83
17 Mar	93	Mid	0.1	0.55	81	73	40.0	41.4	0.0	57.1	0.83
24 Mar	100	Mid	0.0	0.60	83	71	40.0	39.0	0.0	57.1	0.94
17 Apr	124	End	1.2	0.17	49	92	40.0	63.3	0.0	57.1	0.28
23 Apr	End	End	0.0	0.61	98	68					

Totals:

Total gross irrigation	457.1	mm	Total rainfall	14.7	mm
Total net irrigation	320.0	mm	Effective rainfall	14.7	mm
Total irrigation losses	0.0	mm	Total rain loss	0.0	mm
Actual water use by crop	411.2	mm	Moist deficit at harvest	76.5	mm
Potential water use by crop	553.5	mm	Actual irrigation requirement	538.8	mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	100.0	%
Deficiency irrigation schedule	25.7	%			

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.2	15.5	17.8	58.1	25.7	%
Yield response factor	0.20	0.80	0.60	0.20	0.70	
Yield reduction	0.0	12.4	10.7	11.6	18.0	%
Cumulative yield reduction	0.0	12.4	21.8	30.9		%

Cropwat 8.0 Bèta

Table 21 Printout - Deficit irrigation of groundnut

APPENDIX 1

PRINTOUT CLIMATIC DATA FILES

1. **Reference Evapotranspiration Kurnool**
2. **Average Climatic Data Kurnool**
3. **Dry Year Climatic Data Kurnool**
4. **Normal Year Climatic Data Kurnool**
5. **Wet Year Climatic Data Kurnool**
6. **1986 Climatic Data Kurnool**

1. Reference Evapotranspiration Kurnool

MONTHLY ETO PENMAN-MONTEITH DATA
(File: KURNOOL.pen)

Country: Location 9529 Station: KURNOOL
Altitude: 281 m. Latitude: 15.80 °N Longitude: 78.06 °E

Month	Min Temp °C	Max Temp °C	Humidity %	Wind m/s	Sunshine hours	Radiation MJ/m²/day	ETo mm/day
January	17.0	31.3	47	1.2	8.8	18.7	3.79
February	19.3	34.3	37	1.3	9.3	21.2	4.66
March	22.5	37.5	30	1.4	9.7	23.5	5.67
April	26.0	39.3	34	1.6	9.2	23.6	6.42
May	27.2	40.0	37	2.6	8.3	22.2	7.60
June	25.0	35.6	54	4.1	5.8	18.3	6.85
July	23.8	32.5	64	4.2	4.4	16.2	5.52
August	23.5	32.1	63	3.5	4.9	16.9	5.28
September	23.3	31.9	65	2.4	5.5	17.3	4.69
October	22.4	32.4	61	1.1	8.7	20.7	4.49
November	19.2	31.0	56	0.9	7.7	17.6	3.62
December	16.6	30.3	51	0.8	8.4	17.7	3.27
Average	22.1	34.0	50	2.1	7.5	19.5	5.15

Cropwat 8.0 Bèta

2. Average Climatic Data Kurnool

MONTHLY RAIN DATA
(File: KURN-AV.CRM)

Station: KURNOOL

Eff. rain method: Effective rain is 80 % of actual rain

	Rain mm	Eff. rain mm
January	0.0	0.0
February	5.0	4.0
March	2.0	1.6
April	11.0	8.8
May	49.0	39.2
June	79.0	63.2
July	106.0	84.8
August	109.0	87.2
September	128.0	102.4
October	99.0	79.2
November	26.0	20.8
December	2.0	1.6
Total	616.0	492.8

Cropwat 8.0 Bèta

3. Dry Year Climatic Data Kurnool

MONTHLY RAIN DATA
(File: KURN-DRY.CRM)

Station: KURNOOL

Eff. rain method: Effective rain is 80 % of actual rain

	Rain mm	Eff. rain mm
January	0.0	0.0
February	3.4	2.7
March	1.4	1.1
April	7.5	6.0
May	33.6	26.9
June	54.2	43.4
July	72.7	58.2
August	74.8	59.8
September	87.8	70.2
October	67.9	54.3
November	17.8	14.2
December	1.4	1.1
Total	422.5	338.0

Cropwat 8.0 Bèta

4. Normal Year Climatic Data Kurnool

MONTHLY RAIN DATA
(File: KURN-NOR.CRM)

Station: KURNOOL

Eff. rain method: Effective rain is 80 % of actual rain

	Rain mm	Eff. rain mm
January	0.0	0.0
February	4.5	3.6
March	1.8	1.4
April	10.0	8.0
May	44.4	35.5
June	71.6	57.3
July	96.0	76.8
August	98.7	79.0
September	116.0	92.8
October	89.7	71.8
November	23.6	18.9
December	1.8	1.4
Total	558.1	446.5

Cropwat 8.0 Bèta

5. Wet Year Climatic Data Kurnool

MONTHLY RAIN DATA
(File: KURN-WET.CRM)

Station: KURNOOL

Eff. rain method: Effective rain is 80 % of actual rain

	Rain mm	Eff. rain mm
January	0.0	0.0
February	6.7	5.4
March	2.7	2.2
April	14.7	11.8
May	65.4	52.3
June	105.4	84.3
July	141.4	113.1
August	145.4	116.3
September	170.8	136.6
October	132.1	105.7
November	34.7	27.8
December	2.7	2.2
Total	822.0	657.6

Cropwat 8.0 Bèta

6. 1986 Climatic Data Kurnool

MONTHLY RAIN DATA
(File: C:KURN-86.CRM)

Station: KURNOOL

Eff. rain method: Effective rain is 80 % of actual rain

	Rain mm	Eff. rain mm
January	0.0	0.0
February	0.0	0.0
March	0.0	0.0
April	0.0	0.0
May	25.0	20.0
June	50.0	40.0
July	75.0	60.0
August	100.0	80.0
September	8.0	6.4
October	107.0	85.6
November	67.0	53.6
December	0.0	0.0
Total	432.0	345.6

Cropwat 8.0 Bèta

APPENDIX 2

CROP DATA FILES

1. **Paddy**
2. **Sorghum**
3. **Sugarcane**
4. **Cotton**
5. **Groundnut (Kharif)**
6. **Groundnut (Rabi)**

1. Paddy

RICE DATA
(File: KURN-RICE.CRO)

Crop Name: Rice Transplanting date: 10/07 Harvest: 06/11

Stage	nursery	landprep		growth stage				total
		total	puddling	initial	develop	mid	late	
Length (days)	30	20	5	20	30	40	30	150
Kc dry	0.70	0.30		0.50	-->	1.05	0.70	
Kc wet	1.20	1.05		1.10	-->	1.20	1.05	
Rooting depth (m)				0.10	-->	0.60	0.60	
Puddling depth (m)			0.40					
Nursery area (%)	10							
Critical depletion	0.20			0.20	-->	0.20	0.20	
Yield response f.				1.00	1.09	1.32	0.50	1.10
Cropheight (m)						1.00		

Cropwat 8.0 Bèta

2. Sorghum

DRY CROP DATA
(File: KURN-SORGHUM.CRO)

Crop Name: SORGHUM (Grain) Planting date: 15/07 Harvest: 11/11

Stage	initial	develop	mid	late	total
Length (days)	20	40	30	30	120
Kc Values	0.30	-->	1.00	0.55	
Rooting depth (m)	0.30	-->	1.40	1.40	
Critical depletion	0.60	-->	0.50	0.80	
Yield response f.	0.20	0.40	0.55	0.20	0.90
Cropheight (m)			1.50		

Cropwat 8.0 Bèta

3. Sugarcane

DRY CROP DATA
(File: KURN-SUGARCAN.CRO)

Crop Name: Sugarcane (Ratoon) Planting date: 01/01 Harvest: 31/12

Stage	initial	develop	mid	late	total
Length (days)	30	60	180	95	365
Kc Values	0.40	-->	1.25	0.75	
Rooting depth (m)	1.50	-->	1.50	1.50	
Critical depletion	0.65	-->	0.65	0.65	
Yield response f.	0.50	0.75	1.20	0.10	1.20
Cropheight (m)			3.00		

Cropwat 8.0 Bèta

4. Cotton

DRY CROP DATA
(File: KURN-COTTON.CRO)

Crop Name: COTTON Planting date: 01/08 Harvest: 27/01

Stage	initial	develop	mid	late	total
Length (days)	30	50	55	45	180
Kc Values	0.35	-->	1.20	0.60	
Rooting depth (m)	0.30	-->	1.40	1.40	
Critical depletion	0.65	-->	0.65	0.90	
Yield response f.	0.20	0.50	0.50	0.25	0.85
Cropheight (m)			1.30		

Cropwat 8.0 Bèta

5. Groundnut (Kharif)

DRY CROP DATA
(File: KURN-GRONDNUT KHARIF.CRO)

Crop Name: Groudnut Kharif Planting date: 15/07 Harvest: 01/11

Stage	initial	develop	mid	late	total
Length (days)	20	30	25	35	110
Kc Values	0.40	-->	1.15	0.60	
Rooting depth (m)	0.30	-->	0.80	0.80	
Critical depletion	0.45	-->	0.45	0.50	
Yield response f.	0.20	0.80	0.60	0.20	0.70
Cropheight (m)			0.40		

Cropwat 8.0 Bèta

6. Groundnut (Rabi)

DRY CROP DATA
(File: KURN-GRONDNUT RABI.CRO)

Crop Name: Groudnut Rabi Planting date: 15/12 Harvest: 03/04

Stage	initial	develop	mid	late	total
Length (days)	20	30	35	25	110
Kc Values	0.20	-->	1.15	0.60	
Rooting depth (m)	0.30	-->	0.80	0.80	
Critical depletion	0.45	-->	0.45	0.50	
Yield response f.	0.20	0.80	0.60	0.20	0.70
Cropheight (m)			0.40		

Cropwat 8.0 Bèta

APPENDIX 3

SOIL DATA FILES

1. **Black Clay Soil**
2. **Red Sandy Loam**
3. **Red Sandy**
4. **Red Loamy**

1. Black Clay Soil

```
SOIL DATA
(File: BLACK CLAY SOIL.SOI)

Soil name: BLACK CLAY SOIL

General soil data:

  Total available soil moisture (FC - WP)        200.0   mm/meter
  Maximum rain infiltration rate                    30   mm/day
  Maximum rooting depth                            900   centimeters
  Initial soil moisture depletion (% TAM)           50   %
  Initial available soil moisture                100.0   mm/meter

Additional soil data for rice calculations:

  Drainable porosity (SAT - FC)                     10   %
  Critical depletion for puddle cracking          0.60   mm/day
  Water availability at planting                     5   mm WD
  Maximum waterdepth                               120   mm



Cropwat 8.0 Bèta
```

2. Red Sandy Loam

```
SOIL DATA
(File: RED SANDY LOAM.SOI)

Soil name: RED SANDY LOAM

General soil data:

  Total available soil moisture (FC - WP)        140.0   mm/meter
  Maximum rain infiltration rate                    30   mm/day
  Maximum rooting depth                            900   centimeters
  Initial soil moisture depletion (% TAM)            0   %
  Initial available soil moisture                140.0   mm/meter


Cropwat 8.0 Bèta
```

3. Red Sandy

```
SOIL DATA
(File: RED SANDY.SOI)

Soil name: RED SANDY

General soil data:

  Total available soil moisture (FC - WP)        100.0   mm/meter
  Maximum rain infiltration rate                    30   mm/day
  Maximum rooting depth                            900   centimeters
  Initial soil moisture depletion (% TAM)            0   %
  Initial available soil moisture                100.0   mm/meter


Cropwat 8.0 Bèta
```

4. Red Loamy

```
SOIL DATA
(File: RED LOAMY.SOI)

Soil name: RED LOAMY

General soil data:

  Total available soil moisture (FC - WP)        180.0   mm/meter
  Maximum rain infiltration rate                    30   mm/day
  Maximum rooting depth                            900   centimeters
  Initial soil moisture depletion (% TAM)            0   %
  Initial available soil moisture                180.0   mm/meter


Cropwat 8.0 Bèta
```

APPENDIX 4

CROP WATER REQUIREMENT CALCULATIONS

No.	Crop	Planting Date	Harvest Date
1	Paddy	10 July	06 Nov
2	Paddy	20 July	16 Nov
3	Paddy	01 Aug	28 Nov
4	Paddy	10 Aug	07 Dec
5	Paddy	10 Dec	08 Apr
6	Paddy	20 Dec	18 Apr
7	Paddy	01 Jan	30 Apr
8	Cotton	01 Aug	27 Jan
9	Groundnut	15 July	01Nov
10	Groundnut	01 Aug	18 Nov
11	Groundnut	15 Aug	02 Dec
12	Groundnut	15 Dec	03 Apr
13	Groundnut	01 Jan	20 Apr
14	Groundnut	15 Jan	04 May
15	Sorghum	15 July	11 Nov
16	Sorghum	01 Aug	28 Nov
17	Sugarcane	perennial	

1. Paddy (from 10 July to 06 Nov, Black clay soil)

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL (KURN-AV)

Crop: Rice
Planting date: 10/07

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Jun	1	Nurs	1.20	0.85	0.9	1.8	0.9
Jun	2	Nurs/LPr	1.19	1.47	14.7	21.2	90.8
Jun	3	Nurs/LPr	1.06	6.83	68.3	23.5	44.7
Jul	1	Init	1.07	6.30	63.0	26.4	183.9
Jul	2	Init	1.10	5.96	59.6	29.1	30.5
Jul	3	Deve	1.10	5.91	65.0	29.1	35.9
Aug	1	Deve	1.12	5.98	59.8	28.4	31.4
Aug	2	Deve	1.14	6.01	60.1	28.5	31.5
Aug	3	Mid	1.16	5.89	64.8	30.4	34.4
Sep	1	Mid	1.17	5.69	56.9	33.6	23.2
Sep	2	Mid	1.17	5.46	54.6	35.9	18.7
Sep	3	Mid	1.17	5.38	53.8	32.8	21.1
Oct	1	Late	1.16	5.29	52.9	30.1	22.8
Oct	2	Late	1.12	5.02	50.2	28.1	22.1
Oct	3	Late	1.06	4.44	48.9	21.0	27.9
Nov	1	Late	1.01	3.95	23.7	7.3	17.6
					797.0	407.3	637.3

Cropwat 8.0 Bèta

2. Paddy (from 20 July to 16 Nov, Black clay soil)

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL (KURN-AV)

Crop: Rice
Planting date: 20/07

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Jun	2	Nurs	1.20	0.82	0.8	2.1	0.8
Jun	3	Nurs/LPr	1.19	1.37	13.7	23.5	90.8
Jul	1	Nurs/LPr	1.06	6.28	62.8	26.4	36.4
Jul	2	Init	1.07	5.79	57.9	29.1	171.3
Jul	3	Init	1.10	5.91	65.0	29.1	35.9
Aug	1	Deve	1.10	5.90	59.0	28.4	30.5
Aug	2	Deve	1.11	5.88	58.8	28.5	30.3
Aug	3	Deve	1.13	5.76	63.4	30.4	33.0
Sep	1	Mid	1.15	5.63	56.3	33.6	22.6
Sep	2	Mid	1.16	5.42	54.2	35.9	18.3
Sep	3	Mid	1.16	5.34	53.4	32.8	20.7
Oct	1	Mid	1.16	5.27	52.7	30.1	22.6
Oct	2	Late	1.15	5.18	51.8	28.1	23.7
Oct	3	Late	1.11	4.66	51.3	21.0	30.3
Nov	1	Late	1.05	4.12	41.2	12.2	29.0
Nov	2	Late	1.01	3.67	22.0	3.1	19.5
					764.3	394.3	615.7

Cropwat 8.0 Bèta

3. Paddy (from 01 Aug to 28 Nov, Black clay soil)

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL (KURN-AV)

Crop: Rice
Planting date: 01/08

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Jul	1	Nurs	1.20	0.71	6.4	23.8	0.0
Jul	2	Nurs/LPr	1.08	5.26	52.6	29.1	115.6
Jul	3	Nurs/LPr	1.06	5.72	62.9	29.1	178.5
Aug	1	Init	1.10	5.89	58.9	28.4	30.5
Aug	2	Init	1.10	5.81	58.1	28.5	29.5
Aug	3	Deve	1.11	5.64	62.0	30.4	31.6
Sep	1	Deve	1.13	5.50	55.0	33.6	21.4
Sep	2	Mid	1.14	5.36	53.6	35.9	17.7
Sep	3	Mid	1.15	5.31	53.1	32.8	20.4
Oct	1	Mid	1.15	5.24	52.4	30.1	22.3
Oct	2	Mid	1.15	5.16	51.6	28.1	23.6
Oct	3	Late	1.15	4.82	53.1	21.0	32.0
Nov	1	Late	1.11	4.35	43.5	12.2	31.3
Nov	2	Late	1.07	3.85	38.5	5.1	33.5
Nov	3	Late	1.02	3.58	28.6	2.9	25.1
					730.4	370.9	612.9

Cropwat 8.0 Bèta

4. Paddy (from 10 Aug to 07 Dec, Black clay soil)

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL (KURN-AV)

Crop: Rice
Planting date: 10/08

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Jul	2	Nurs	1.20	0.65	6.5	29.1	0.0
Jul	3	Nurs/LPr	1.06	5.72	62.9	29.1	126.1
Aug	1	Init	1.07	5.72	57.2	28.4	171.7
Aug	2	Init	1.10	5.81	58.1	28.5	29.5
Aug	3	Deve	1.10	5.59	61.5	30.4	31.1
Sep	1	Deve	1.11	5.43	54.3	33.6	20.6
Sep	2	Deve	1.13	5.28	52.8	35.9	16.9
Sep	3	Mid	1.14	5.28	52.8	32.8	20.0
Oct	1	Mid	1.15	5.22	52.2	30.1	22.1
Oct	2	Mid	1.15	5.15	51.5	28.1	23.4
Oct	3	Mid	1.15	4.82	53.0	21.0	32.0
Nov	1	Late	1.14	4.47	44.7	12.2	32.5
Nov	2	Late	1.11	4.01	40.1	5.1	35.0
Nov	3	Late	1.06	3.72	37.2	3.6	33.6
Dec	1	Late	1.02	3.46	24.2	1.2	22.5
					708.9	349.0	617.1

Cropwat 8.0 Bèta

5. Paddy (from 10 Dec to 08 Apr, Black clay soil)

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL (KURN-AV)

Crop: Rice
Planting date: 10/12

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Nov	1	Nurs	1.20	0.47	0.5	1.2	0.5
Nov	2	Nurs/LPr	1.19	0.78	7.8	5.1	93.1
Nov	3	Nurs/LPr	1.06	3.73	37.3	3.6	33.7
Dec	1	Init	1.07	3.62	36.2	1.7	184.2
Dec	2	Init	1.10	3.60	36.0	0.0	36.0
Dec	3	Deve	1.10	3.79	41.7	0.0	41.7
Jan	1	Deve	1.12	4.06	40.6	0.0	40.5
Jan	2	Deve	1.15	4.37	43.7	0.0	43.7
Jan	3	Mid	1.18	4.82	53.1	0.1	53.0
Feb	1	Mid	1.19	5.20	52.0	1.1	51.0
Feb	2	Mid	1.19	5.55	55.5	1.6	53.9
Feb	3	Mid	1.19	5.95	47.6	1.2	46.4
Mar	1	Late	1.19	6.35	63.5	0.5	62.9
Mar	2	Late	1.16	6.56	65.6	0.1	65.5
Mar	3	Late	1.10	6.54	71.9	1.1	70.8
Apr	1	Late	1.06	6.51	52.1	1.1	50.7
					704.9	18.4	927.5

Cropwat 8.0 Bèta

6. Paddy (from 20 Dec to 18 Apr, Black clay soil)

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL (KURN-AV)

Crop: Rice
Planting date: 20/12

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Nov	2	Nurs	1.20	0.43	0.4	0.5	0.4
Nov	3	Nurs/LPr	1.19	0.75	7.5	3.6	94.4
Dec	1	Nurs/LPr	1.06	3.61	36.1	1.7	34.4
Dec	2	Init	1.07	3.49	34.9	0.0	176.1
Dec	3	Init	1.10	3.79	41.6	0.0	41.6
Jan	1	Deve	1.10	3.98	39.8	0.0	39.8
Jan	2	Deve	1.12	4.25	42.5	0.0	42.5
Jan	3	Deve	1.15	4.71	51.8	0.1	51.7
Feb	1	Mid	1.18	5.18	51.8	1.1	50.7
Feb	2	Mid	1.19	5.55	55.5	1.6	53.9
Feb	3	Mid	1.19	5.95	47.6	1.2	46.4
Mar	1	Mid	1.19	6.35	63.5	0.5	63.0
Mar	2	Late	1.19	6.75	67.5	0.1	67.3
Mar	3	Late	1.15	6.83	75.2	1.1	74.1
Apr	1	Late	1.10	6.79	67.9	1.4	66.4
Apr	2	Late	1.05	6.76	54.1	1.5	52.2
					737.8	14.4	955.0

Cropwat 8.0 Bèta

7. Paddy (from 01 Jan to 30 Apr, Black clay soil)

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL (KURN-AV)

Crop: Rice
Planting date: 01/01

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Dec	1	Nurs	1.20	0.41	3.7	1.5	2.0
Dec	2	Nurs/LPr	1.08	3.17	31.7	0.0	123.0
Dec	3	Nurs/LPr	1.06	3.67	40.3	0.0	182.3
Jan	1	Init	1.10	3.98	39.8	0.0	39.7
Jan	2	Init	1.10	4.17	41.7	0.0	41.7
Jan	3	Deve	1.12	4.56	50.2	0.1	50.1
Feb	1	Deve	1.15	5.03	50.3	1.1	49.2
Feb	2	Mid	1.18	5.50	55.0	1.6	53.4
Feb	3	Mid	1.19	5.95	47.6	1.2	46.4
Mar	1	Mid	1.19	6.35	63.5	0.5	63.0
Mar	2	Mid	1.19	6.75	67.5	0.1	67.4
Mar	3	Mid	1.19	7.05	77.5	1.1	76.5
Apr	1	Late	1.16	7.17	71.7	1.4	70.2
Apr	2	Late	1.11	7.12	71.2	1.9	69.3
Apr	3	Late	1.06	7.19	71.9	5.6	66.3
					783.5	16.2	1000.5

Cropwat 8.0 Bèta

8. Cotton (from 01 Aug to 27 Jan, Black clay soil)

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL

Crop: COTTON
Planting date: 01/08

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Aug	1	Init	0.35	1.88	18.8	28.4	0.0
Aug	2	Init	0.35	1.85	18.5	28.5	0.0
Aug	3	Deve	0.35	1.79	19.6	30.4	0.0
Sep	1	Deve	0.45	2.22	22.2	33.6	0.0
Sep	2	Deve	0.61	2.88	28.8	35.9	0.0
Sep	3	Deve	0.78	3.58	35.8	32.8	3.1
Oct	1	Deve	0.94	4.26	42.6	30.1	12.5
Oct	2	Mid	1.09	4.91	49.1	28.1	21.1
Oct	3	Mid	1.15	4.84	53.2	21.0	32.2
Nov	1	Mid	1.15	4.51	45.1	12.2	32.9
Nov	2	Mid	1.15	4.17	41.7	5.1	36.6
Nov	3	Mid	1.15	4.04	40.4	3.6	36.8
Dec	1	Mid	1.15	3.90	39.0	1.7	37.3
Dec	2	Late	1.12	3.65	36.5	0.0	36.5
Dec	3	Late	0.99	3.39	37.3	0.0	37.3
Jan	1	Late	0.85	3.08	30.8	0.0	30.8
Jan	2	Late	0.72	2.74	27.4	0.0	27.4
Jan	3	Late	0.61	2.51	17.6	0.1	17.5
					604.4	291.4	362.0

Cropwat 8.0 Bèta

9. Groundnut (from 15 July to 1Nov, Red sandy loam soil)

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL

Crop: Groudnut Kharif
Planting date: 15/07

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Jul	2	Init	0.40	2.17	13.0	17.5	0.0
Jul	3	Init	0.40	2.15	23.6	29.1	0.0
Aug	1	Deve	0.47	2.51	25.1	28.4	0.0
Aug	2	Deve	0.70	3.71	37.1	28.5	8.5
Aug	3	Deve	0.96	4.86	53.4	30.4	23.0
Sep	1	Mid	1.12	5.48	54.8	33.6	21.2
Sep	2	Mid	1.12	5.27	52.7	35.9	16.8
Sep	3	Late	1.12	5.15	51.5	32.8	18.8
Oct	1	Late	0.99	4.50	45.0	30.1	14.9
Oct	2	Late	0.83	3.71	37.1	28.1	9.0
Oct	3	Late	0.66	2.75	30.3	21.0	9.3
Nov	1	Late	0.56	2.18	2.2	1.2	2.2
					425.7	316.6	123.6

Cropwat 8.0 Bèta

10. Groundnut (from 01 Aug to 18 Nov, Red sandy loam soil)

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL

Crop: Groudnut Kharif
Planting date: 01/08

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Aug	1	Init	0.40	2.14	21.4	28.4	0.0
Aug	2	Init	0.40	2.11	21.1	28.5	0.0
Aug	3	Deve	0.54	2.76	30.3	30.4	0.0
Sep	1	Deve	0.79	3.87	38.7	33.6	5.1
Sep	2	Mid	1.03	4.82	48.2	35.9	12.3
Sep	3	Mid	1.11	5.15	51.5	32.8	18.7
Oct	1	Mid	1.11	5.08	50.8	30.1	20.7
Oct	2	Late	1.08	4.86	48.6	28.1	20.5
Oct	3	Late	0.93	3.89	42.7	21.0	21.7
Nov	1	Late	0.76	2.97	29.7	12.2	17.5
Nov	2	Late	0.62	2.23	17.9	4.1	12.8
					400.9	285.1	129.3

Cropwat 8.0 Bèta

11. Groundnut (from 15 Aug to 2 Dec, Red sandy loam soil)

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL

Crop: Groudnut Kharif
Planting date: 15/08

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Aug	2	Init	0.40	2.11	12.7	17.1	0.0
Aug	3	Init	0.40	2.03	22.4	30.4	0.0
Sep	1	Deve	0.47	2.28	22.8	33.6	0.0
Sep	2	Deve	0.69	3.25	32.5	35.9	0.0
Sep	3	Deve	0.93	4.30	43.0	32.8	10.2
Oct	1	Mid	1.10	5.01	50.1	30.1	20.0
Oct	2	Mid	1.11	4.97	49.7	28.1	21.6
Oct	3	Late	1.10	4.61	50.7	21.0	29.7
Nov	1	Late	0.98	3.81	38.1	12.2	25.9
Nov	2	Late	0.82	2.97	29.7	5.1	24.6
Nov	3	Late	0.67	2.33	23.3	3.6	19.8
Dec	1	Late	0.57	1.94	3.9	0.3	3.9
					378.9	250.1	155.9

Cropwat 8.0 Bèta

12. Groundnut (from 15 Dec to 3 Apr, Red sandy loam soil)

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL

Crop: Groudnut Rabi
Planting date: 15/12

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Dec	2	Init	0.20	0.65	3.9	0.0	3.9
Dec	3	Init	0.20	0.69	7.6	0.0	7.6
Jan	1	Deve	0.29	1.04	10.4	0.0	10.4
Jan	2	Deve	0.59	2.25	22.5	0.0	22.5
Jan	3	Deve	0.92	3.77	41.4	0.1	41.3
Feb	1	Mid	1.14	4.98	49.8	1.1	48.8
Feb	2	Mid	1.14	5.33	53.3	1.6	51.7
Feb	3	Mid	1.14	5.71	45.7	1.2	44.5
Mar	1	Late	1.14	6.08	60.8	0.5	60.3
Mar	2	Late	1.00	5.67	56.7	0.1	56.5
Mar	3	Late	0.77	4.55	50.0	1.1	49.0
Apr	1	Late	0.61	3.79	11.4	0.4	10.6
					413.5	6.2	407.1

Cropwat 8.0 Bèta

13. Groundnut (from 01 Jan to 20 Apr, Red sandy loam soil)

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL

Crop: Groudnut Rabi
Planting date: 01/01

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Jan	1	Init	0.20	0.72	7.2	0.0	7.2
Jan	2	Init	0.20	0.76	7.6	0.0	7.6
Jan	3	Deve	0.39	1.59	17.4	0.1	17.4
Feb	1	Deve	0.72	3.14	31.4	1.1	30.4
Feb	2	Mid	1.03	4.80	48.0	1.6	46.4
Feb	3	Mid	1.14	5.71	45.7	1.2	44.5
Mar	1	Mid	1.14	6.10	61.0	0.5	60.4
Mar	2	Mid	1.14	6.48	64.8	0.1	64.7
Mar	3	Late	1.11	6.59	72.4	1.1	71.4
Apr	1	Late	0.91	5.61	56.1	1.4	54.7
Apr	2	Late	0.69	4.41	44.1	1.9	42.2
					455.9	9.0	446.8

Cropwat 8.0 Bèta

14. Groundnut (from 15 Jan to 4 May, Red sandy loam soil)

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL

Crop: Groudnut Rabi
Planting date: 15/01

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Jan	2	Init	0.20	0.76	4.5	0.0	4.5
Jan	3	Init	0.20	0.82	9.0	0.1	8.9
Feb	1	Deve	0.29	1.26	12.6	1.1	11.5
Feb	2	Deve	0.59	2.76	27.6	1.6	26.0
Feb	3	Deve	0.87	4.37	35.0	1.2	33.7
Mar	1	Mid	1.11	5.92	59.2	0.5	58.7
Mar	2	Mid	1.14	6.47	64.7	0.1	64.6
Mar	3	Mid	1.14	6.76	74.3	1.1	73.2
Apr	1	Late	1.14	7.03	70.3	1.4	68.8
Apr	2	Late	1.00	6.40	64.0	1.9	62.2
Apr	3	Late	0.78	5.29	52.9	5.6	47.3
May	1	Late	0.62	4.57	18.3	3.9	13.3
					492.4	18.6	472.9

Cropwat 8.0 Bèta

15. Sorghum (from 15 July to 11 Nov, Red sandy loam soil)

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL

Crop: SORGHUM (Grain)
Planting date: 15/07

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Jul	2	Init	0.30	1.63	9.8	17.5	0.0
Jul	3	Init	0.30	1.61	17.7	29.1	0.0
Aug	1	Deve	0.35	1.85	18.5	28.4	0.0
Aug	2	Deve	0.50	2.66	26.6	28.5	0.0
Aug	3	Deve	0.67	3.43	37.7	30.4	7.3
Sep	1	Deve	0.85	4.13	41.3	33.6	7.7
Sep	2	Mid	0.95	4.45	44.5	35.9	8.6
Sep	3	Mid	0.95	4.40	44.0	32.8	11.2
Oct	1	Mid	0.95	4.34	43.4	30.1	13.3
Oct	2	Late	0.90	4.03	40.3	28.1	12.2
Oct	3	Late	0.74	3.09	34.0	21.0	13.0
Nov	1	Late	0.58	2.25	22.5	12.2	10.3
Nov	2	Late	0.49	1.78	1.8	0.5	1.8
					382.0	328.1	85.4

Cropwat 8.0 Bèta

16. Sorghum (from 01 Aug to 28 Nov, Red sandy loam soil)

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL

Crop: SORGHUM (Grain)
Planting date: 01/08

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Aug	1	Init	0.30	1.61	16.1	28.4	0.0
Aug	2	Init	0.30	1.58	15.8	28.5	0.0
Aug	3	Deve	0.40	2.01	22.1	30.4	0.0
Sep	1	Deve	0.56	2.75	27.5	33.6	0.0
Sep	2	Deve	0.72	3.38	33.8	35.9	0.0
Sep	3	Mid	0.88	4.06	40.6	32.8	7.9
Oct	1	Mid	0.94	4.27	42.7	30.1	12.6
Oct	2	Mid	0.94	4.21	42.1	28.1	14.0
Oct	3	Late	0.93	3.92	43.1	21.0	22.1
Nov	1	Late	0.83	3.23	32.3	12.2	20.2
Nov	2	Late	0.68	2.47	24.7	5.1	19.6
Nov	3	Late	0.55	1.93	15.4	2.9	11.8
					356.2	288.9	108.1

Cropwat 8.0 Bèta

17. Sugarcane (perennial, Red sandy loam soil)

CROP WATER REQUIREMENTS

ETo station: KURNOOL
Rain station: KURNOOL (KURN-AV)

Crop: Sugarcane (Ratoon)
Planting date: 01/01

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Jan	1	Init	0.40	1.45	14.5	0.0	14.4
Jan	2	Init	0.40	1.52	15.2	0.0	15.2
Jan	3	Deve	0.40	1.64	18.0	0.1	17.9
Feb	1	Deve	0.49	2.15	21.5	1.1	20.5
Feb	2	Deve	0.63	2.96	29.6	1.6	28.0
Feb	3	Deve	0.76	3.81	30.5	1.2	29.3
Mar	1	Deve	0.89	4.75	47.5	0.5	47.0
Mar	2	Deve	1.03	5.85	58.5	0.1	58.4
Mar	3	Deve	1.18	6.99	76.9	1.1	75.9
Apr	1	Mid	1.25	7.73	77.3	1.4	75.8
Apr	2	Mid	1.25	8.04	80.4	1.9	78.5
Apr	3	Mid	1.25	8.53	85.3	5.6	79.7
May	1	Mid	1.25	9.19	91.9	9.9	82.0
May	2	Mid	1.25	9.76	97.6	13.3	84.3
May	3	Mid	1.25	9.37	103.1	15.9	87.2
Jun	1	Mid	1.25	8.89	88.9	18.5	70.5
Jun	2	Mid	1.25	8.58	85.8	21.2	64.7
Jun	3	Mid	1.25	8.02	80.2	23.5	56.7
Jul	1	Mid	1.25	7.38	73.8	26.4	47.4
Jul	2	Mid	1.25	6.78	67.8	29.1	38.7
Jul	3	Mid	1.25	6.73	74.0	29.1	44.9
Aug	1	Mid	1.25	6.71	67.1	28.4	38.7
Aug	2	Mid	1.25	6.61	66.1	28.5	37.6
Aug	3	Mid	1.25	6.36	70.0	30.4	39.6
Sep	1	Mid	1.25	6.11	61.1	33.6	27.5
Sep	2	Mid	1.25	5.87	58.7	35.9	22.7
Sep	3	Late	1.25	5.77	57.7	32.8	24.9
Oct	1	Late	1.20	5.47	54.7	30.1	24.7
Oct	2	Late	1.14	5.13	51.3	28.1	23.2
Oct	3	Late	1.08	4.54	49.9	21.0	28.9
Nov	1	Late	1.02	3.98	39.8	12.2	27.6
Nov	2	Late	0.96	3.47	34.7	5.1	29.6
Nov	3	Late	0.90	3.15	31.5	3.6	27.9
Dec	1	Late	0.84	2.84	28.4	1.7	26.8
Dec	2	Late	0.78	2.55	25.5	0.0	25.5
Dec	3	Late	0.72	2.47	27.2	0.0	27.2
					2042.1	492.9	1549.2

Cropwat 8.0 Bèta

APPENDIX 5.1

IRRIGATION SCHEDULING RUNS

Indicative Irrigation Schedules:

Groundnut

Run 1	**:**	**Full replenishment at critical depletion**
Run 2	**:**	**Application of 40 mm after 40 mm depletion**
Run 3	**:**	**Application of 40 mm every 7 days**
Run 4	**:**	**Application of 40 mm every 10 days**
Run 5	**:**	**Application of 45 mm every 10 days**
Run 6	**:**	**Application of 45 mm every 10 days starting 40th day**
Run 7	**:**	**Same as Run 6 for Light Soil**
Run 8	**:**	**Same as Run 6 for Heavy Soil**

Cotton

Run 1	**:**	**Full replenishment at critical depletion**
Run 2	**:**	**Application of 80 mm after 80 mm depletion**
Run 3	**:**	**Application of 80 mm every 20 days after 81st day**
Run 4	**:**	**Application of 70 mm every 20 days after 81st day**
Run 5	**:**	**Four applications of 70 mm after day 100**
Run 6	**:**	**Same as Run 5 for Medium Soil**
Run 7	**:**	**Same as Run 5 for Light Soil**
Run 8	**:**	**Same as Run 5 for Dry Year**
Run 9	**:**	**Same as Run 5 for Wet Year**
Run 10	**:**	**One application (70 mm) on day 130 for Wet Year**

Groundnut, Run 1 : Full replenishment at critical depletion

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: Groudnut Rabi Planting date: 15/12
Rain station: KURNOOL Soil: RED SANDY LOAM Harvest date: 03/04

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at 100 % depletion
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
19 Jan	36	Dev	0.0	1.00	100	46	42.1	0.0	0.0	60.1	0.19
2 Feb	50	Dev	0.0	1.00	100	48	53.6	0.0	0.0	76.5	0.63
13 Feb	61	Mid	0.9	1.00	100	49	54.4	0.0	0.0	77.6	0.82
23 Feb	71	Mid	0.7	1.00	100	47	52.9	0.0	0.0	75.5	0.87
4 Mar	80	Mid	0.0	1.00	100	46	51.9	0.0	0.0	74.2	0.95
13 Mar	89	End	0.1	1.00	100	47	53.2	0.0	0.0	76.0	0.98
24 Mar	100	End	0.0	1.00	100	51	57.2	0.0	0.0	81.8	0.86
3 Apr	End	End	0.0	1.00	0	34					

Totals:

Total gross irrigation	521.7	mm	Total rainfall	7.2	mm
Total net irrigation	365.2	mm	Effective rainfall	6.6	mm
Total irrigation losses	0.0	mm	Total rain loss	0.6	mm
Actual water use by crop	409.8	mm	Moist deficit at harvest	38.0	mm
Potential water use by crop	409.8	mm	Actual irrigation requirement	403.2	mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	91.6	%
Deficiency irrigation schedule	0.0	%			

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.20	0.80	0.60	0.20	0.70	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

Cropwat 8.0 Bèta

Groundnut, Run 2 : Application of 40 mm after 40 mm depletion

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: Groudnut Rabi Planting date: 15/12
Rain station: KURNOOL Soil: RED SANDY LOAM Harvest date: 03/04

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at 40 mm depletion
Application: Fixed application depth of 40 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
19 Jan	36	Dev	0.0	1.00	100	46	40.0	2.1	0.0	57.1	0.18
30 Jan	47	Dev	0.0	1.00	100	39	40.0	1.9	0.0	57.1	0.60
8 Feb	56	Mid	0.0	1.00	100	40	40.0	4.3	0.0	57.1	0.73
15 Feb	63	Mid	0.0	1.00	100	36	40.0	0.1	0.0	57.1	0.94
23 Feb	71	Mid	0.7	1.00	100	38	40.0	2.3	0.0	57.1	0.83
2 Mar	78	Mid	0.0	1.00	100	38	40.0	2.3	0.0	57.1	0.94
9 Mar	85	Mid	0.0	1.00	100	40	40.0	4.3	0.0	57.1	0.94
16 Mar	92	End	0.0	1.00	100	40	40.0	4.4	0.0	57.1	0.94
23 Mar	99	End	0.6	1.00	100	36	40.0	0.0	0.0	57.1	0.94
2 Apr	109	End	0.0	1.00	100	39	40.0	3.4	0.0	57.1	0.66
3 Apr	End	End	0.0	1.00	0	2					

Totals:

Total gross irrigation	571.4	mm	Total rainfall	7.2	mm
Total net irrigation	400.0	mm	Effective rainfall	7.2	mm
Total irrigation losses	0.0	mm	Total rain loss	0.0	mm
Actual water use by crop	409.8	mm	Moist deficit at harvest	2.6	mm
Potential water use by crop	409.8	mm	Actual irrigation requirement	402.6	mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	100.0	%
Deficiency irrigation schedule	0.0	%			

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.20	0.80	0.60	0.20	0.70	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

Cropwat 8.0 Bèta

Groundnut, Run 3 : Application of 40 mm every 7 days

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: Groudnut Rabi Planting date: 15/12
Rain station: KURNOOL Soil: RED SANDY LOAM Harvest date: 03/04

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 7, Dev 7, Mid 7, Late 7)
Application: Fixed application depth of 40 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
21 Dec	7	Init	0.0	1.00	100	9	40.0	0.0	35.4	57.1	0.94
28 Dec	14	Init	0.0	1.00	100	8	40.0	0.0	35.2	57.1	0.94
4 Jan	21	Dev	0.0	1.00	100	9	40.0	0.0	33.8	57.1	0.94
11 Jan	28	Dev	0.0	1.00	100	10	40.0	0.0	31.5	57.1	0.94
18 Jan	35	Dev	0.0	1.00	100	17	40.0	0.0	24.3	57.1	0.94
25 Jan	42	Dev	0.0	1.00	100	23	40.0	0.0	16.7	57.1	0.94
1 Feb	49	Dev	0.0	1.00	100	25	40.0	0.0	12.5	57.1	0.94
8 Feb	56	Mid	0.0	1.00	100	30	40.0	0.0	6.3	57.1	0.94
15 Feb	63	Mid	0.0	1.00	100	32	40.0	0.0	4.3	57.1	0.94
22 Feb	70	Mid	0.0	1.00	100	33	40.0	0.0	2.8	57.1	0.94
1 Mar	77	Mid	0.0	1.00	100	35	40.0	0.0	0.3	57.1	0.94
8 Mar	84	Mid	0.0	1.00	100	38	40.0	2.0	0.0	57.1	0.94
15 Mar	91	End	0.0	1.00	100	38	40.0	2.5	0.0	57.1	0.94
22 Mar	98	End	0.0	1.00	100	36	40.0	0.0	0.1	57.1	0.94
29 Mar	105	End	0.0	1.00	100	28	40.0	0.0	8.8	57.1	0.94
3 Apr	End	End	0.0	1.00	0	14					

Totals:

Total gross irrigation	857.1	mm	Total rainfall	7.2	mm
Total net irrigation	600.0	mm	Effective rainfall	5.9	mm
Total irrigation losses	212.0	mm	Total rain loss	1.3	mm
Actual water use by crop	409.8	mm	Moist deficit at harvest	15.9	mm
Potential water use by crop	409.8	mm	Actual irrigation requirement	403.9	mm
Efficiency irrigation schedule	64.7	%	Efficiency rain	82.0	%
Deficiency irrigation schedule	0.0	%			

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.20	0.80	0.60	0.20	0.70	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

Cropwat 8.0 Bèta

Groundnut, Run 4 : Application of 40 mm every 10 days

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: Groudnut Rabi Planting date: 15/12
Rain station: KURNOOL Soil: RED SANDY LOAM Harvest date: 03/04

Yield red.: 5.3 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Fixed application depth of 40 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
24 Dec	10	Init	0.0	1.00	100	12	40.0	0.0	33.3	57.1	0.66
3 Jan	20	Init	0.0	1.00	100	11	40.0	0.0	32.1	57.1	0.66
13 Jan	30	Dev	0.0	1.00	100	17	40.0	0.0	26.0	57.1	0.66
23 Jan	40	Dev	0.0	1.00	100	28	40.0	0.0	13.0	57.1	0.66
2 Feb	50	Dev	0.0	1.00	100	36	40.0	0.1	0.0	57.1	0.66
12 Feb	60	Mid	0.0	1.00	100	45	40.0	9.9	0.0	57.1	0.66
22 Feb	70	Mid	0.0	0.90	99	55	40.0	21.6	0.0	57.1	0.66
4 Mar	80	Mid	0.0	0.69	92	66	40.0	33.8	0.0	57.1	0.66
14 Mar	90	End	0.0	0.54	82	73	40.0	42.2	0.0	57.1	0.66
24 Mar	100	End	0.0	0.54	80	74	40.0	43.1	0.0	57.1	0.66
3 Apr	End	End	0.0	0.66	0	68					

Totals:

Total gross irrigation	571.4 mm	Total rainfall	7.2	mm
Total net irrigation	400.0 mm	Effective rainfall	6.6	mm
Total irrigation losses	104.4 mm	Total rain loss	0.5	mm
Actual water use by crop	378.6 mm	Moist deficit at harvest	76.4	mm
Potential water use by crop	409.8 mm	Actual irrigation requirement	403.1	mm
Efficiency irrigation schedule	73.9 %	Efficiency rain	92.4	%
Deficiency irrigation schedule	7.6 %			

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	3.2	20.8	7.6	%
Yield response factor	0.20	0.80	0.60	0.20	0.70	
Yield reduction	0.0	0.0	1.9	4.2	5.3	%
Cumulative yield reduction	0.0	0.0	1.9	6.0		%

Cropwat 8.0 Bèta

Groundnut, Run 5 : Application of 45 mm every 10 days

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: Groudnut Rabi Planting date: 15/12
Rain station: KURNOOL Soil: RED SANDY LOAM Harvest date: 03/04

Yield red.: 2.4 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 10, Dev 10, Mid 10, Late 10)
Application: Fixed application depth of 45 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
24 Dec	10	Init	0.0	1.00	100	12	45.0	0.0	38.3	64.3	0.74
3 Jan	20	Init	0.0	1.00	100	11	45.0	0.0	37.1	64.3	0.74
13 Jan	30	Dev	0.0	1.00	100	17	45.0	0.0	31.0	64.3	0.74
23 Jan	40	Dev	0.0	1.00	100	28	45.0	0.0	18.0	64.3	0.74
2 Feb	50	Dev	0.0	1.00	100	36	45.0	0.0	4.9	64.3	0.74
12 Feb	60	Mid	0.0	1.00	100	45	45.0	4.9	0.0	64.3	0.74
22 Feb	70	Mid	0.0	0.98	100	51	45.0	12.1	0.0	64.3	0.74
4 Mar	80	Mid	0.0	0.81	97	60	45.0	22.2	0.0	64.3	0.74
14 Mar	90	End	0.0	0.66	91	67	45.0	30.6	0.0	64.3	0.74
24 Mar	100	End	0.0	0.66	90	68	45.0	31.7	0.0	64.3	0.74
3 Apr	End	End	0.0	0.82	0	61					

Totals:

Total gross irrigation	642.9	mm	Total rainfall	7.2	mm
Total net irrigation	450.0	mm	Effective rainfall	6.6	mm
Total irrigation losses	129.3	mm	Total rain loss	0.6	mm
Actual water use by crop	395.5	mm	Moist deficit at harvest	68.3	mm
Potential water use by crop	409.8	mm	Actual irrigation requirement	403.2	mm
Efficiency irrigation schedule	71.3	%	Efficiency rain	91.6	%
Deficiency irrigation schedule	3.5	%			

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	1.0	10.2	3.5	%
Yield response factor	0.20	0.80	0.60	0.20	0.70	
Yield reduction	0.0	0.0	0.6	2.0	2.4	%
Cumulative yield reduction	0.0	0.0	0.6	2.6		%

Cropwat 8.0 Bèta

Groundnut, Run 6 : Application of 45 mm every 10 days starting 40th day

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: Groudnut Rabi Planting date: 15/12
Rain station: KURNOOL Soil: RED SANDY LOAM Harvest date: 03/04

Yield red.: 3.2 %

Crop scheduling options
Timing: Irrigate at user defined intervals
Application: Fixed application depth of 45 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
23 Jan	40	Dev	0.0	0.86	98	56	45.0	9.7	0.0	64.3	0.19
2 Feb	50	Dev	0.0	1.00	100	44	45.0	4.7	0.0	64.3	0.74
12 Feb	60	Mid	0.0	1.00	100	48	45.0	9.0	0.0	64.3	0.74
22 Feb	70	Mid	0.0	0.92	99	54	45.0	15.8	0.0	64.3	0.74
4 Mar	80	Mid	0.0	0.76	95	62	45.0	24.9	0.0	64.3	0.74
14 Mar	90	End	0.0	0.63	89	69	45.0	32.3	0.0	64.3	0.74
24 Mar	100	End	0.0	0.64	88	69	45.0	32.7	0.0	64.3	0.74
3 Apr	End	End	0.0	0.80	0	62					

Totals:

Total gross irrigation	450.0	mm	Total rainfall	7.2	mm
Total net irrigation	315.0	mm	Effective rainfall	7.2	mm
Total irrigation losses	0.0	mm	Total rain loss	0.0	mm
Actual water use by crop	391.2	mm	Moist deficit at harvest	69.1	mm
Potential water use by crop	409.8	mm	Actual irrigation requirement	402.6	mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	100.0	%
Deficiency irrigation schedule	4.5	%			

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	1.2	1.7	11.8	4.5	%
Yield response factor	0.20	0.80	0.60	0.20	0.70	
Yield reduction	0.0	0.9	1.0	2.4	3.2	%
Cumulative yield reduction	0.0	0.9	2.0	4.3		%

Cropwat 8.0 Bèta

Groundnut, Run 7 : Same as Run 6 for Light Soil

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: Groudnut Rabi Planting date: 15/12
Rain station: KURNOOL Soil: RED SANDY Harvest date: 03/04

Yield red.: 6.5 %

Crop scheduling options
Timing: Irrigate at user defined intervals
Application: Fixed application depth of 45 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
23 Jan	40	Dev	0.0	0.60	88	70	45.0	4.1	0.0	64.3	0.19
2 Feb	50	Dev	0.0	0.93	99	55	45.0	0.0	1.2	64.3	0.74
12 Feb	60	Mid	0.0	0.81	97	61	45.0	3.5	0.0	64.3	0.74
22 Feb	70	Mid	0.0	0.71	94	66	45.0	7.7	0.0	64.3	0.74
4 Mar	80	Mid	0.0	0.58	89	73	45.0	13.1	0.0	64.3	0.74
14 Mar	90	End	0.0	0.49	83	77	45.0	16.8	0.0	64.3	0.74
24 Mar	100	End	0.0	0.53	85	75	45.0	15.3	0.0	64.3	0.74
3 Apr	End	End	0.0	0.76	0	64					

Totals:

Total gross irrigation	450.0	mm	Total rainfall	7.2	mm
Total net irrigation	315.0	mm	Effective rainfall	6.6	mm
Total irrigation losses	1.2	mm	Total rain loss	0.6	mm
Actual water use by crop	371.9	mm	Moist deficit at harvest	51.5	mm
Potential water use by crop	409.8	mm	Actual irrigation requirement	403.2	mm
Efficiency irrigation schedule	99.6	%	Efficiency rain	91.6	%
Deficiency irrigation schedule	9.2	%			

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	8.5	5.8	16.5	9.2	%
Yield response factor	0.20	0.80	0.60	0.20	0.70	
Yield reduction	0.0	6.8	3.5	3.3	6.5	%
Cumulative yield reduction	0.0	6.8	10.0	13.0		%

Cropwat 8.0 Bèta

Groundnut, Run 8 : Same as Run 6 for Heavy Soil

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: Groudnut Rabi Planting date: 15/12
Rain station: KURNOOL Soil: RED LOAMY Harvest date: 03/04

Yield red.: 1.0 %

Crop scheduling options
Timing: Irrigate at user defined intervals
Application: Fixed application depth of 45 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
23 Jan	40	Dev	0.0	1.00	100	44	45.0	10.6	0.0	64.3	0.19
2 Feb	50	Dev	0.0	1.00	100	35	45.0	5.7	0.0	64.3	0.74
12 Feb	60	Mid	0.0	1.00	100	38	45.0	10.0	0.0	64.3	0.74
22 Feb	70	Mid	0.0	1.00	100	43	45.0	17.2	0.0	64.3	0.74
4 Mar	80	Mid	0.0	0.96	100	51	45.0	28.9	0.0	64.3	0.74
14 Mar	90	End	0.0	0.81	96	59	45.0	40.6	0.0	64.3	0.74
24 Mar	100	End	0.0	0.78	95	62	45.0	44.3	0.0	64.3	0.74
3 Apr	End	End	0.0	0.90	0	57					

Totals:

Total gross irrigation	450.0	mm	Total rainfall	7.2 mm
Total net irrigation	315.0	mm	Effective rainfall	7.2 mm
Total irrigation losses	0.0	mm	Total rain loss	0.0 mm
Actual water use by crop	403.9	mm	Moist deficit at harvest	81.7 mm
Potential water use by crop	409.8	mm	Actual irrigation requirement	402.6 mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	100.0 %
Deficiency irrigation schedule	1.4	%		

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.1	4.7	1.4	%
Yield response factor	0.20	0.80	0.60	0.20	0.70	
Yield reduction	0.0	0.0	0.1	0.9	1.0	%
Cumulative yield reduction	0.0	0.0	0.1	1.0		%

Cropwat 8.0 Bèta

Cotton, Run 1 : Full replenishment at critical depletion

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: COTTON Planting date: 01/08
Rain station: KURNOOL Soil: BLACK CLAY SOIL Harvest date: 27/01

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at 100 % depletion
Application: Refill to 100 % of field capacity
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
18 Nov	110	Mid	0.0	1.00	100	65	183.1	0.0	0.0	261.5	0.28
27 Jan	End	End	0.0	1.00	0	82					

Totals:

Total gross irrigation	261.5	mm	Total rainfall	330.1	mm
Total net irrigation	183.1	mm	Effective rainfall	330.1	mm
Total irrigation losses	0.0	mm	Total rain loss	0.0	mm
Actual water use by crop	601.9	mm	Moist deficit at harvest	228.7	mm
Potential water use by crop	601.9	mm	Actual irrigation requirement	271.8	mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	100.0	%
Deficiency irrigation schedule	0.0	%			

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.20	0.50	0.50	0.25	0.85	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

Cropwat 8.0 Bèta

Cotton, Run 2 : Application of 80 mm after 80 mm depletion

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: COTTON Planting date: 01/08
Rain station: KURNOOL Soil: BLACK CLAY SOIL Harvest date: 27/01

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at 80 mm depletion
Application: Fixed application depth of 80 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
15 Oct	76	Dev	0.0	1.00	100	30	80.0	2.0	0.0	114.3	0.17
10 Nov	102	Mid	0.0	1.00	100	29	80.0	0.3	0.0	114.3	0.51
2 Dec	124	Mid	0.0	1.00	100	29	80.0	0.3	0.0	114.3	0.60
24 Dec	146	End	0.0	1.00	100	29	80.0	0.3	0.0	114.3	0.60
20 Jan	173	End	0.0	1.00	100	29	80.0	2.3	0.0	114.3	0.49
27 Jan	End	End	0.0	1.00	0	6					

Totals:

Total gross irrigation	571.4	mm	Total rainfall	330.1	mm
Total net irrigation	400.0	mm	Effective rainfall	324.6	mm
Total irrigation losses	0.0	mm	Total rain loss	5.5	mm
Actual water use by crop	601.9	mm	Moist deficit at harvest	17.2	mm
Potential water use by crop	601.9	mm	Actual irrigation requirement	277.2	mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	98.3	%
Deficiency irrigation schedule	0.0	%			

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.20	0.50	0.50	0.25	0.85	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

Cropwat 8.0 Bèta

Cotton, Run 3 : Application of 80 mm every 20 days after 81st day

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: COTTON Planting date: 01/08
Rain station: KURNOOL Soil: BLACK CLAY SOIL Harvest date: 27/01

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 100, Dev 100, Mid 20, Late 20)
Application: Fixed application depth of 80 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
20 Oct	81	Mid	0.0	1.00	100	34	80.0	14.9	0.0	114.3	0.16
9 Nov	101	Mid	0.0	1.00	100	25	80.0	0.0	9.0	114.3	0.66
29 Nov	121	Mid	0.0	1.00	100	26	80.0	0.0	7.4	114.3	0.66
19 Dec	141	End	0.0	1.00	100	26	80.0	0.0	6.0	114.3	0.66
8 Jan	161	End	0.0	1.00	100	23	80.0	0.0	14.4	114.3	0.66
27 Jan	End	End	0.0	1.00	0	17					

Totals:

Total gross irrigation	571.4	mm	Total rainfall	330.1	mm
Total net irrigation	400.0	mm	Effective rainfall	330.1	mm
Total irrigation losses	36.8	mm	Total rain loss	0.0	mm
Actual water use by crop	601.9	mm	Moist deficit at harvest	48.6	mm
Potential water use by crop	601.9	mm	Actual irrigation requirement	271.8	mm
Efficiency irrigation schedule	90.8	%	Efficiency rain	100.0	%
Deficiency irrigation schedule	0.0	%			

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.20	0.50	0.50	0.25	0.85	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

Cropwat 8.0 Bèta

Cotton, Run 4 : Application of 70 mm every 20 days after 81st day

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: COTTON Planting date: 01/08
Rain station: KURNOOL Soil: BLACK CLAY SOIL Harvest date: 27/01

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at fixed intervals per stage
(Intervals in days: Init 100, Dev 100, Mid 20, Late 20)
Application: Fixed application depth of 70 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
20 Oct	81	Mid	0.0	1.00	100	34	70.0	24.9	0.0	100.0	0.14
9 Nov	101	Mid	0.0	1.00	100	29	70.0	11.0	0.0	100.0	0.58
29 Nov	121	Mid	0.0	1.00	100	30	70.0	13.7	0.0	100.0	0.58
19 Dec	141	End	0.0	1.00	100	31	70.0	17.6	0.0	100.0	0.58
8 Jan	161	End	0.0	1.00	100	30	70.0	13.2	0.0	100.0	0.58
27 Jan	End	End	0.0	1.00	0	22					

Totals:

Total gross irrigation	500.0	mm	Total rainfall	330.1	mm
Total net irrigation	350.0	mm	Effective rainfall	330.1	mm
Total irrigation losses	0.0	mm	Total rain loss	0.0	mm
Actual water use by crop	601.9	mm	Moist deficit at harvest	61.8	mm
Potential water use by crop	601.9	mm	Actual irrigation requirement	271.8	mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	100.0	%
Deficiency irrigation schedule	0.0	%			

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.20	0.50	0.50	0.25	0.85	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

Cropwat 8.0 Bèta

Cotton, Run 5 : Four applications of 70 mm after day 100

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: COTTON Planting date: 01/08
Rain station: KURNOOL Soil: BLACK CLAY SOIL Harvest date: 27/01

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at user defined intervals
Application: Fixed application depth of 70 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
8 Nov	100	Mid	0.0	1.00	100	52	70.0	76.5	0.0	100.0	0.12
28 Nov	120	Mid	0.0	1.00	100	53	70.0	79.6	0.0	100.0	0.58
18 Dec	140	End	0.0	1.00	100	55	70.0	84.0	0.0	100.0	0.58
7 Jan	160	End	0.0	1.00	100	54	70.0	80.1	0.0	100.0	0.58
27 Jan	End	End	0.0	1.00	0	47					

Totals:

Total gross irrigation	400.0	mm	Total rainfall	330.1	mm
Total net irrigation	280.0	mm	Effective rainfall	330.1	mm
Total irrigation losses	0.0	mm	Total rain loss	0.0	mm
Actual water use by crop	601.9	mm	Moist deficit at harvest	131.8	mm
Potential water use by crop	601.9	mm	Actual irrigation requirement	271.8	mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	100.0	%
Deficiency irrigation schedule	0.0	%			

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.20	0.50	0.50	0.25	0.85	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

Cropwat 8.0 Bèta

Cotton, Run 6 : Same as Run 5 for Medium Soil

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: COTTON Planting date: 01/08
Rain station: KURNOOL Soil: RED SANDY LOAM Harvest date: 27/01

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at user defined intervals
Application: Fixed application depth of 70 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
8 Nov	100	Mid	0.0	1.00	100	47	70.0	21.9	0.0	100.0	0.12
28 Nov	120	Mid	0.0	1.00	100	48	70.0	25.0	0.0	100.0	0.58
18 Dec	140	End	0.0	1.00	100	51	70.0	29.4	0.0	100.0	0.58
7 Jan	160	End	0.0	1.00	100	49	70.0	25.6	0.0	100.0	0.58
27 Jan	End	End	0.0	1.00	0	39					

Totals:

Total gross irrigation	400.0	mm	Total rainfall	330.1	mm
Total net irrigation	280.0	mm	Effective rainfall	244.7	mm
Total irrigation losses	0.0	mm	Total rain loss	85.4	mm
Actual water use by crop	601.9	mm	Moist deficit at harvest	77.2	mm
Potential water use by crop	601.9	mm	Actual irrigation requirement	357.2	mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	74.1	%
Deficiency irrigation schedule	0.0	%			

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.20	0.50	0.50	0.25	0.85	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

Cropwat 8.0 Bèta

Cotton, Run 7 : Same as Run 5 for Light Soil

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: COTTON Planting date: 01/08
Rain station: KURNOOL Soil: RED SANDY Harvest date: 27/01

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at user defined intervals
Application: Fixed application depth of 70 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
8 Nov	100	Mid	0.0	1.00	100	66	70.0	21.9	0.0	100.0	0.12
28 Nov	120	Mid	0.0	1.00	100	68	70.0	25.0	0.0	100.0	0.58
18 Dec	140	End	0.0	0.98	100	71	70.0	29.3	0.0	100.0	0.58
7 Jan	160	End	0.0	1.00	100	68	70.0	25.5	0.0	100.0	0.58
27 Jan	End	End	0.0	1.00	0	55					

Totals:

Total gross irrigation	400.0	mm	Total rainfall	330.1 mm
Total net irrigation	280.0	mm	Effective rainfall	244.7 mm
Total irrigation losses	0.0	mm	Total rain loss	85.4 mm
Actual water use by crop	601.8	mm	Moist deficit at harvest	77.1 mm
Potential water use by crop	601.9	mm	Actual irrigation requirement	357.2 mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	74.1 %
Deficiency irrigation schedule	0.0	%		

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.1	0.0	%
Yield response factor	0.20	0.50	0.50	0.25	0.85	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

Cropwat 8.0 Bèta

Cotton, Run 8 : Same as Run 5 for Dry Year

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: COTTON Planting date: 01/08
Rain station: KURNOOL Soil: BLACK CLAY SOIL Harvest date: 27/01

Yield red.: 2.9 %

Crop scheduling options
Timing: Irrigate at user defined intervals
Application: Fixed application depth of 70 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
8 Nov	100	Mid	0.0	0.70	97	77	70.0	144.5	0.0	100.0	0.12
28 Nov	120	Mid	0.0	0.71	92	76	70.0	143.6	0.0	100.0	0.58
18 Dec	140	End	0.0	0.77	94	76	70.0	143.5	0.0	100.0	0.58
7 Jan	160	End	0.0	1.00	100	75	70.0	139.6	0.0	100.0	0.58
27 Jan	End	End	0.0	1.00	0	68					

Totals:

Total gross irrigation	400.0 mm	Total rainfall	250.0	mm
Total net irrigation	280.0 mm	Effective rainfall	250.0	mm
Total irrigation losses	0.0 mm	Total rain loss	0.0	mm
Actual water use by crop	581.3 mm	Moist deficit at harvest	191.2	mm
Potential water use by crop	601.9 mm	Actual irrigation requirement	351.9	mm
Efficiency irrigation schedule	100.0 %	Efficiency rain	100.0	%
Deficiency irrigation schedule	3.4 %			

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	7.3	2.6	3.4	%
Yield response factor	0.20	0.50	0.50	0.25	0.85	
Yield reduction	0.0	0.0	3.6	0.7	2.9	%
Cumulative yield reduction	0.0	0.0	3.6	4.3		%

Cropwat 8.0 Bèta

Cotton, Run 9 : Same as Run 5 for Wet Year

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: COTTON Planting date: 01/08
Rain station: KURNOOL Soil: BLACK CLAY SOIL Harvest date: 27/01

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at user defined intervals
Application: Fixed application depth of 70 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
8 Nov	100	Mid	0.0	1.00	100	19	70.0	0.0	16.5	100.0	0.12
28 Nov	120	Mid	0.0	1.00	100	24	70.0	0.0	1.5	100.0	0.58
18 Dec	140	End	0.0	1.00	100	26	70.0	3.5	0.0	100.0	0.58
7 Jan	160	End	0.0	1.00	100	25	70.0	0.0	0.4	100.0	0.58
27 Jan	End	End	0.0	1.00	0	18					

Totals:

Total gross irrigation	400.0	mm	Total rainfall	485.9	mm
Total net irrigation	280.0	mm	Effective rainfall	428.6	mm
Total irrigation losses	18.4	mm	Total rain loss	57.3	mm
Actual water use by crop	601.9	mm	Moist deficit at harvest	51.6	mm
Potential water use by crop	601.9	mm	Actual irrigation requirement	173.3	mm
Efficiency irrigation schedule	93.4	%	Efficiency rain	88.2	%
Deficiency irrigation schedule	0.0	%			

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.20	0.50	0.50	0.25	0.85	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

Cropwat 8.0 Bèta

Cotton, Run 10: One application (70 mm) on day 130 for Wet Year

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: COTTON Planting date: 01/08
Rain station: KURNOOL Soil: BLACK CLAY SOIL Harvest date: 27/01

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at user defined intervals
Application: Fixed application depth of 70 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	Eta %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
8 Dec	130	Mid	0.0	1.00	100	57	70.0	88.5	0.0	100.0	0.09
27 Jan	End	End	0.0	1.00	0	87					

Totals:

Total gross irrigation	100.0	mm	Total rainfall	485.9 mm
Total net irrigation	70.0	mm	Effective rainfall	428.6 mm
Total irrigation losses	0.0	mm	Total rain loss	57.3 mm
Actual water use by crop	601.9	mm	Moist deficit at harvest	243.3 mm
Potential water use by crop	601.9	mm	Actual irrigation requirement	173.3 mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	88.2 %
Deficiency irrigation schedule	0.0	%		

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.20	0.50	0.50	0.25	0.85	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

Cropwat 8.0 Bèta

APPENDIX 5.2

EVALUATION OF IRRIGATION PRACTICES

1. **Sorghum-HYV File**
2. **CWR Sorghum-HYV**
3. **Irrigation Schedule as practised by farmer**

1. Sorghum-HYV File

DRY CROP DATA
(File: KURN-SORGHUM-HYV.CRO)

Crop Name: SORGHUM (Grain) Planting date: 13/09 Harvest: 17/01

Stage	initial	develop	mid	late	total
Length (days)	27	35	35	30	127
Kc Values	0.50	-->	1.15	0.60	
Rooting depth (m)	0.30	-->	1.00	1.00	
Critical depletion	0.50	-->	0.50	0.80	
Yield response f.	0.60	0.60	1.20	0.80	1.00
Cropheight (m)					

Cropwat 8.0 Bèta

2. CWR Sorghum-HYV

CROP WATER REQUIREMENTS

ETo station: KURNOOL Crop: SORGHUM-HYV
Rain station: KURNOOL (KURN-86) Planting date: 13/09

Month	Decade	Stage	Kc coeff	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Sep	2	Init	0.50	2.34	18.7	0.0	18.7
Sep	3	Init	0.50	2.31	23.1	3.4	19.7
Oct	1	Deve	0.50	2.29	22.9	23.2	0.0
Oct	2	Deve	0.62	2.79	27.9	33.8	0.0
Oct	3	Deve	0.82	3.43	37.7	28.5	9.2
Nov	1	Deve	1.01	3.95	39.5	22.1	17.4
Nov	2	Mid	1.14	4.14	41.4	18.9	22.6
Nov	3	Mid	1.15	4.03	40.3	12.6	27.7
Dec	1	Mid	1.15	3.89	38.9	0.1	38.8
Dec	2	Late	1.14	3.74	37.4	0.0	37.4
Dec	3	Late	1.00	3.45	38.0	0.0	38.0
Jan	1	Late	0.81	2.93	29.3	0.0	29.3
Jan	2	Late	0.66	2.48	17.4	0.0	17.4
					412.5	142.5	276.3

Cropwat 8.0 Bèta

3. Irrigation Schedule as practised by farmer

CROP IRRIGATION SCHEDULE

ETo station: KURNOOL Crop: SORGHUM (Grain) Planting date: 13/09
Rain station: KURNOOL Soil: RED LOAMY Harvest date: 17/01

Yield red.: 0.0 %

Crop scheduling options
Timing: Irrigate at user defined intervals
Application: Fixed application depth of 70 mm
Field eff. 70 %

Table format: Irrigation schedule

Date	Day	Stage	Rain mm	Ks fract.	ETa %	Depl %	Net Irr mm	Deficit mm	Loss mm	Gr. Irr mm	Flow l/s/ha
23 Nov	72	Mid	7.9	1.00	100	29	70.0	0.0	16.9	100.0	0.16
14 Dec	93	Mid	0.0	1.00	100	41	70.0	4.1	0.0	100.0	0.55
4 Jan	114	End	0.0	1.00	100	42	70.0	6.2	0.0	100.0	0.55
17 Jan	End	End	0.0	1.00	100	22					

Totals:

Total gross irrigation	300.0	mm	Total rainfall	178.2	mm
Total net irrigation	210.0	mm	Effective rainfall	178.2	mm
Total irrigation losses	16.9	mm	Total rain loss	0.0	mm
Actual water use by crop	410.0	mm	Moist deficit at harvest	38.7	mm
Potential water use by crop	410.0	mm	Actual irrigation requirement	231.8	mm
Efficiency irrigation schedule	91.9	%	Efficiency rain	100.0	%
Deficiency irrigation schedule	0.0	%			

Yield reductions:

Stagelabel	A	B	C	D	Season	
Reductions in ETc	0.0	0.0	0.0	0.0	0.0	%
Yield response factor	0.60	0.60	1.20	0.80	1.00	
Yield reduction	0.0	0.0	0.0	0.0	0.0	%
Cumulative yield reduction	0.0	0.0	0.0	0.0		%

Cropwat 8.0 Bèta