



**Food and Agriculture
Organization of the
United Nations**



Crop Module 1

Introduction to AquaCrop

Jorge Alvar-Beltrán
(13-12-2022)

Content







Day 1

- How do crop models work
- AquaCrop interface
- AquaCrop: climate and crop modules






Day 2


- AquaCrop: management and soil modules
- Run simulations and interpret outputs


Environment and Crop

1		Climate	(None)	Specify climatic data when Running AquaCrop
2		Crop	DEFAULT.CRO	Growing cycle: Day 1 after sowing: 22 March - Maturity: 24 July a generic crop Calendar mode
3		Irrigation	(None)	Rainfed cropping
		Field	(None)	No specific field management
4		Soil profile	DEFAULT.SOL	deep loamy soil profile
		Groundwater	(None)	no shallow groundwater table

Simulation

	Simulation period	Simulation period: from 22 March - to 24 July
	Initial conditions	(None) Soil water profile at Field Capacity
	Off-season	Simulation period linked to cropping period
	Project	(None) No specific project
	Field data	(None) No field observations

 **Run** <<<<

 **Exit Program**



Data used for this simulation

Climate module: AquaCrop default climatic files for Córdoba (south Spain) for year 1981. YESTERDAY

Crop module: AquaCrop default crop files (daily values) for tomato grown in Córdoba and sown 1st May. YESTERDAY

Management module:

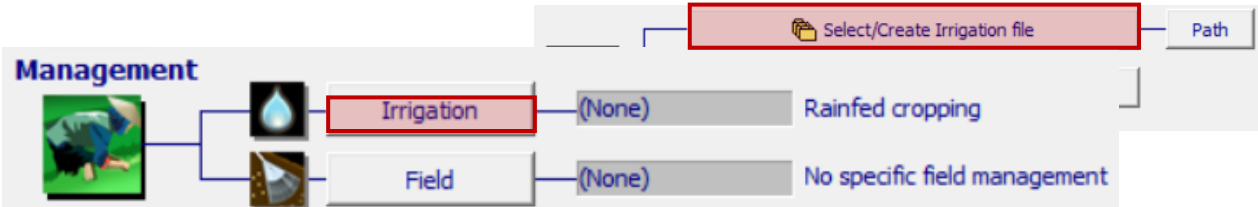
- Irrigation sub-module: create our own irrigation files. TODAY
- Field sub-module: AquaCrop default field files (moderate soil fertility). TODAY

Soil module:

- Soil profile: AquaCrop default soil files (sandy-loam). TODAY
- Groundwater sub-module: AquaCrop default groundwater files (constant water at 2m depth). TODAY

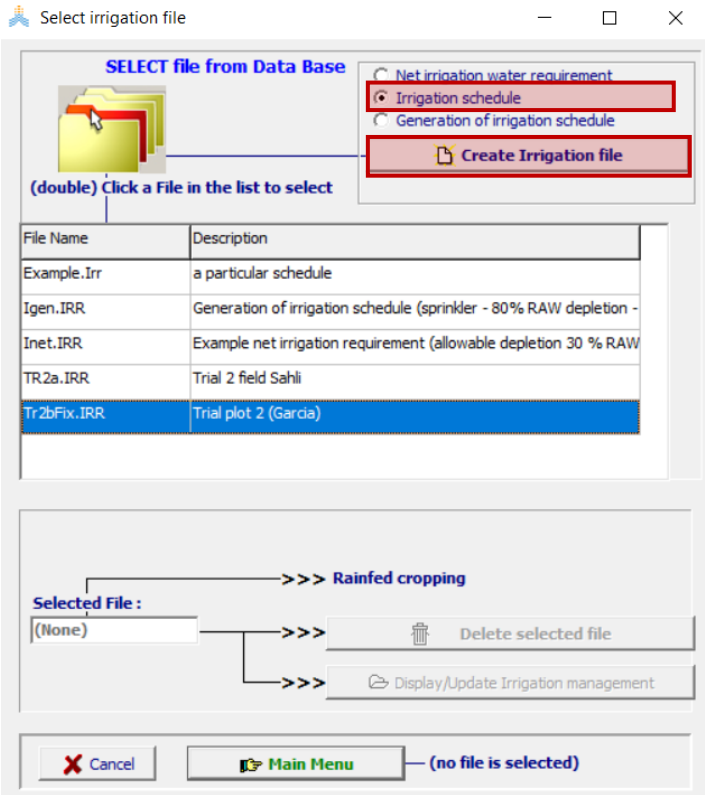


Management module: irrigation

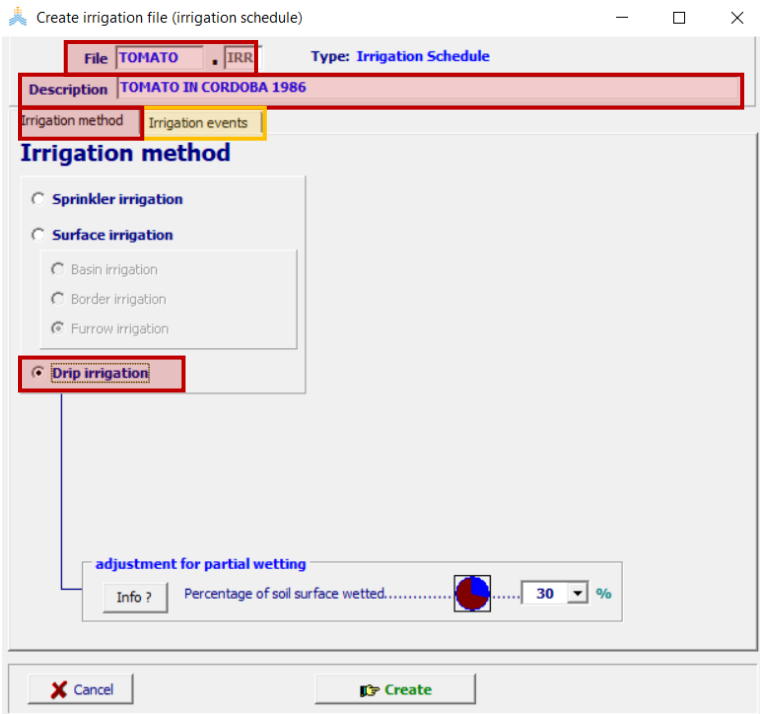


Step 1: click on **irrigation** and then **select/create irrigation file**

Step 2: click on **irrigation** schedule and then **create irrigation file**



Step 3: name your file "**tomato**" and provide a description "**tomato in Córdoba 1986**" and select the irrigation method, in our case, **drip irrigation**. Then click on **irrigation events**



Management module: irrigation

Step 1: click on **add events** and add **10**

Create irrigation file (irrigation schedule)

File: TOMATO . IRR Type: Irrigation Schedule

Description: TOMATO CORDOBA 1986

Irrigation method: Irrigation events

Irrigation events

EC_w: 0.0 dS/m

Irrigation water quality: excellent

add 1 events

Day No. 1 - day 1 after planting: 1 May 1986

Event	Date	When?	Depth?	Quality
		Day No.	Net application (mm)	dS/m
1				
2				
3				
4				
5				
6				
7				
8				

Day No. 130 - maturity: 7 September 1986

Clear All Events

Cancel Create

add 1 events

Day No. 1

MARCH

1 2 3 4 5 6 7
8 9 10 11 12 13
14 15 16 17 18 19 20
21 22 23 24 25 26 27

10

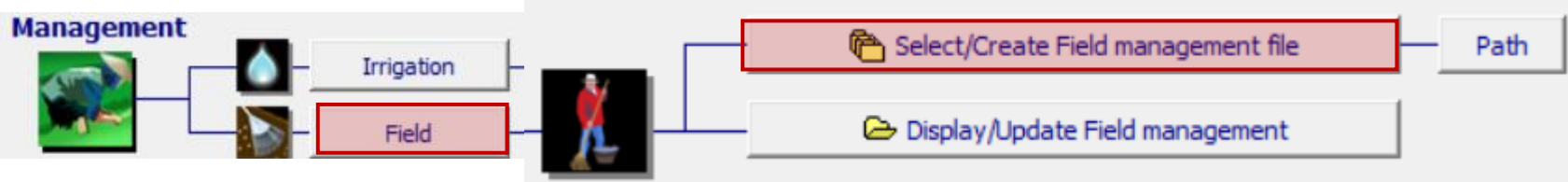
Step 2: type the frequency of irrigation, **5** days, as well as the net application of water, **10**mm. In total, you should have 20 irrigation events each with 10mm (200mm of irrigation)

Event	Date	Day No.	Net application (mm)	dS/m
1	5 May 1986	5	10	0.0
2	10 May 1986	10	10	0.0
3	15 May 1986	15	10	0.0
4	20 May 1986	20	10	0.0
5	25 May 1986	25	10	0.0
6	30 May 1986	30	10	0.0
7	4 June 1986	35	10	0.0
8	9 June 1986	40	10	0.0

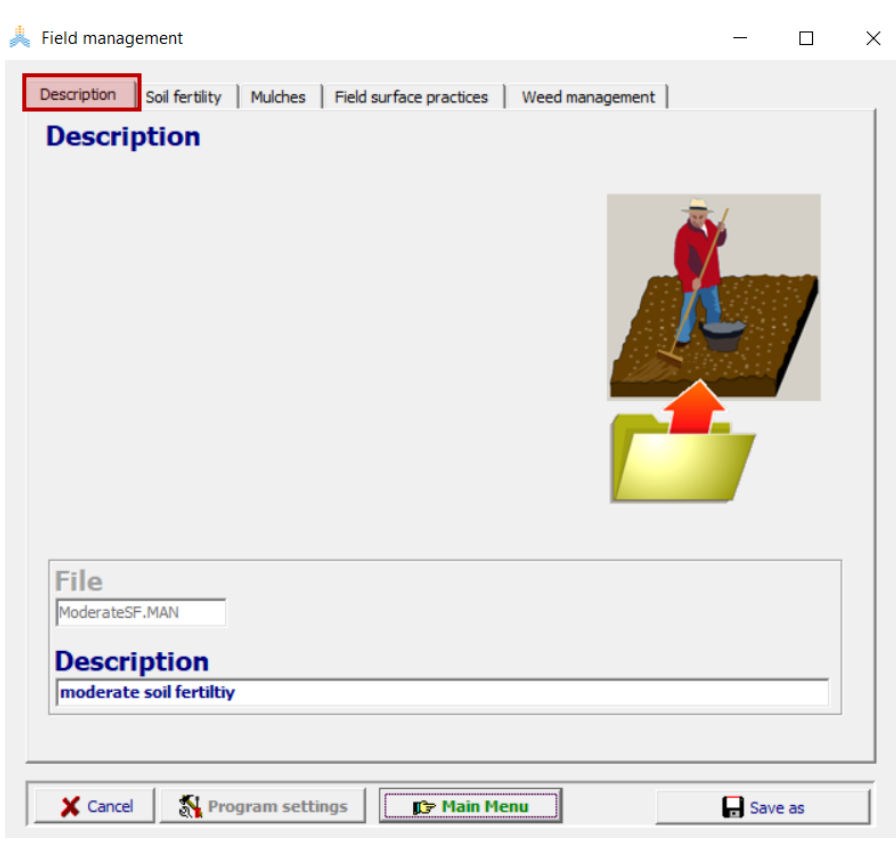
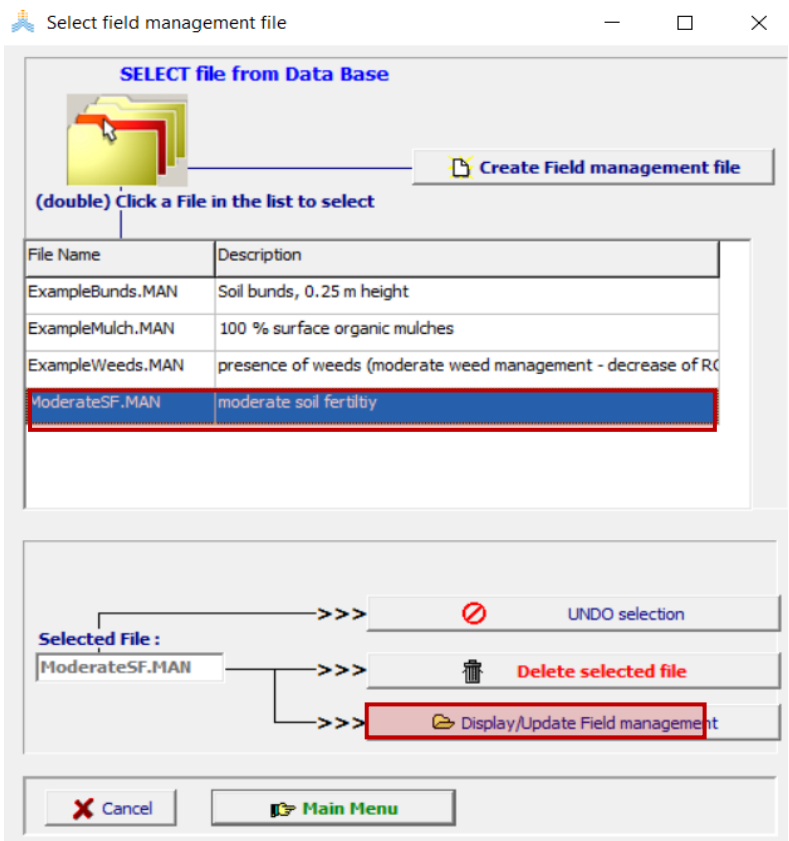
Step 3: click on **create**. AquaCrop should have created the irrigation file with the frequency and amount specified!

Management module: field management

Step 1: click on **field** and **select/create field management file**



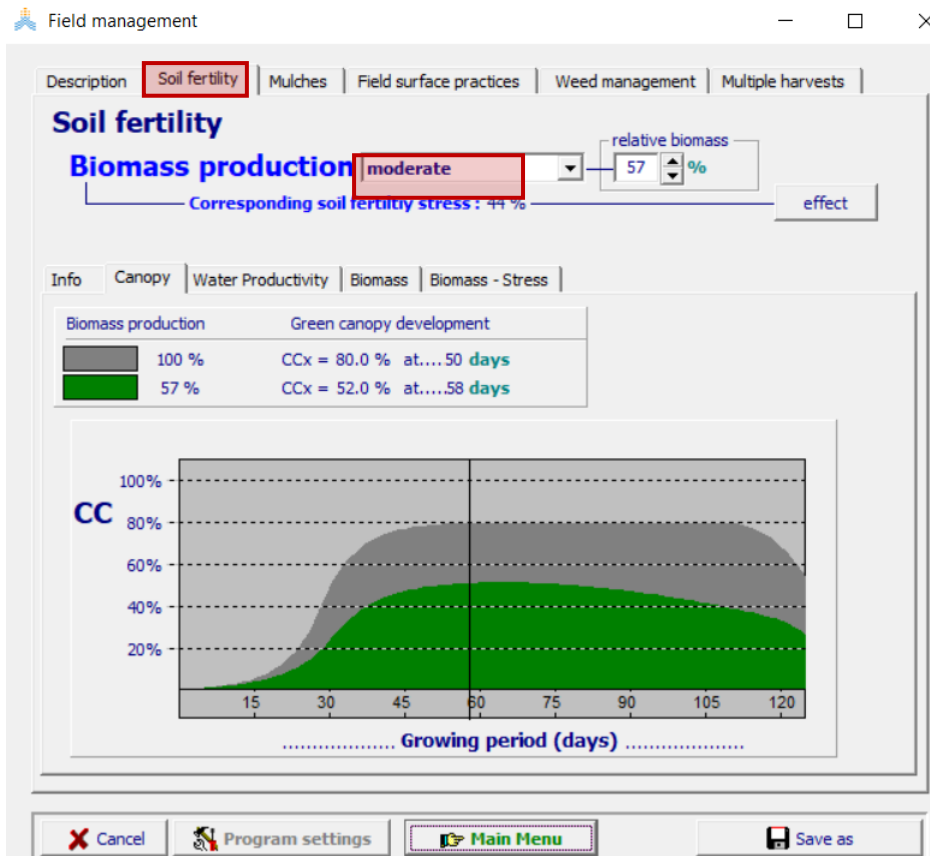
Step 2: click once on **moderate soil fertility** and **display/update field management**



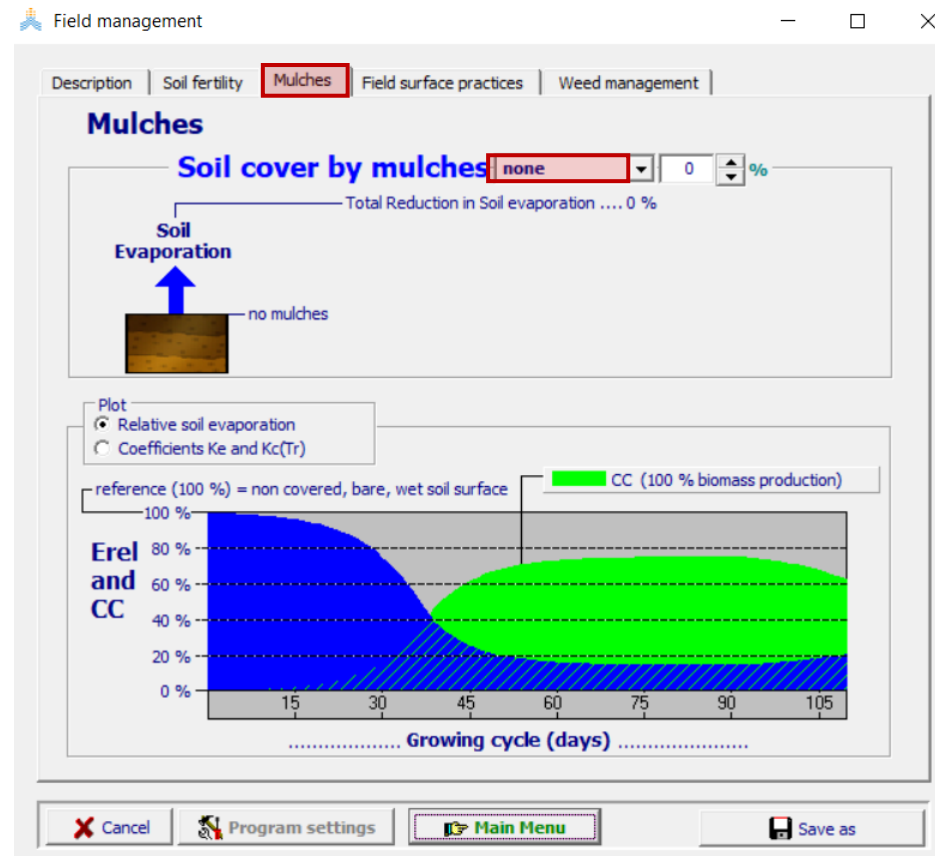
Management module: field management

Field management practices are choices of soil fertility levels, weed management, and practices that affect the soil water balance such as mulching to reduce soil evaporation, soil bunds to store water in the field, and tillage practices such as soil ridging or contours reducing run-off of rainwater.

Step 1: click on **soil fertility**



Step 2: click on **mulches**





Management module: field management

Step 1: click on **field surface practices**





Field management

Description | Soil fertility | Mulches | **Field surface practices** | Weed management

Field surface practices

- ☒ do NOT affect surface runoff
Estimation of surface runoff is based on soil profile characteristic (valid for crop type: 'small grain')
- ☐ affect surface runoff
- ☐ prevent surface runoff
- ☐ soil bunds

surface runoff

-  soil profile characteristic CN = 61
-  not affected by management CN = 61
-  surface runoff inhibited CN = N/A
-  storage of excess water CN = N/A

Cancel | Program settings | **Main Menu** | Save as

Step 2: click on **weed management**

Field management

Description | Soil fertility | Mulches | Field surface practices | **Weed management**

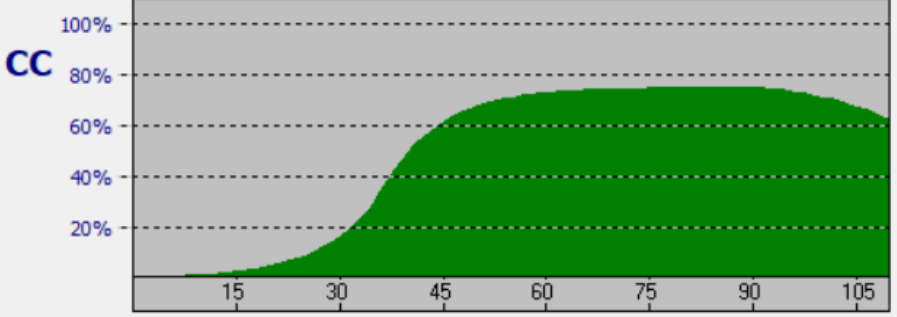
Weed management

Relative cover (RC) of weeds in season %

Management **perfect**

Canopy cover | Biomass

CC



..... Growing cycle (days)

Canopy Cover (CC)

- crop and weeds
- crop and weeds

unlimited soil fertility

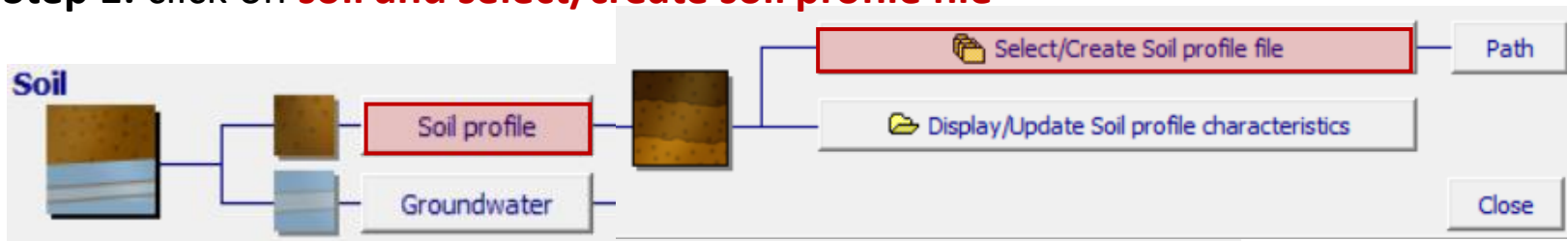
weeds

crop

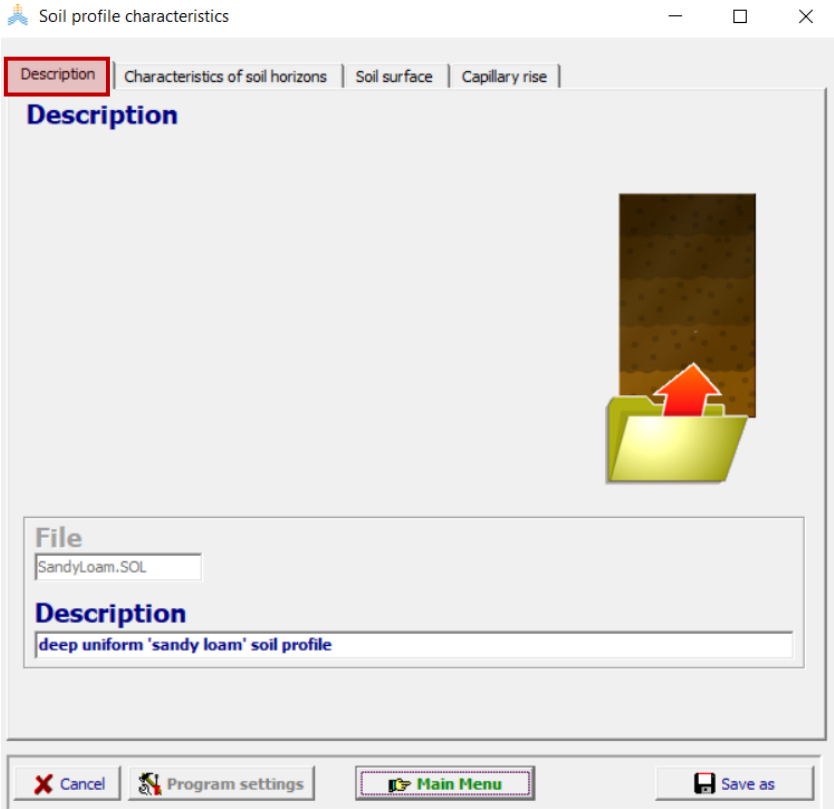
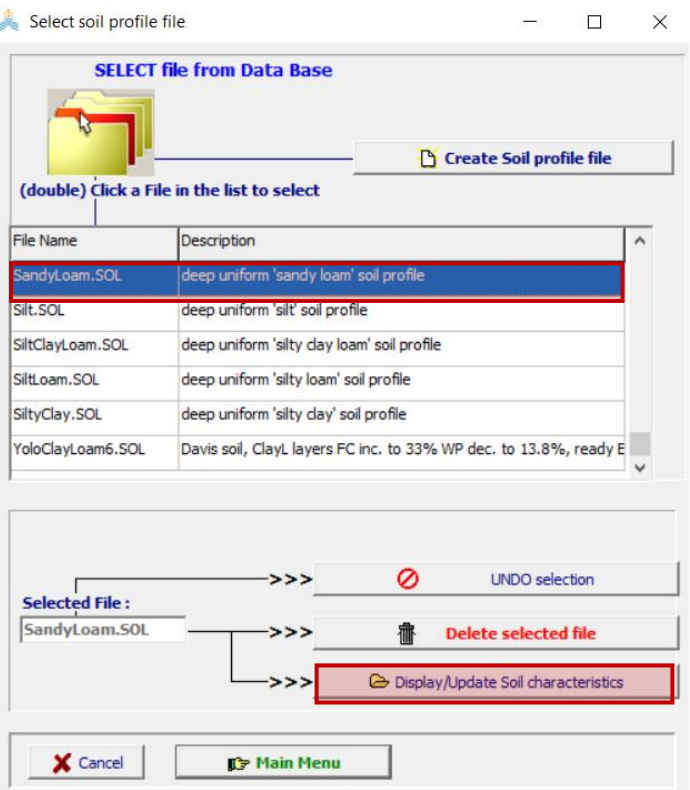
Cancel | Program settings | **Main Menu** | Save as

Soil module: soil profile & texture classes

Step 1: click on **soil** and select/create soil profile file



Step 2: click once on **sandy-loam** and then click on **display soil characteristics**



Soil module: soil profile & texture classes

The soil profile can be composed of up to five different horizons of variable depth, each with their own physical characteristics. The characteristics are the water retention in the fine soil fraction at saturation (SAT), field capacity (FC), and at permanent wilting point (PWP), and the hydraulic conductivity of the soil at saturation (Ksat).

Step 1: click on **characteristics of soil horizons**

Soil profile characteristics

Description | **Characteristics of soil horizons** | Soil surface | Capillary rise

Characteristics

Number soil horizons: 1

Click button to select indicative hydraulic properties from list

horizon	description	thickness m	TAW mm/m	Soil water retention in fine soil fraction vol %			hydraulic conductivity mm/day	
				PWP	FC	SAT	Ksat	tau
1	sandy loam	4.00	120	10.0	22.0	41.0	1200.0	1.00

Plot: soil water

Update list of soil hydraulic characteristics

Cancel | Program settings | Main Menu | Save as

Step 2: click on **capillary rise**

Soil profile characteristics

Description | Characteristics of soil horizons | Soil surface | **Capillary rise**

Plot: ☐ Evaporation zone (max : 0.30m) ☒ Rooting depth (max : 1.00m)

Capillary rise from groundwater table

calibrate: sandy loam 1

groundwater

Calibration: Reset Parameters

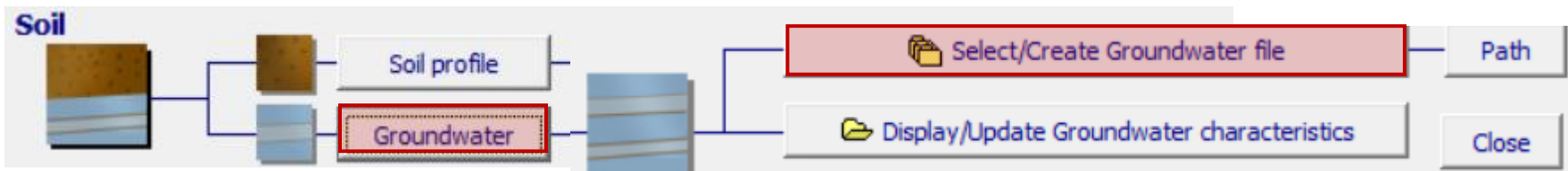
Capillary rise mm/day

For depth groundwater table below soil surface: 4.00 m

Cancel | Program settings | Main Menu | Save as

Soil module: groundwater

Step 1: click on **soil** and **groundwater**, then **select/create groundwater file**



Step 2: click once on **Constant 2** and then click **display**

Select groundwater file

SELECT file from Data Base

(double) Click a File in the list to select

File Name	Description
Const15.GWT	constant groundwater table at 1.50 m and with salinity level of 1.5
Constant2.GWT	2 meter and 2 dS/m
Var4.GWT	varying depth and salinity

☒ Constant depth and water quality
☐ Varying depth and/or water quality

Create Groundwater file

Selected File : Constant2.GWT

>>> UNDO selection
 >>> Delete selected file
 >>> Display/Update Groundwater characteristics

Cancel Main Menu

Step 3: click on **Groundwater table**

Groundwater characteristics

Description Groundwater table Plot

Groundwater table

☒ Present
☐ Absent

☐ Varying in depth and/or salinity
☒ Constant depth and salinity

Characteristics of groundwater table

Depth 2.00 meter below soil surface

Salinity 2.0 dS/m

groundwater

Cancel Main Menu Save as



Summary of input files

Below you will find a summary of selected files to run the simulations, including climate file **(Cordoba)**, crop file **(tomato)**, irrigation schedule **(tomato)**, field management **(moderate)**, soil profile **(sandy-loam)**, and groundwater **(constant)**

Environment and Crop

Climate



Climate

Cordoba.CLI

Cordoba, Spain 1Jan-31Dec1986 - Data by University of Cordoba

Crop



Crop

Growing cycle: Day 1 after transplanting: 1 May 1986 - Maturity: 18 August 1986

Tomato.CRO

Default Tomato, Calendar (Cordoba, 1May86)

Calendar mode

Management



Irrigation

TOMATO.IRR

TOMATO CORDOBA 1986

Field

ModerateSF.MAN

moderate soil fertiltiy

Soil



Soil profile

SandyLoam.SOL

deep uniform 'sandy loam' soil profile

Groundwater

Constant2.GWT

2 meter and 2 dS/m



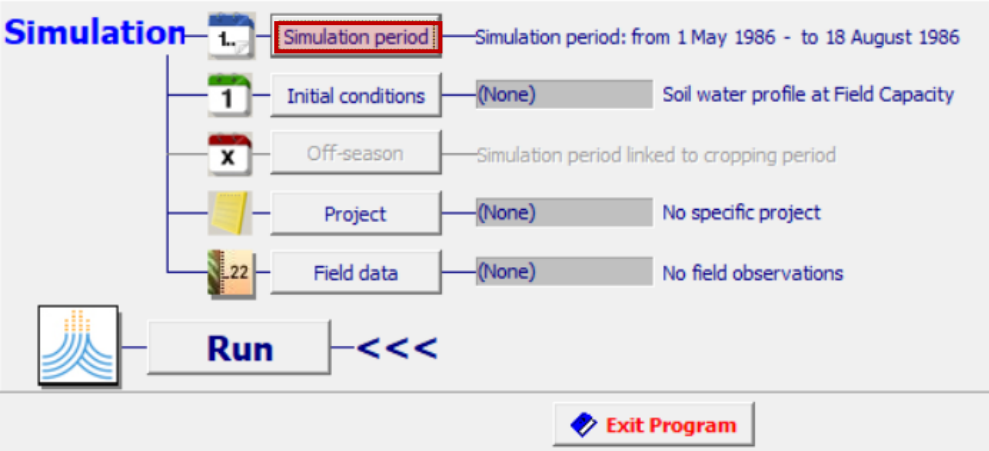
Running the simulations

Objective:

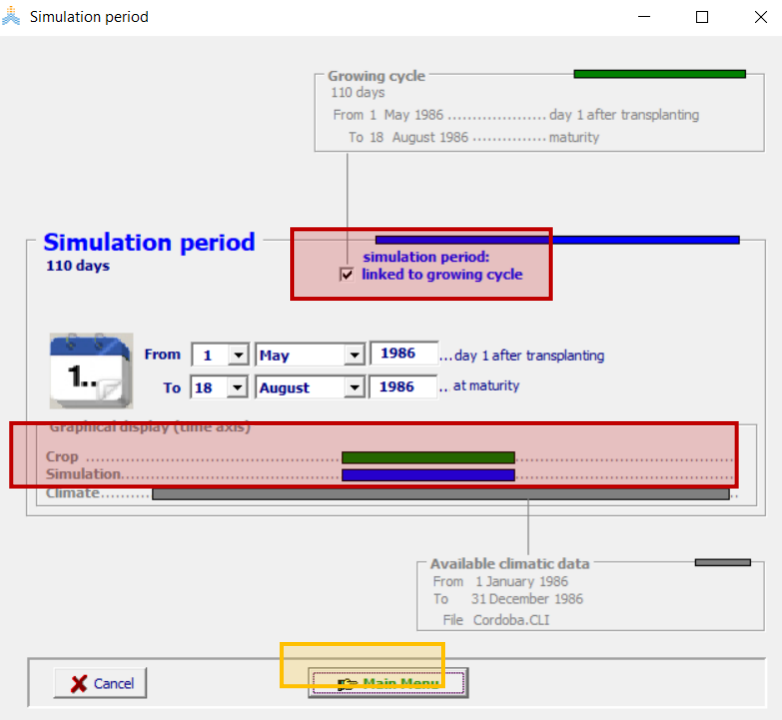
- In this session, we will run all the climate, crop, management and soil modules for tomato grown in Córdoba (South Spain) for the year 1981!
- We will also study some of the emerging outputs from the simulations, specially (i) yield production, (ii) abiotic stresses to crop development and production, (iii) climate and water balance, (iv) transpiration rates, canopy cover development, and root zone depletion.
- If we have time, we will also look at other outputs emerging from AquaCrop.



Simulation period

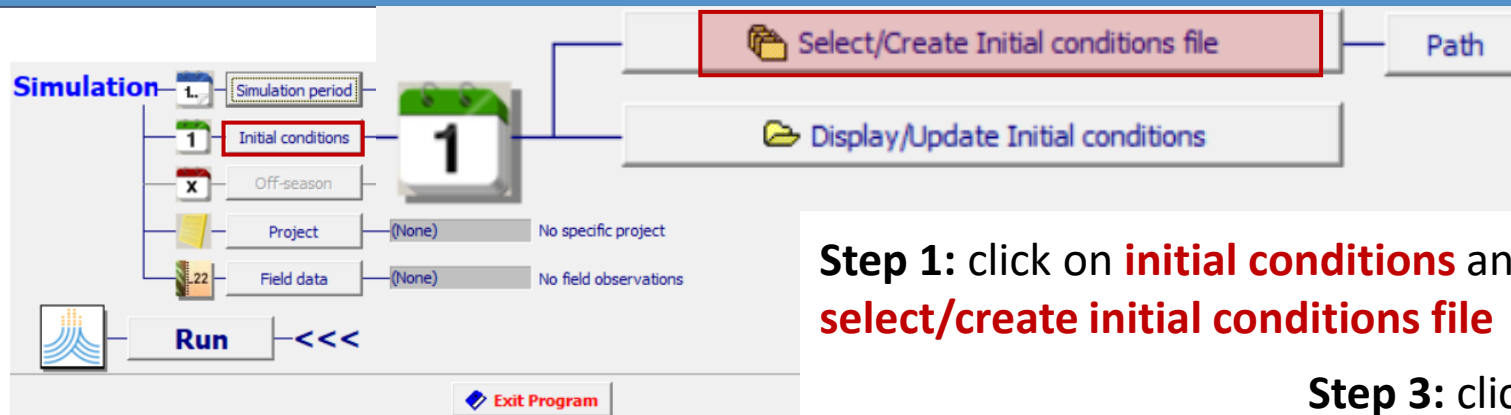


Step 1: click on **simulation period**



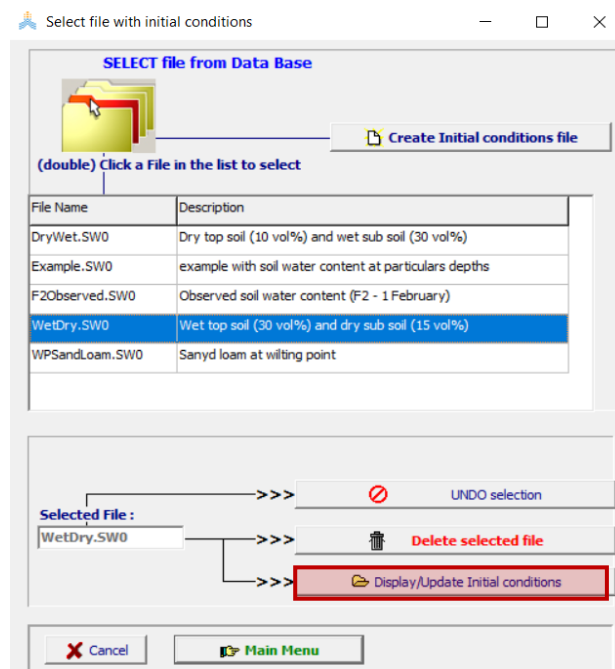
Step 2: double-check that the **simulation period** coincides or its within the timeframe of the climatic file

Initial conditions

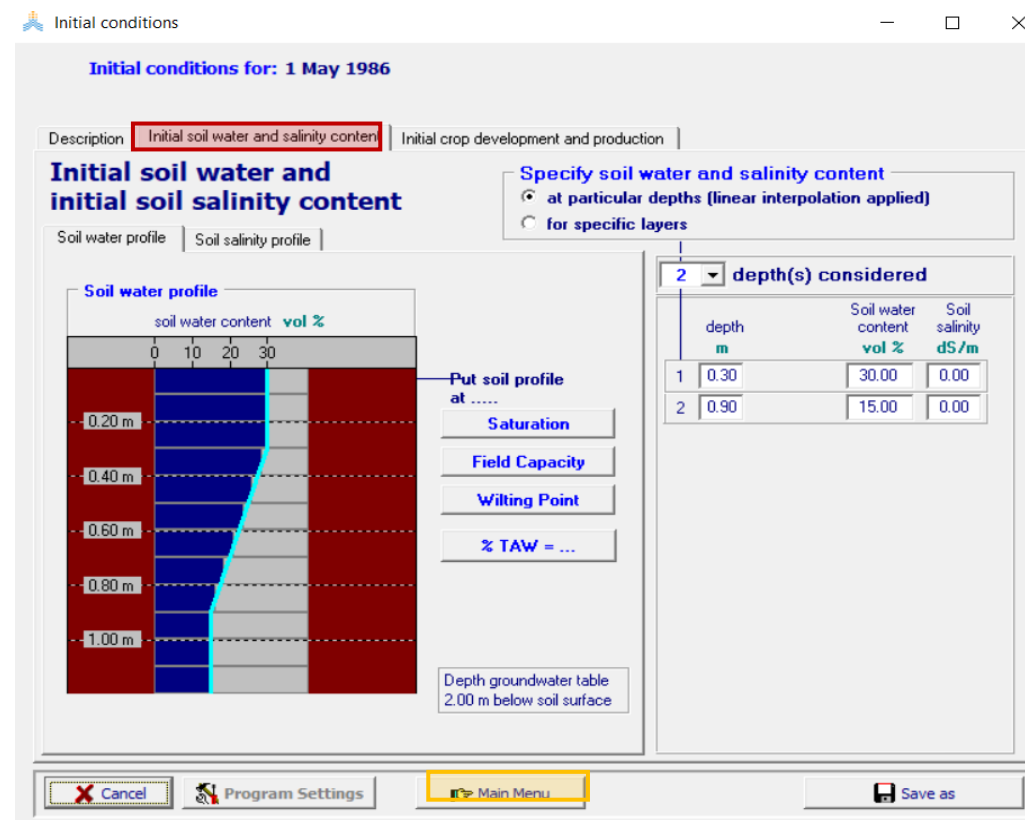


Step 1: click on **initial conditions** and then **select/create initial conditions file**

Step 2: click once on **wet/dry** and click on **display/update initial conditions**



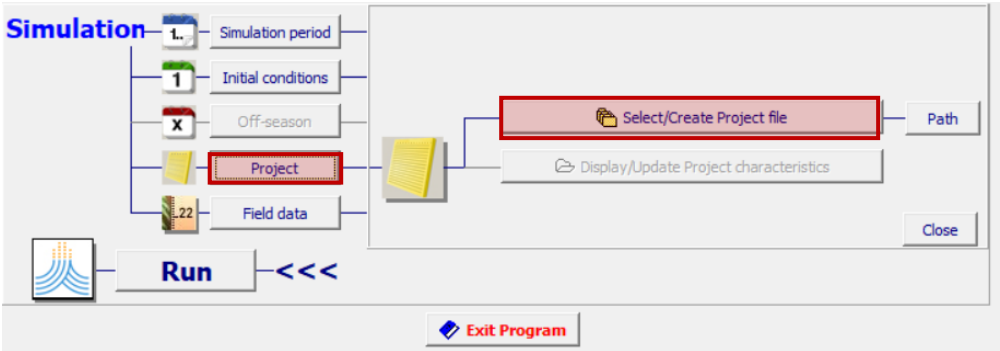
Step 3: click on **initial soil water and salinity content**



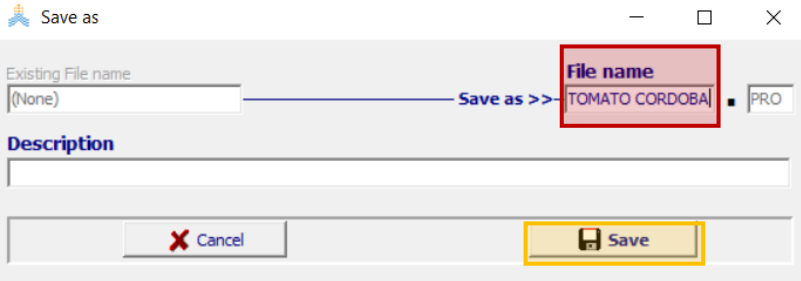
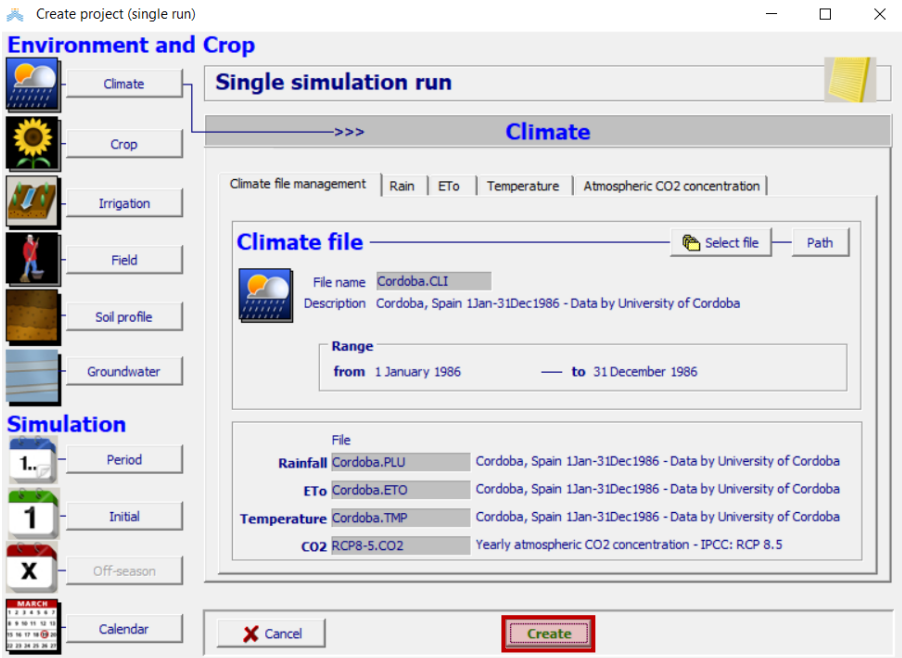


Create project file

Step 1: click on **project**, then **select/create project file** and click on **create project file**

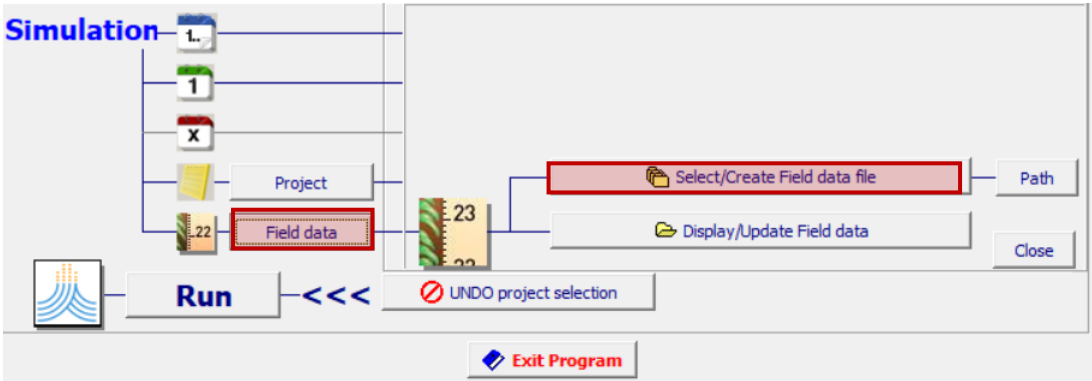


Step 2: click on **create**, name the file as “**tomato Cordoba**” and **save** the file





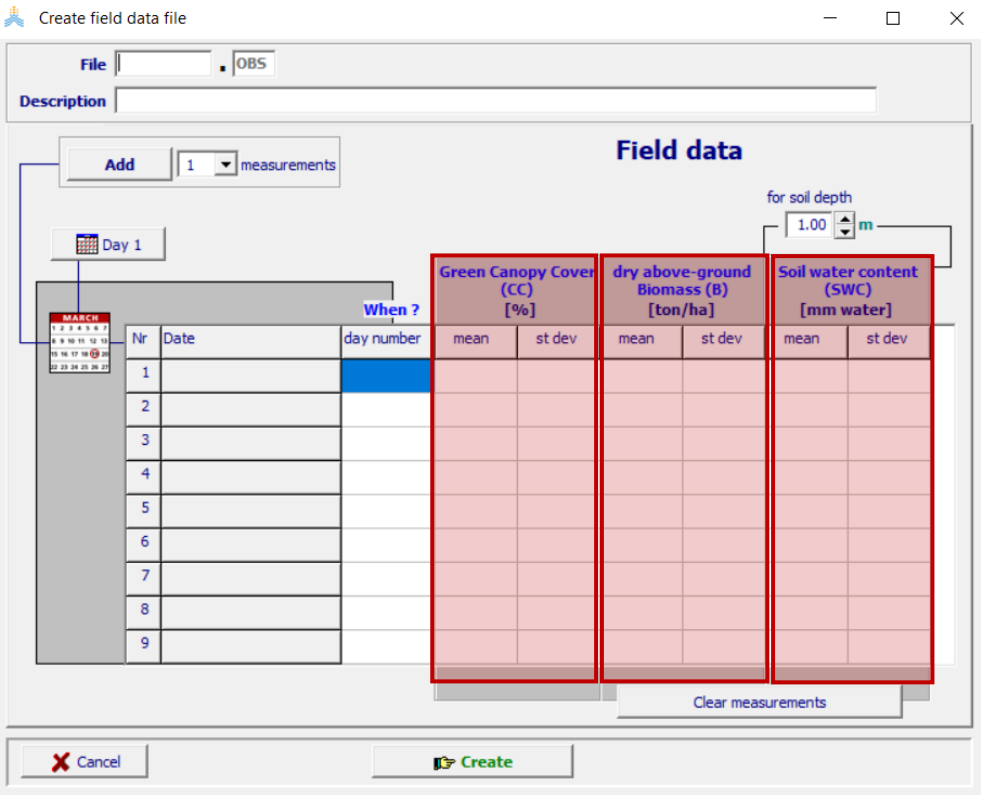
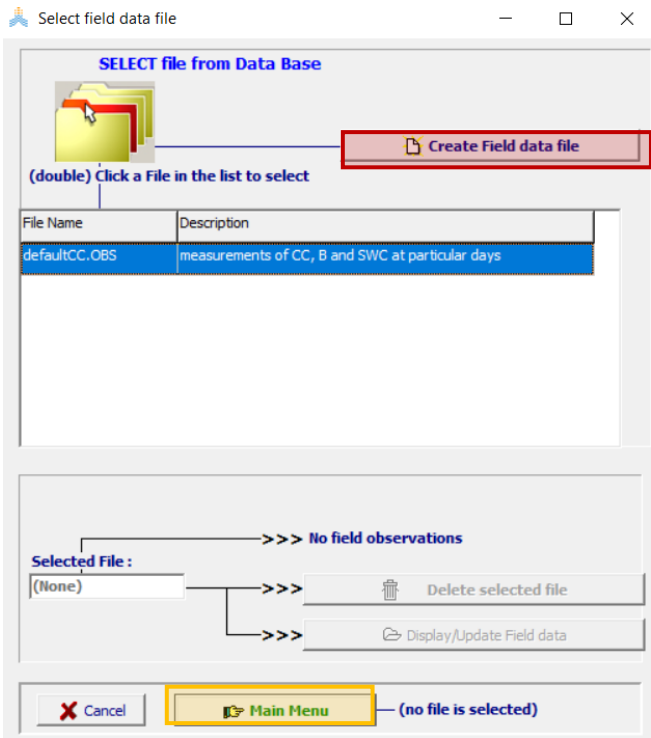
Field data: CC, biomass and SWC observations



Step 1: click on **field data**, then
select/create project file

*You can introduce field observations
(CC, biomass and SWC) to better
calibrate the model*

Step 2-3: click on **create field data file**, but then click on **cancel**





Run the simulations

Simulation

Simulation period: from 1 May 1986 - to 18 August 1986

1 WetDry.SW0 Wet top soil (30 vol%) and dry sub soil (15 vol%)

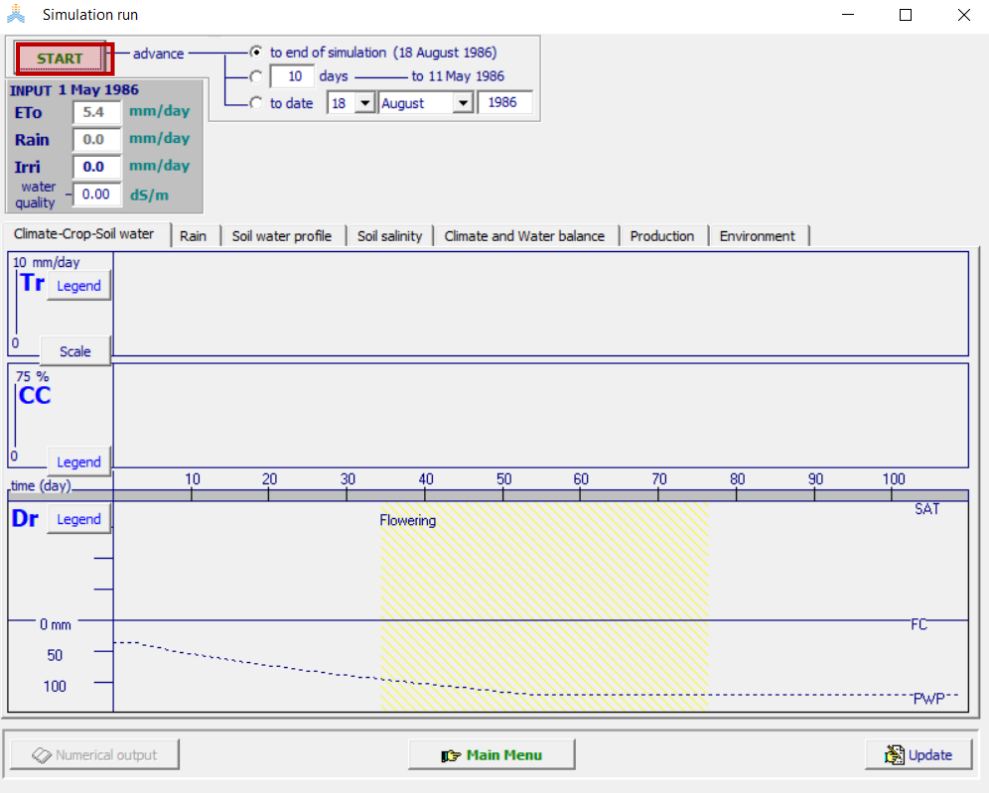
X Simulation period linked to cropping period

Project TOMATOCORDOBA.I

Field data (None) No field observations

Run <<< UNDO project selection

Step 1: click on **Run**

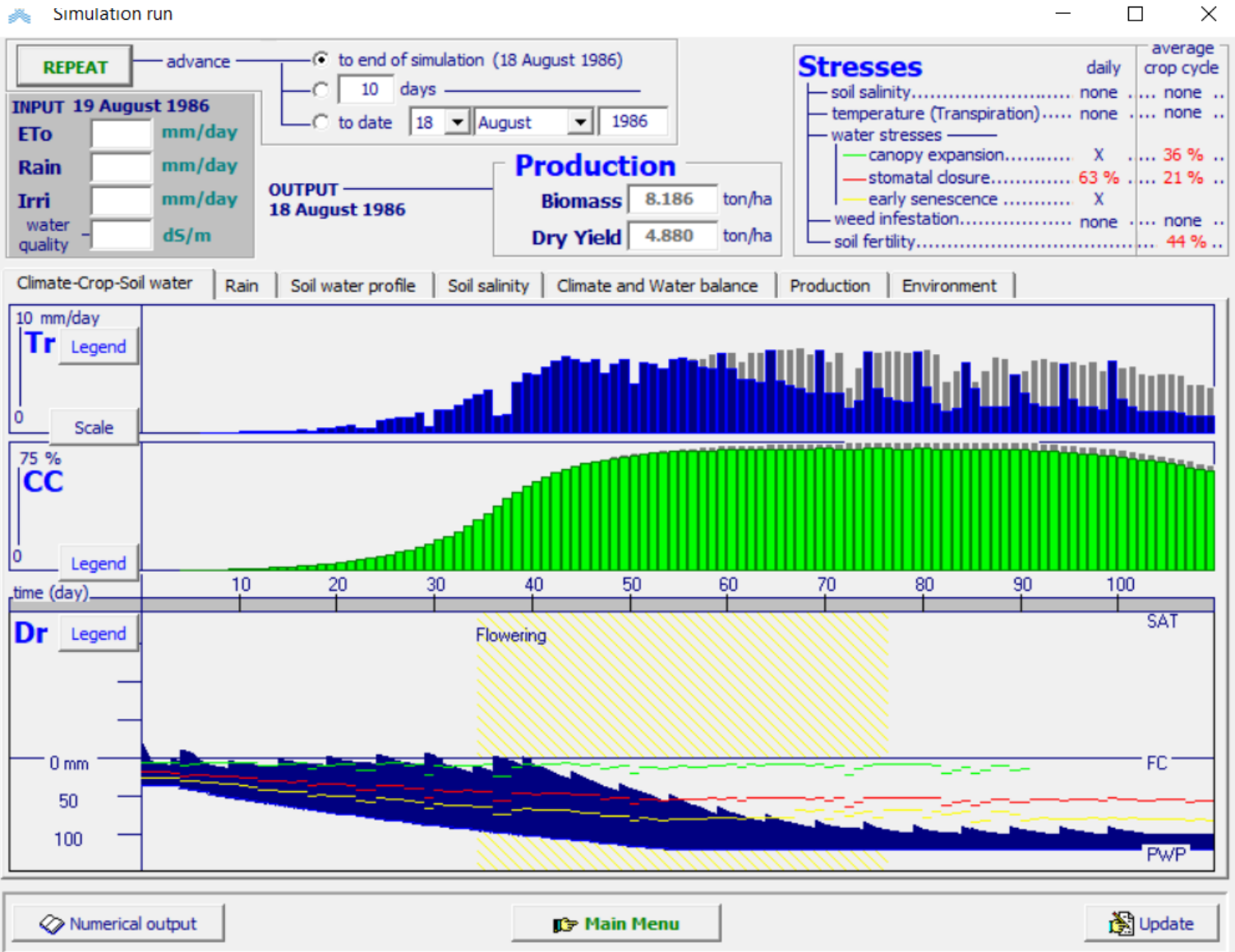


Step 2: click on **START**



Simulation outputs: production & stresses

Step 1: click on **climate-crop-soil water**



← Abiotic stresses

← Transpiration

← Canopy cover

← Root zone depletion

Simulation outputs: climate and water balance

Step 1: click on **Climate and Water Balance**

Simulation run

REPEAT

advance

to end of simulation (18 August 1986)

10 days

to date 18 August 1986

INPUT 19 August 1986

ETo

mm/day

Rain

mm/day

Irri

mm/day

water quality

dS/m

OUTPUT 18 August 1986

Biomass

8.186 ton/ha

Dry Yield

4.880 ton/ha

Stresses

soil salinity..... none ... none ..

temperature (Transpiration)..... none ... none ..

water stresses

canopy expansion..... X ... 36 % ..

stomatal closure..... 63 % ... 21 % ..

early senescence X

weed infestation..... none ... none ..

soil fertility..... none ... 44 % ..

Climate-Crop-Soil water

Rain

Soil water profile

Soil salinity

Climate and Water balance

Production

Environment

Climate

INPUT 19 August 1986

growing degrees

°C.day

CO2 347.19 ppm

ETo . mm

Rain . mm

Irri . mm

from : 1 May 1986
to : 18 August 1986

GD 1620.0 °C

ETo 663.5 mm

Rain 33.0 mm

Irri 200.0 mm

Soil water balance

OUTPUT 18 August 1986

From: 1 May 1986 to 18 August 1986

Ex 0.5 mm/day

Trx 3.7 mm/day

Total (mm) 138.0

Total (mm) 426.1

Evaporation (E) 0.0 mm/day

in growing cycle 82.2 mm

Transpiration (Tr) 1.4 mm/day

Total (mm) 304.8

Surface Water 0.0 mm

Runoff 0.0 mm

Infiltrated 0.0 mm

Drained 0.0 mm

Capillary Rise 1.4 mm

Groundwater table at 2.00 m

Irrigation events

Numerical output

Main Menu

Update



Simulation outputs: crop development & production

Step 1: click on **Numerical output**

Numerical output

Main Menu

Update

Daily

Crop development and production

Time Aggregate

Day

10-day

Month

Year

Range

From 1 May 1986

To 18 August 1986

Select Output File

☒ Crop development and production

☐ Profile/Root zone soil water center

☐ Soil water balance

☐ Climate input data

☐ Compartments soil water center

☐ Net irrigation requirement

Legend

Day	Month	Year	DAP	Stage	Kc(Tr)	Trx	Tr	TrW	Tr/Trx	WP	Biomass
1	5	1986	1	1	-	mm	mm	mm	%	g/m2	ton/ha
2	5	1986	2	1		0.0	0.0	0.0	100	17.0	0.000
3	5	1986	3	1		0.0	0.0	0.0	100	17.0	0.000
4	5	1986	4	1		0.0	0.0	0.0	100	17.0	0.000
5	5	1986	5	2	0.01	0.0	0.0	0.0	100	17.0	0.002
6	5	1986	6	2	0.02	0.1	0.1	0.1	100	17.0	0.005
7	5	1986	7	2	0.02	0.1	0.1	0.1	100	17.0	0.008
8	5	1986	8	2	0.02	0.1	0.1	0.1	100	17.0	0.012
9	5	1986	9	2	0.02	0.1	0.1	0.1	100	17.0	0.016
10	5	1986	10	2	0.03	0.2	0.2	0.2	100	17.0	0.020

Scroll

up

down

Scroll to date

OK

Step 2: click on **Main Menu**, click on **Yes** and save **seasonal results**

Exit simulation run

Save output on disk ?

No

Yes

Save:

☒ seasonal results

☐ daily results

☒ evaluation of simulation results

Cancel

Exit run

Step 3: click on **Output files**, and verify the output file.
Name the file **"FIRST SIMULATION"**

Step 4: click on **Exit run**

Output files

Common part File Name

TOPHATOCORDOBA

Assign

Output files

seasonal results

☒ Totals simulation runs

file name

TOPHATOCORDOBARun.OUT

daily results

all

Climate input data

Crop development and production

Parameters of the soil water balance

Soil water content (profile and root zone)

Soil balance (profile and root zone)

Soil water content (compartments)

Soil salinity (compartments)

Net irrigation requirement

TOPHATOCORDOBASim.OUT

TOPHATOCORDOBACrop.OUT

TOPHATOCORDOBASWbal.OUT

TOPHATOCORDOBASWvol.OUT

TOPHATOCORDOBASalt.OUT

TOPHATOCORDOBASWWC.OUT

TOPHATOCORDOBASWEC.OUT

TOPHATOCORDOBASaltE.OUT

Cancel

OK

Thank you!

Contact details:

jorge.alvarbeltran@fao.org

riccardo.soldan@fao.org