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Crop Module 1
Introduction to AquaCrop

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Content

- Practical applications of crop models
- AquaCrop compared to other models
- How do crop models work?
- AquaCrop: user interface
- AquaCrop: climate module
- AquaCrop: crop module

Crop models: what are they useful for?

Crop models are sets of mathematical equations that represent processes within a predefined plant system as well as the interactions between crops and its environment.

Crops models can contribute to agriculture in many ways:

- understanding crop responses to environmental changes;
- comparing attainable and actual yields;
- identifying constraints to crop producton and water productivity;
- developing irrigation schedules for maximizing production;
- studying the effect of climate change and promote agricultural transformation;
- supporting decision-making on water allocations and water related policies;

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Some of the most widely used crop models

Model name	Main features/advantages	Link
AquaCrop	Crop-water productivity	link
AEZ	Maximum potential yield	link
APSIM	Crops and agricultural inputs	link
EPIC	Focuses on soil erosion	link
DSSAT	Crop growth and development	link
CropSyst	Effect of management on productivity	link

Useful overview of crop models

AquaCrop compared to other crop models

- AquaCrop produces much finer outputs (for site-specific locations) than other models and, as a result, its spatial applications are narrower.
- AquaCrop does not consider the leaf area index (LAI) as done by many other crop simulation models (i.e., GAEZ, DSSAT and CropSyst)
- Uses a relatively low number of parameters and mostly-intuitive input variables that can be determined by simple methods.
- AquaCrop simulates one crop at the time and cannot run multiple crops for comparative economic assessments (GAEZ).
- AquaCrop considers abiotic/biotic stresses (temperature & weeds), while other models do not (WOFOST)
- AquaCrop does not take into account other reducing factors such as pests and diseases

Limitations of crop models

Every model has its strengths and weaknesses and, therefore, the selection process is a critical step determined by the robustness of the model, as well as on the applications, context and objective of the impact assessment.

A potential threat in crop modelling is that users are not always familiar with the intended use and limitations of each tool and, consequently, are not necessarily aware of the uncertainties associated with their outputs

- A major limitation of crop growth models is the lack of spatial information of the actual conditions of each field or region.
- Many crop-growth models require a significant amount of input data, sometimes difficult to retrieve.
- Many crop-water productivity models lack of a comprehensive fertilizer management and pests and diseases modules.

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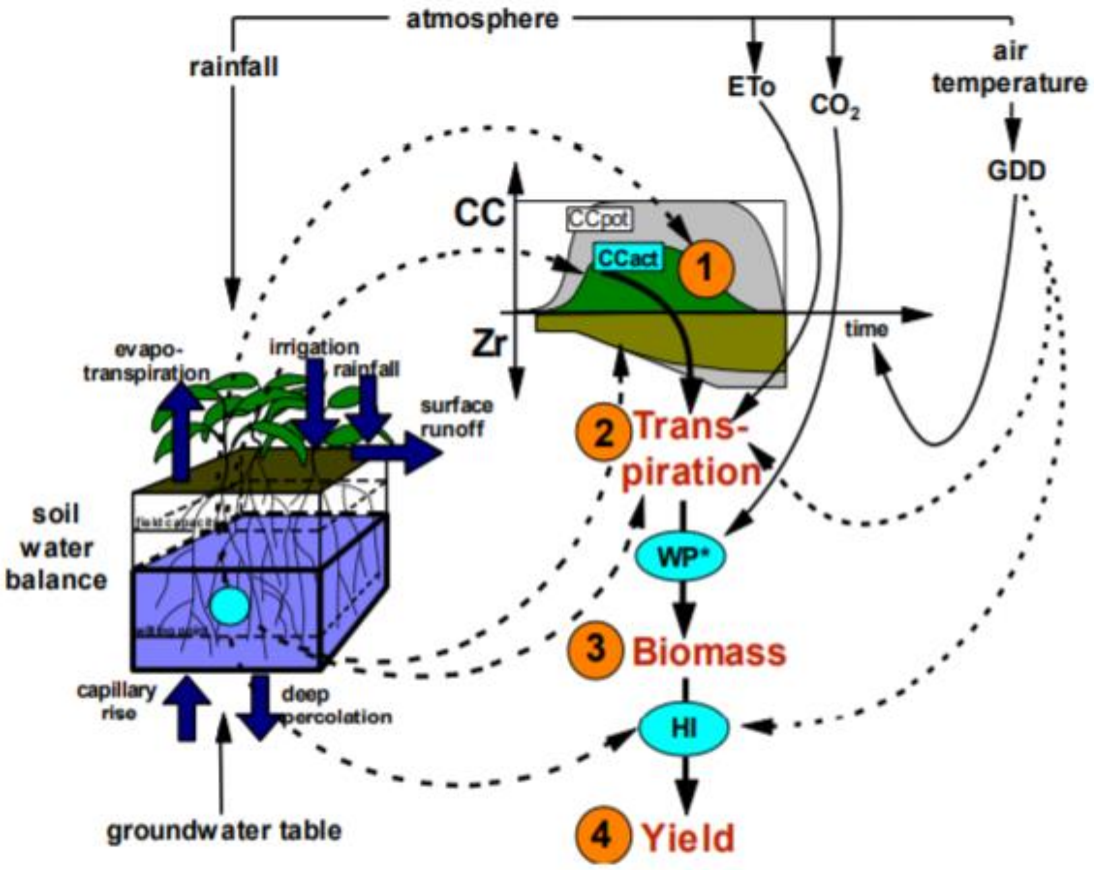
AquaCrop: introduction



AquaCrop simulates crop yield in different steps:

1) crop development
2) crop transpiration
3) biomass production
4) yield formation

<u>Evapotranspiration:</u> location, air temperature, humidity and solar radiation…

Penman Monteith equation:

$$\lambda ET = \frac{\Delta(R_n - G) + \rho_a c_p \frac{(e_s - e_a)}{r_a}}{\Delta + \gamma\left(1 + \frac{r_s}{r_a}\right)}$$

Data used for this simulation

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

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

Management module:

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

Soil module:

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

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The core of the model

DATA	02/05/2018 10:20	Carpeta de archivos	
IMPORT	02/05/2018 10:20	Carpeta de archivos	
OBS	02/05/2018 10:20	Carpeta de archivos	
OUTP	02/05/2018 10:20	Carpeta de archivos	
SIMUL	02/05/2018 10:20	Carpeta de archivos	
_DEISREG.ISR	02/05/2018 10:29	Archivo ISR	1 KB
_ISREG32.DLL	23/04/1997 1:16	Extensión de la ap...	40 KB
AquaCrop	02/05/2018 9:35	Aplicación	12.867 KB
AquaCrop	20/12/2006 9:15	Icono	2 KB
DelsL1.isu	02/05/2018 10:29	Archivo ISU	10 KB

Step 1: open the AquaCrop folder in your desktop

Step 2: launch AquaCrop

PaddyRiceGDD.CRO	17/04/2017 16:42	Archivo CRO	7 KB
Patancheru.CLI	29/01/2009 12:12	Archivo CLI	1 KB
Patancheru.ETo	29/01/2009 12:12	Archivo ETO	3 KB
Patancheru.PLU	29/01/2009 12:12	Archivo PLU	2 KB
Patancheru.TMP	29/01/2009 12:12	Archivo TMP	4 KB
ModerateSF.MAN	17/04/2017 11:15	Archivo MAN	1 KB
Sand.SOL	17/04/2017 10:02	Archivo SOL	1 KB
RCP8-5.CO2	12/07/2015 14:12	Archivo CO2	3 KB
TR2a.IRR	31/12/2009 10:38	Archivo IRR	1 KB
WPSandLoam.SW0	24/12/2011 7:14	Archivo SW0	1 KB

Many of these files (ETO, PLU, TMP) are automatically created by AquaCrop when preparing the climatic files.

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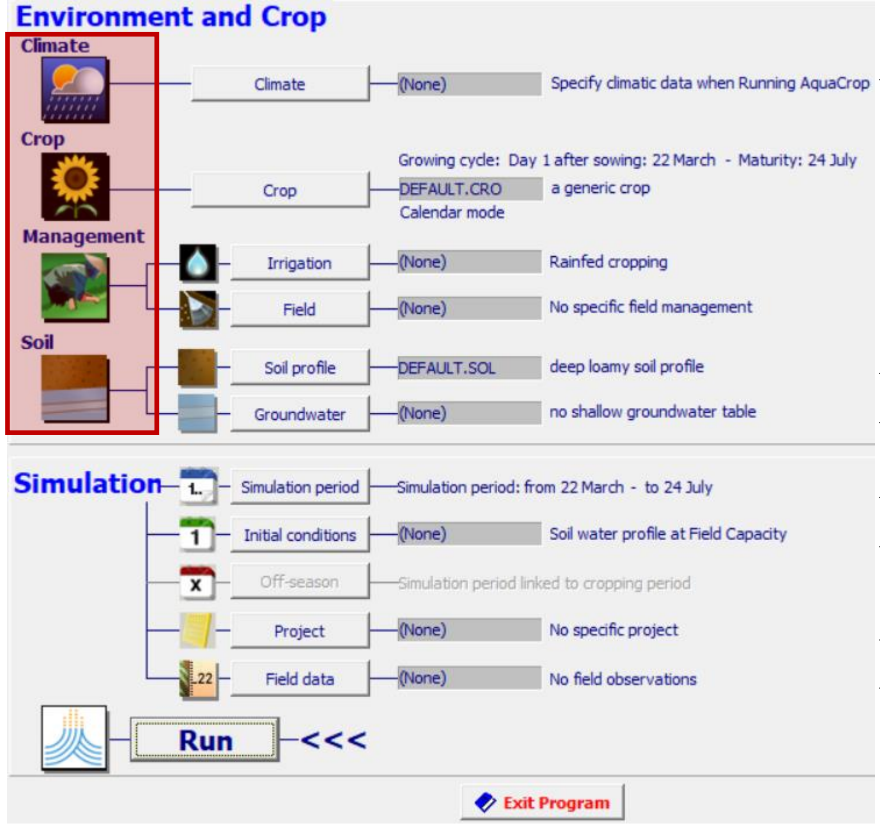
AquaCrop: the interface

Step 1: open AquaCrop, select the language and click on **start**



← Weather data collected in the field and or from gridded/point geospatial climate datasets.

← Observed crop characteristics

← Irrigation method, application depth & time etc.

← Soil fertility & practices affecting soil-water balance

← Soil profile characteristics (texture, FC, PWP, SAT)

← Water depth below soil surface and soil salinity

← Simulations coinciding with the growing cycle of the crop

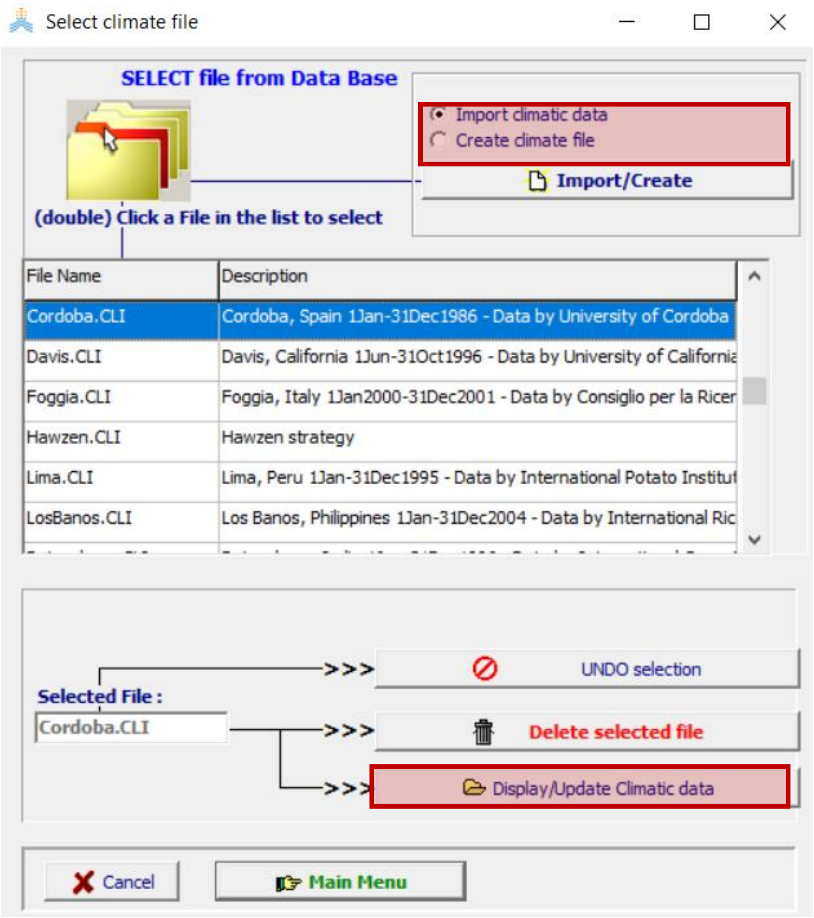
← Soil water content at the date of sowing

← Aggregation of the above files into one project file

← Observations from the field (CC, Biomass and SWC)

Climate module: selecting a climatic file

Steps 1-2: click on the **climate** module and then click on **select/create climate file**

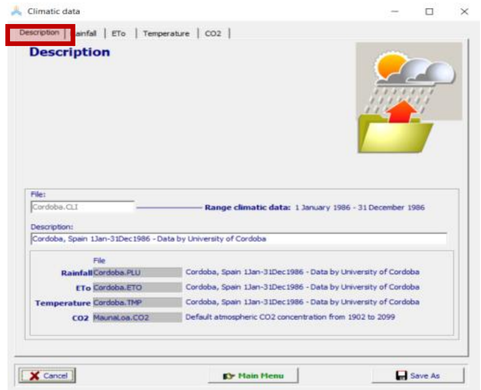


Remember! We are importing default climatic files from AquaCrop, we are not creating them…

Step 3: click once (but not twice!) on the climatic file of **Córdoba, Spain**

Step 4: click on **display/update climatic data**

Climate module: climate data

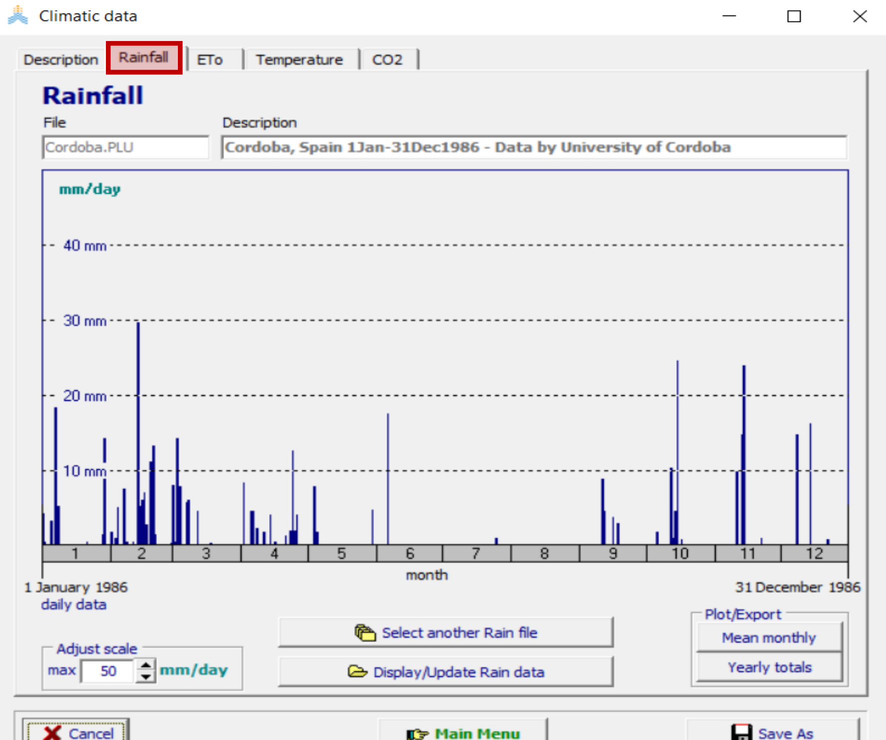


Step 1: click on **description**

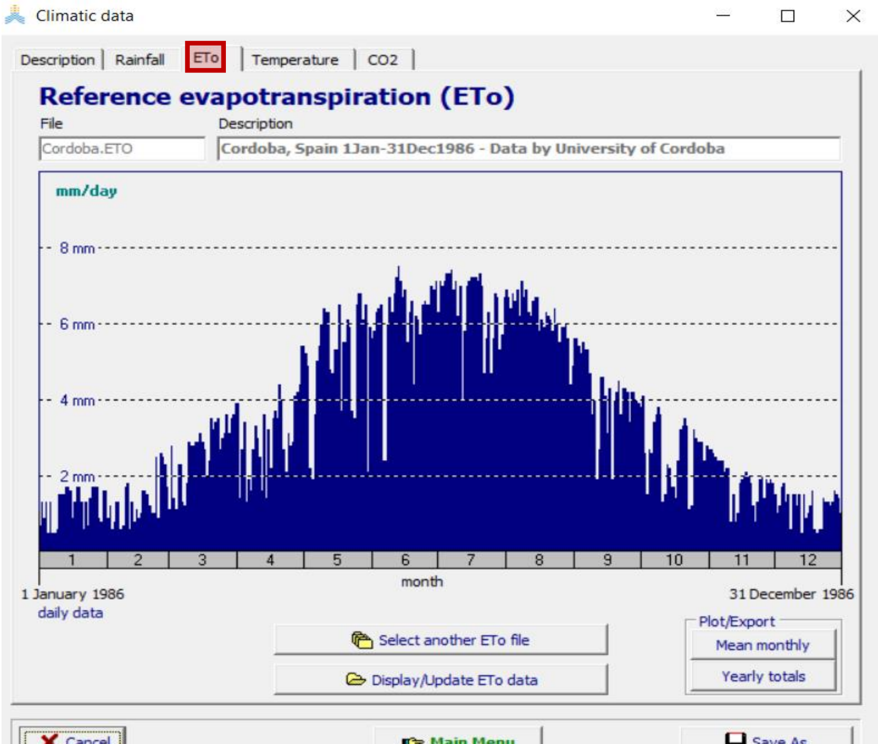
Here you will find all the files within the selected climatic folder, each of these files with its respective extension: PLU, ETO, TMP, CO2…

We will be running simulations for the summer of 1986!

Step 2: click on **rainfall**



Step 3: click on **ETo**



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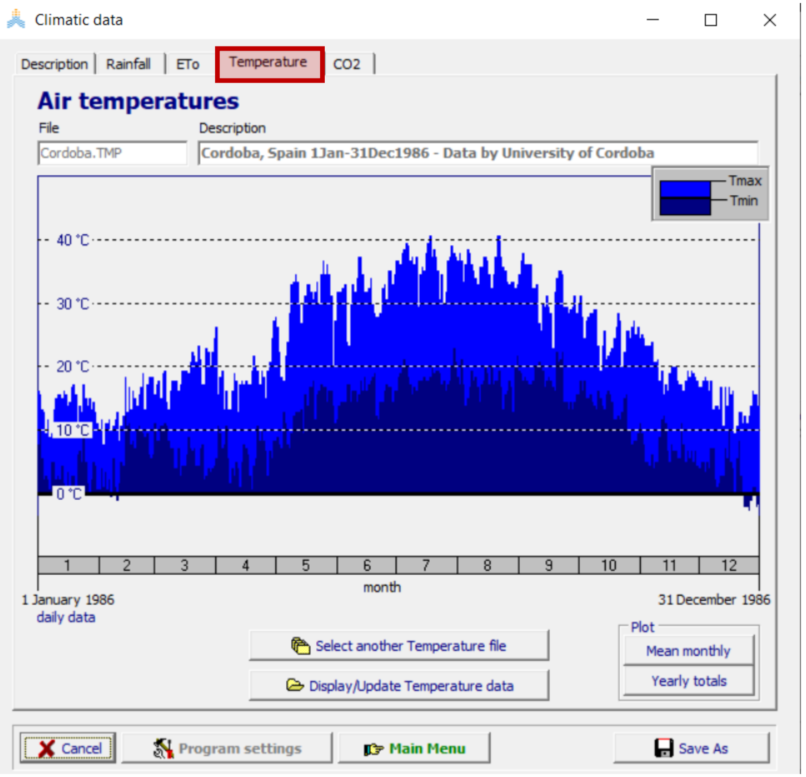
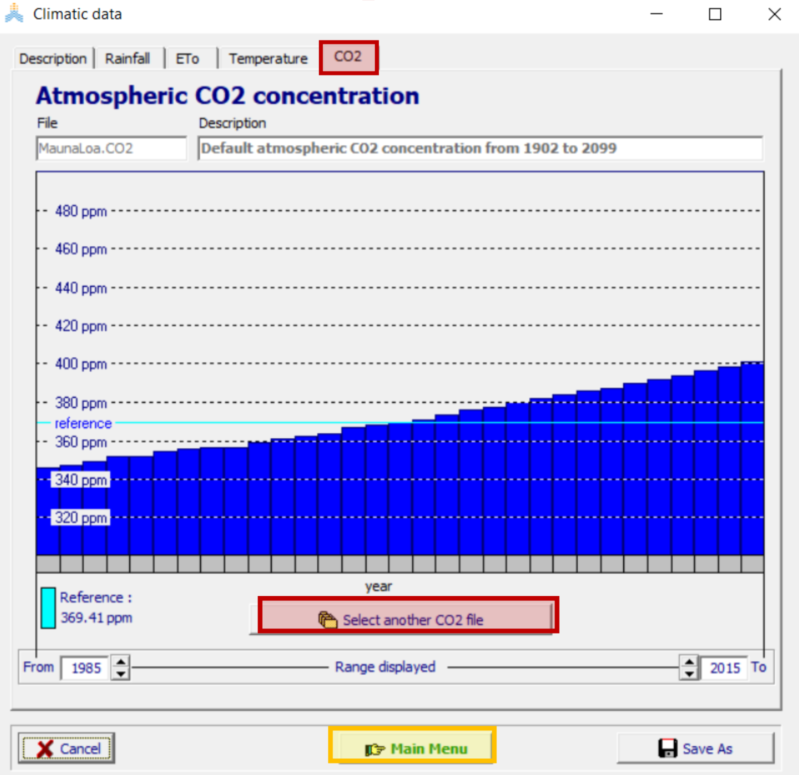
Climate module: climate data

Step 1: click on **temperature**

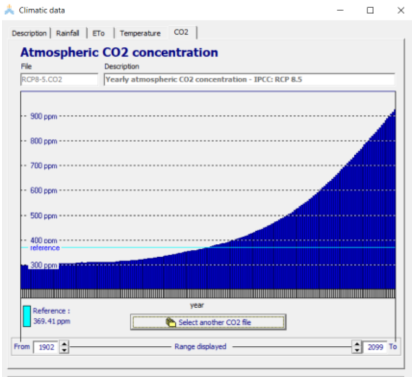


Step 2: click on CO_2



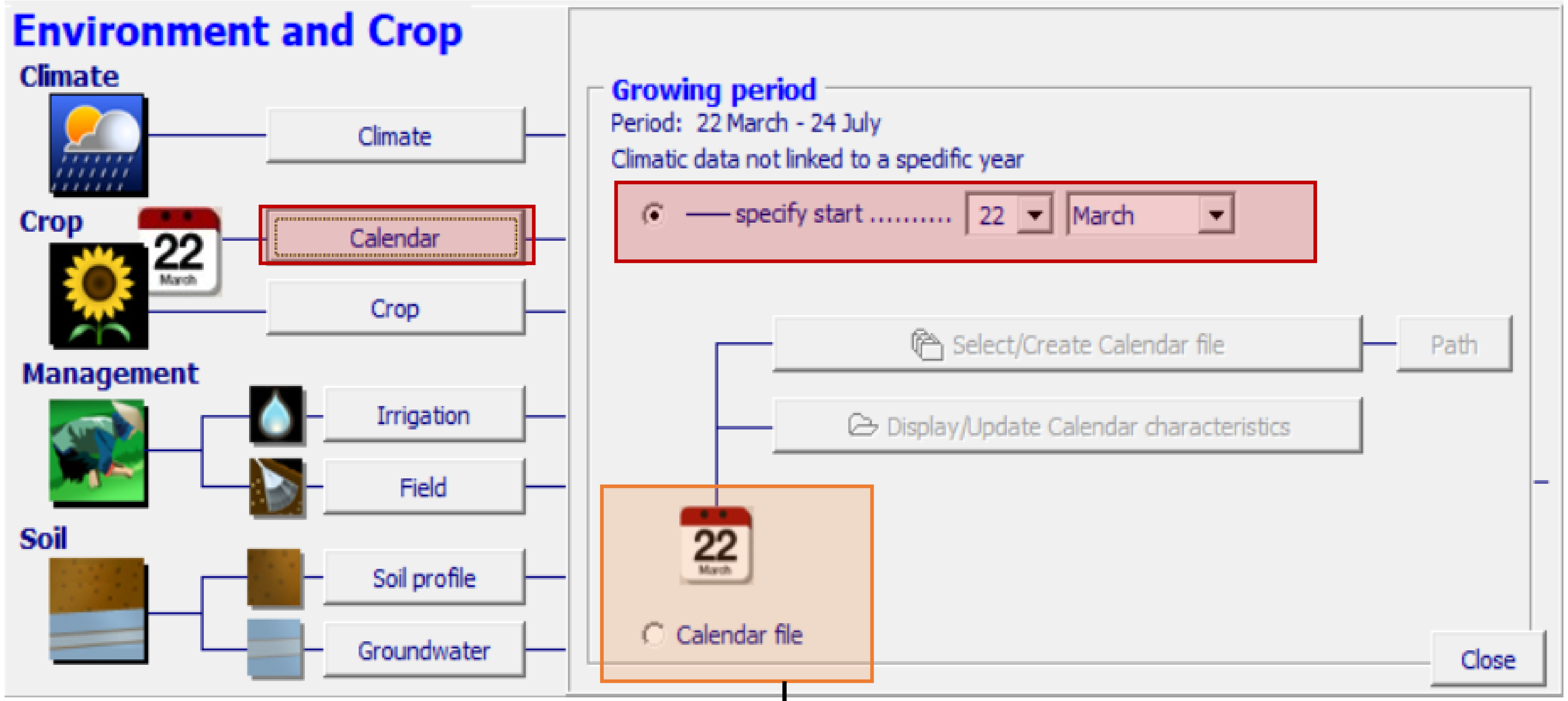
RCP 2.6
RCP 4.5
RCP 6.0
RCP 8.5

Step 3: test another CO_2 file



Crop module: calendar information

Step 1: click on **calendar** and select a **sowing date**

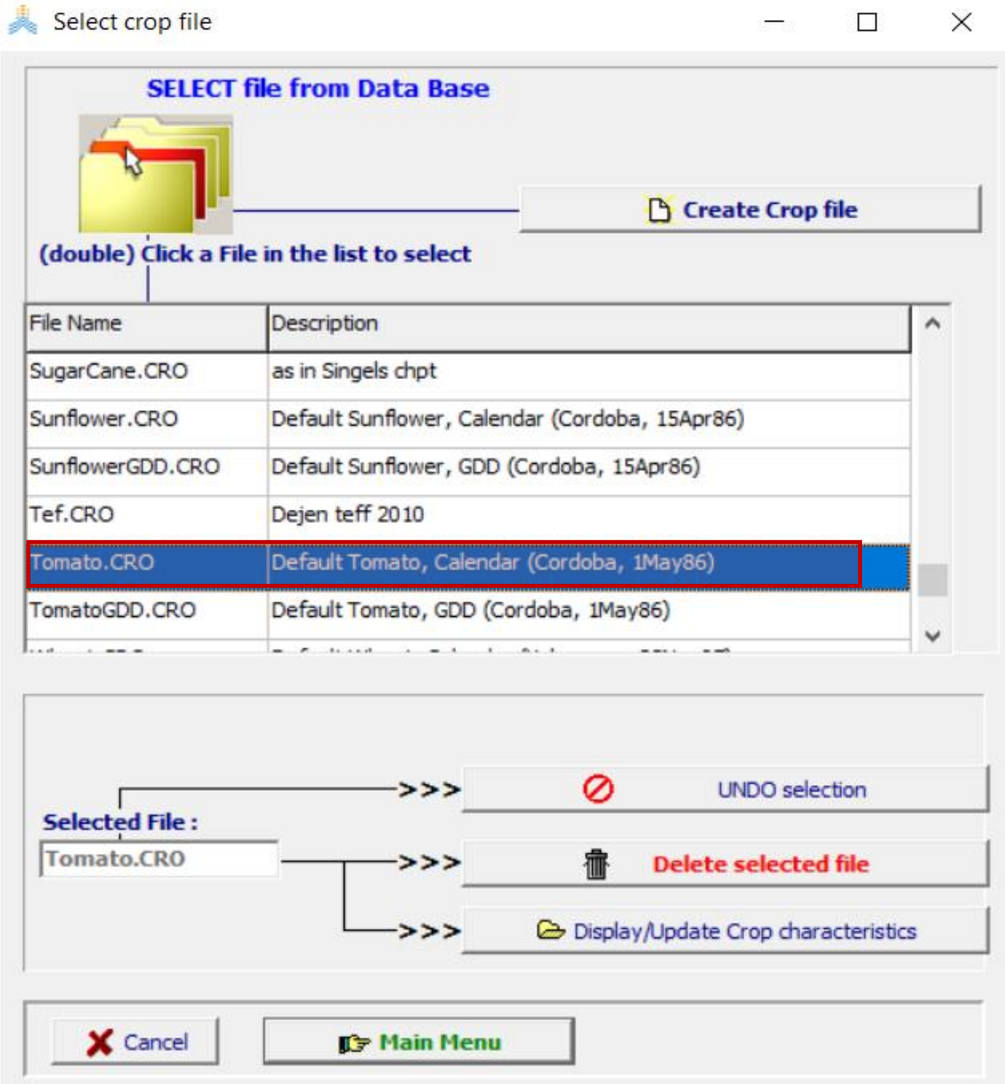


__Sowing date:__ it needs to be within the timeframe of the climatic file!

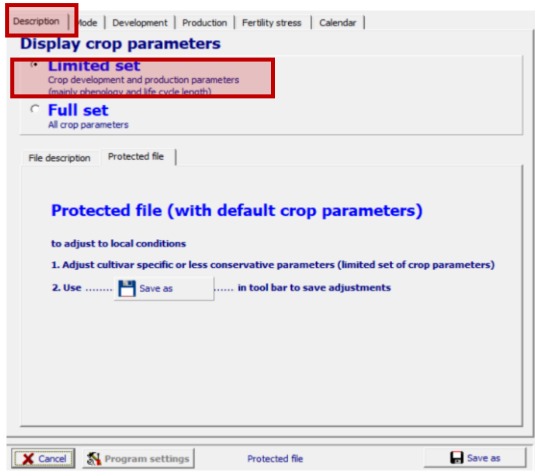
You can also create your own calendar file (for advanced users!)

Crop module: crop information

Step 1: click on **crop** and select **default tomato days**

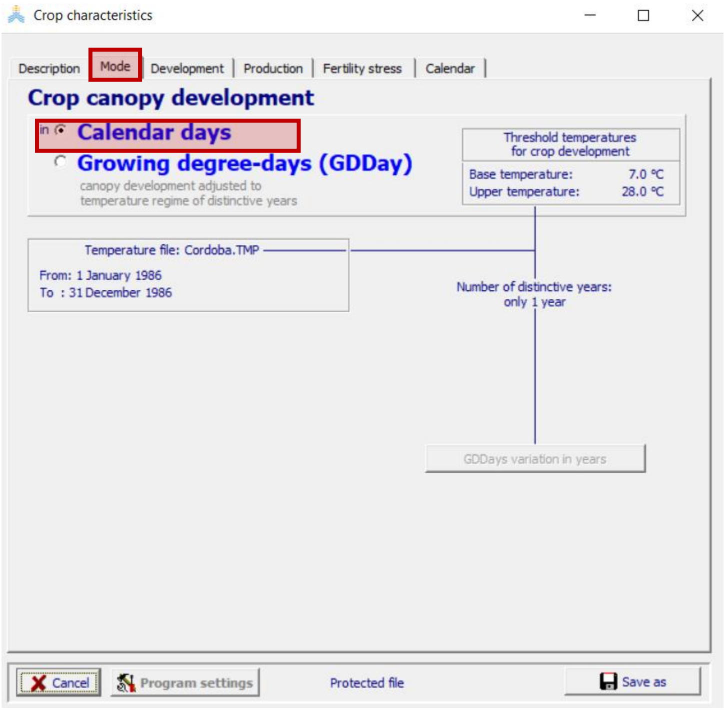


Crop module: crop information



Step 1: click on **limited set**

While **limited set** does not include crop's responses to stresses (water, temperature, salinity, fertility), **full set** does.



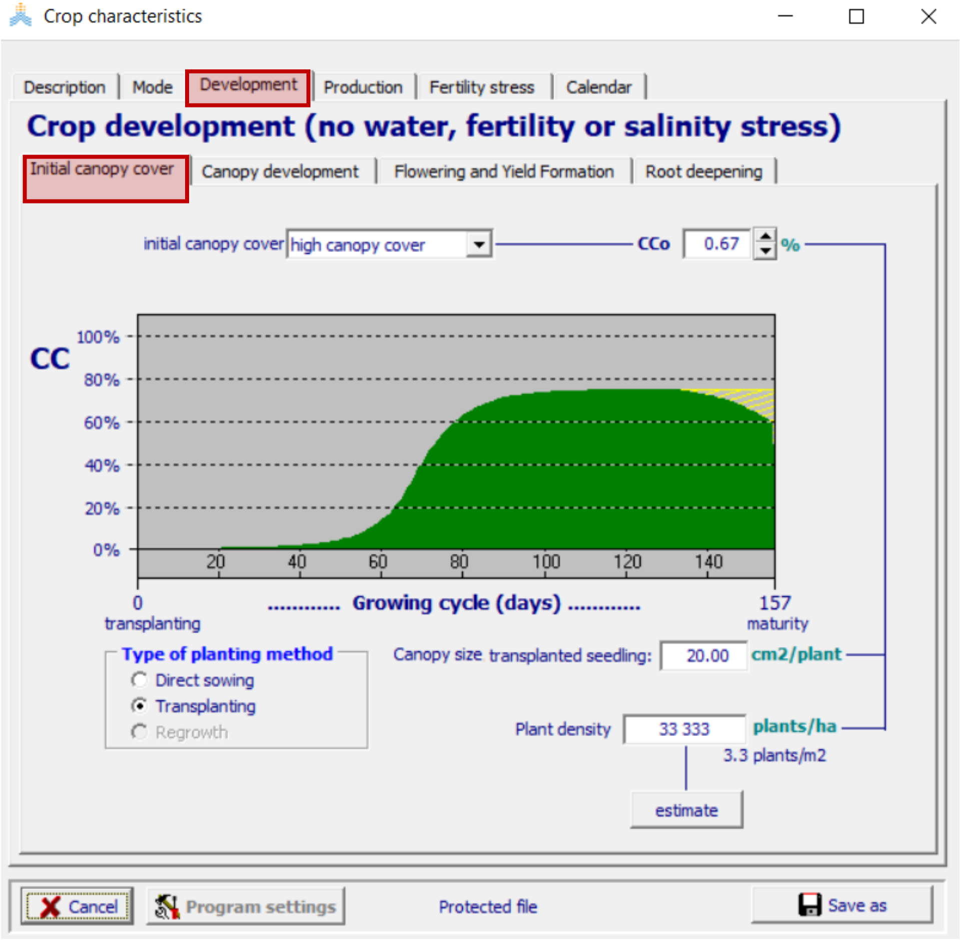
Step 2: click on **mode** and select **calendar days**

The second option is to select GDD (cumulative heat units throughout the growing cycle) (for advanced users!)

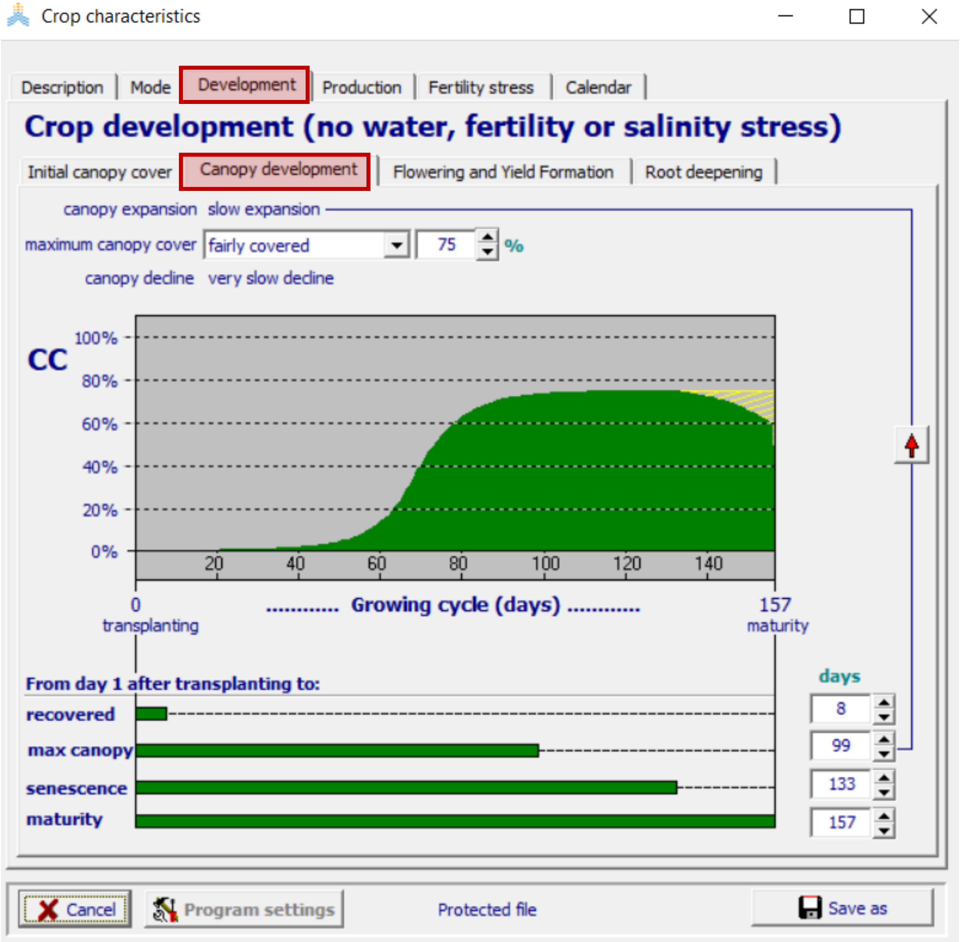
$$\mathrm{GDD} = \left[\frac{(\text{Max Temp} + \text{Min Temp})}{2}\right] - \text{Base Temp}$$

Crop module: crop development

Step 1: click on **development** and then **initial canopy cover**

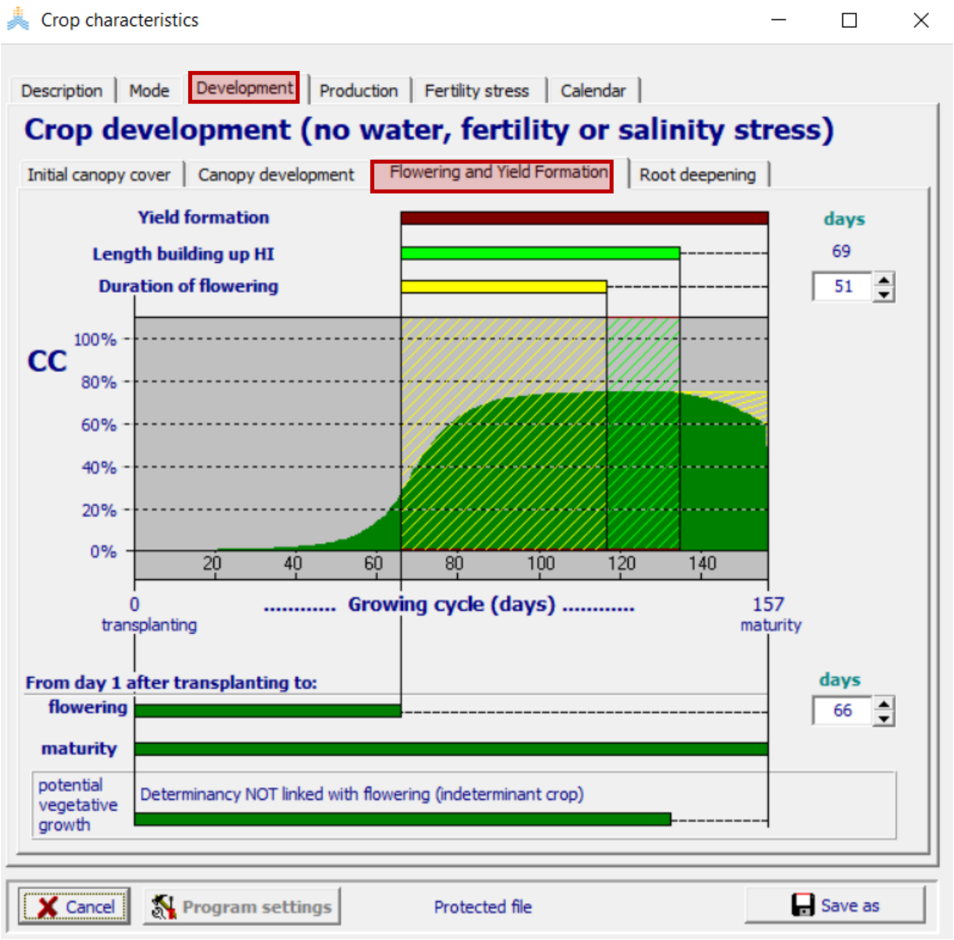


Step 2: click on **development** and then **canopy development**

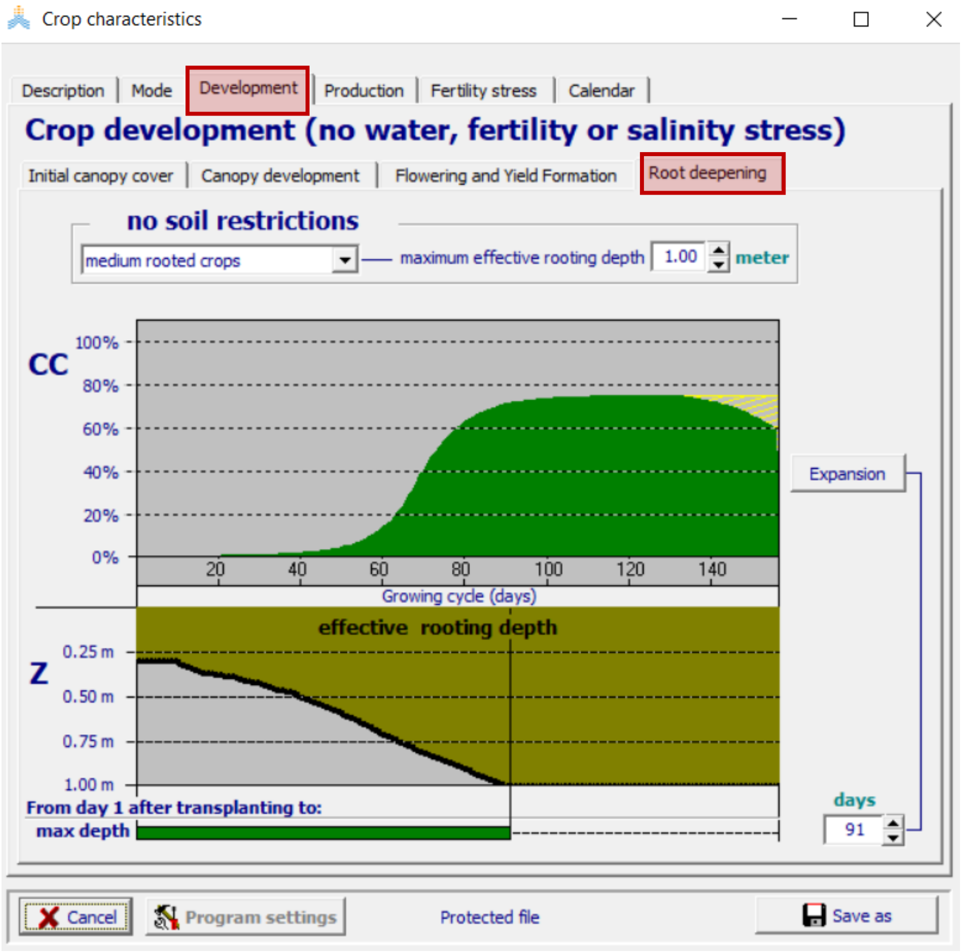


Crop module: crop development

Step 1: click on **development** and then **flowering & yield formation**



Step 2: click on **development** and then **root deepening**



Crop module: crop evapotranspiration

Crop transpiration (Tr) is calculated by multiplying the evaporating power of the atmosphere with the crop coefficient (KcTr) and by considering water stresses (Ks) and temperature stress (KsTr):

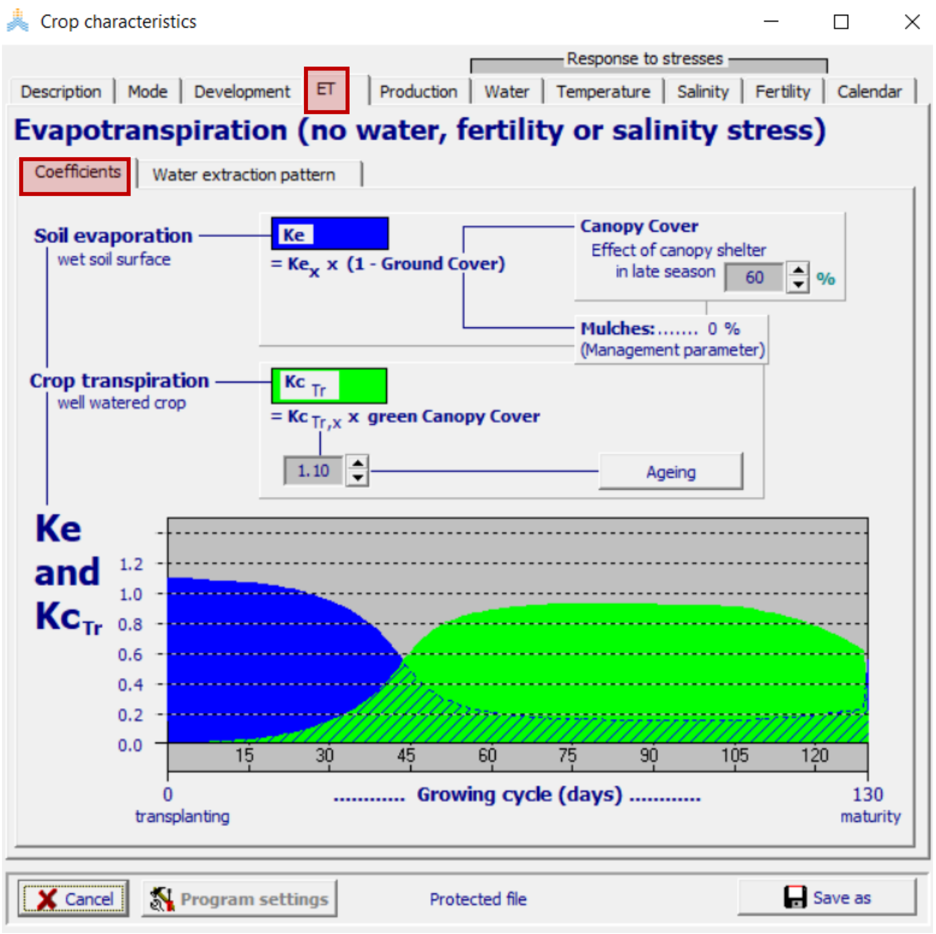
Tr = Ks * KsTr * (KcTr,x CC*) * Eto

where the evaporating power (ETo) is expressed by the reference grass evapotranspiration as determined by the FAO Penman-Monteith equation. The crop transpiration coefficient (KcTr = KcTr,x CC*) is proportional to the fractional canopy cover (CC) and, as such, continuously adjusted to the simulated canopy development.

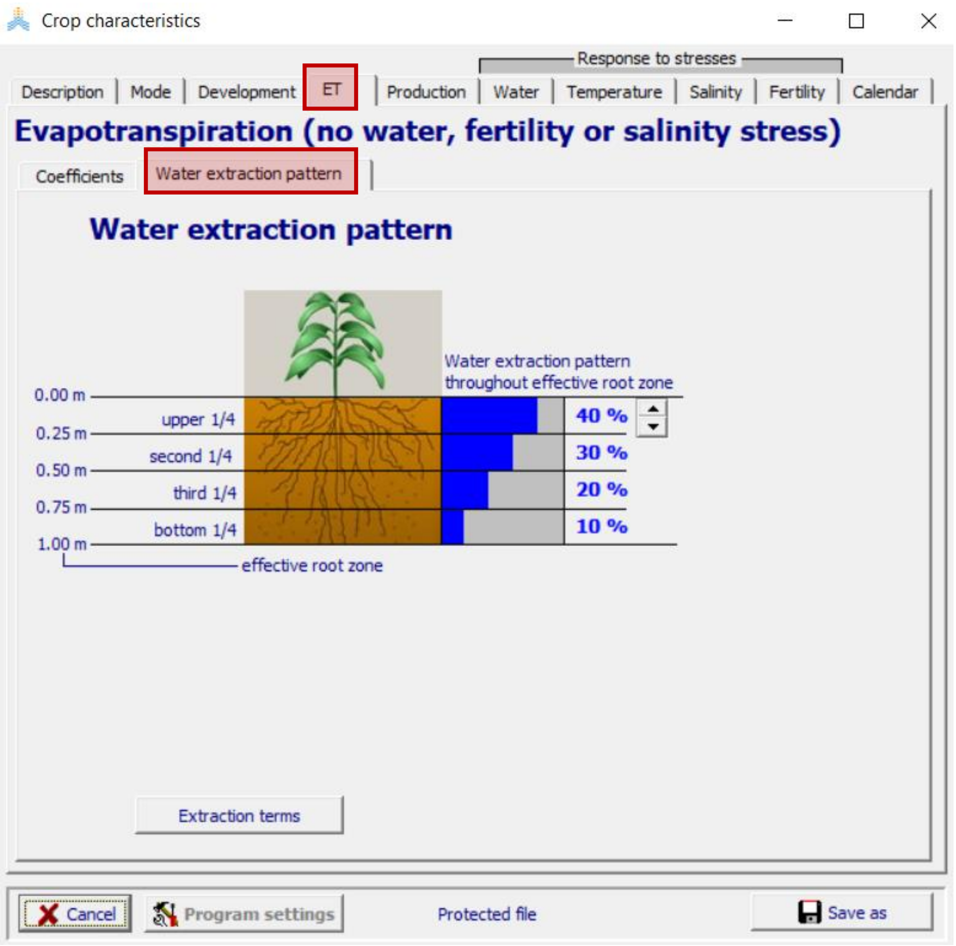
$$\lambda ET = \frac{\Delta (R_n - G) + \rho_a c_p \frac{(e_s - e_a)}{r_a}}{\Delta + \gamma \left(1 + \frac{r_s}{r_a}\right)}$$

Crop module: crop evapotranspiration

Step 1: click on **ET** and then click on **coefficients**

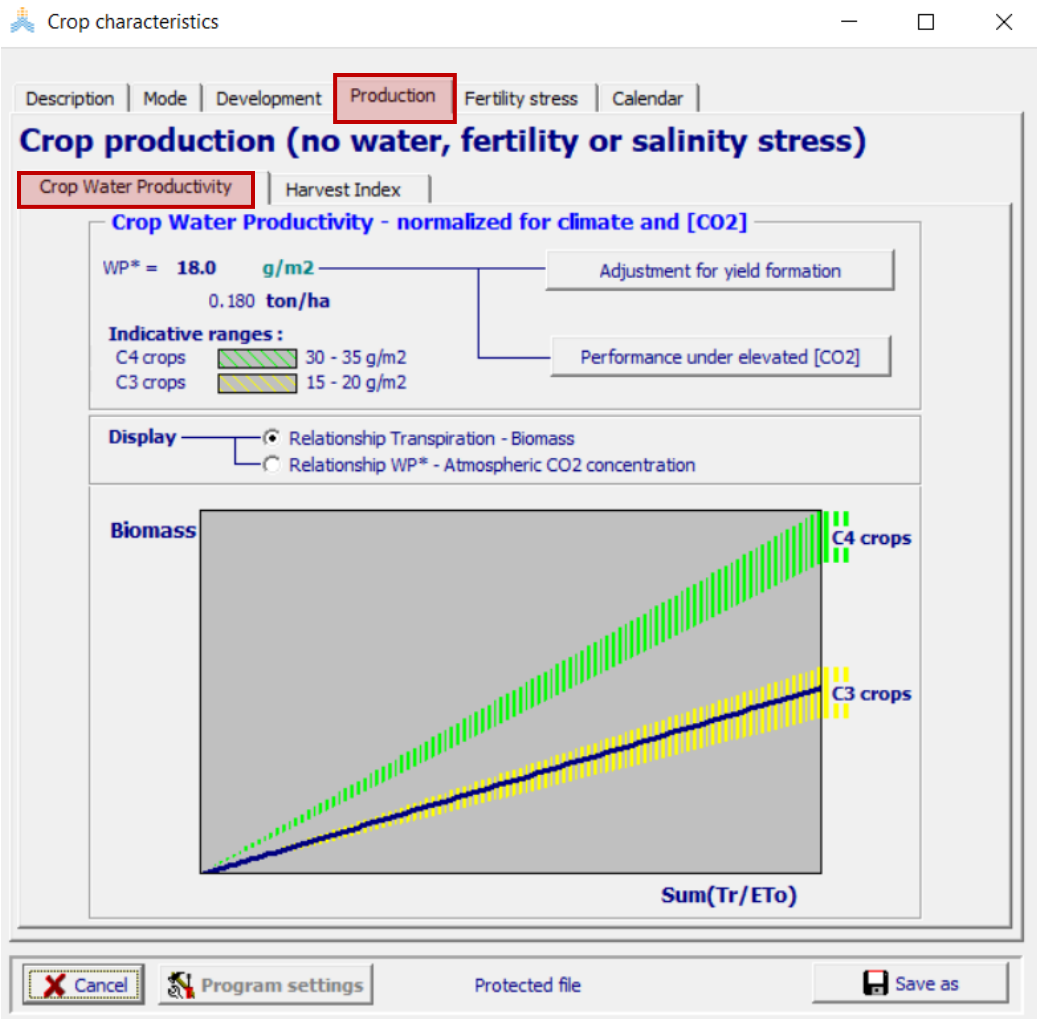


Step 2: click on **ET** and then click on **water extraction pattern**

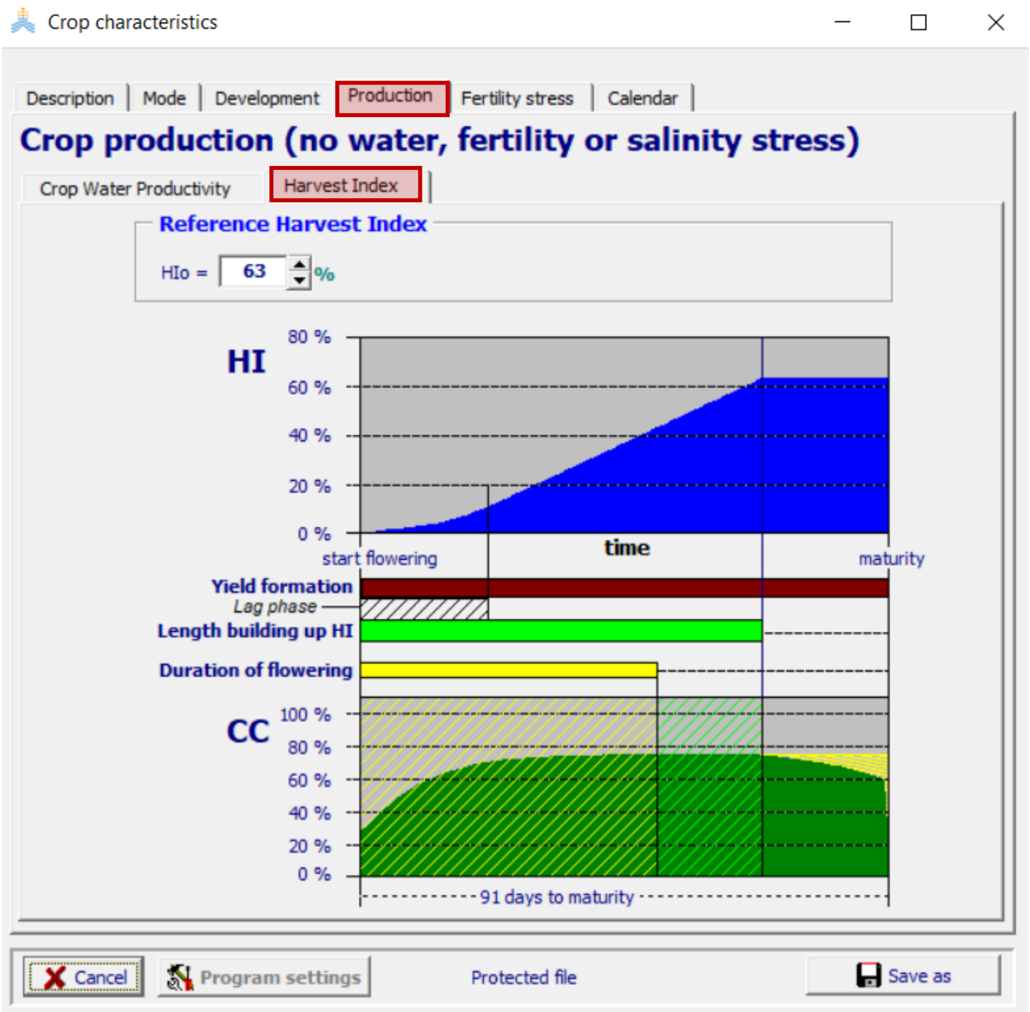


Crop module: crop production

Step 1: click on **production** and then **crop productivity**



Step 2: click on **production** and then **harvest index**



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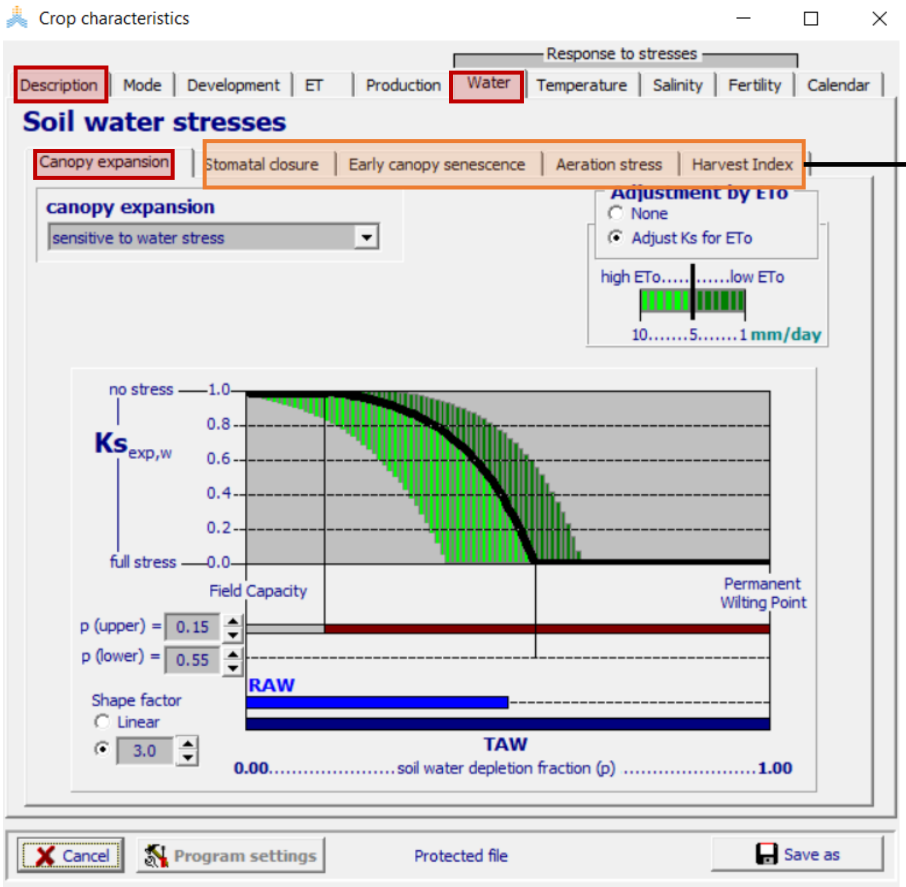
Crop module: soil-water stress

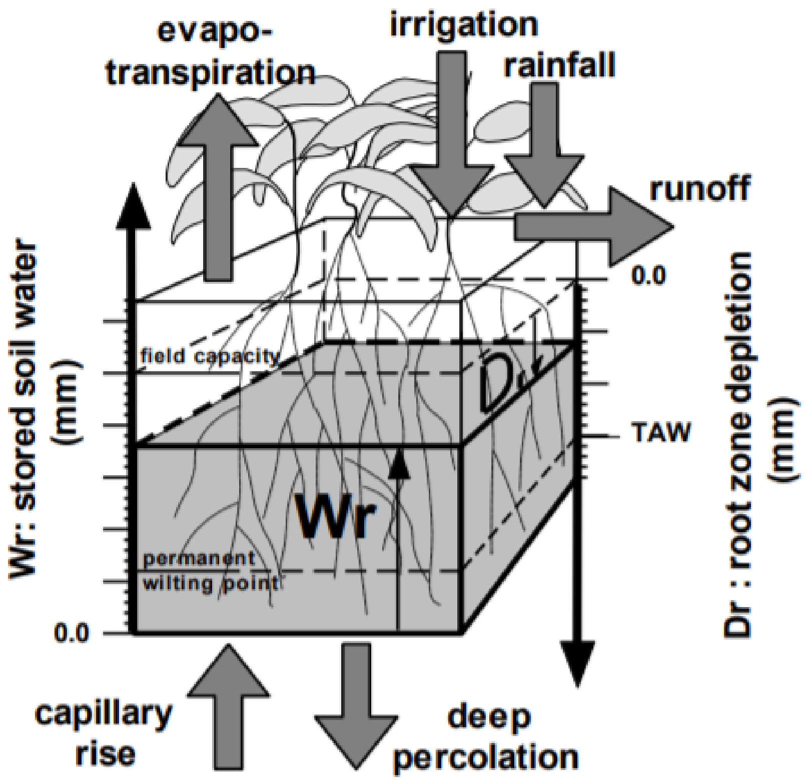
Soil water stress: start to affect a particular process when the stored soil water in the root zone drops below an upper threshold level (FC and PWP)

Step 1: go back to **description** and click on **full set**, then click on **water** and **canopy expansion**



For advanced users!

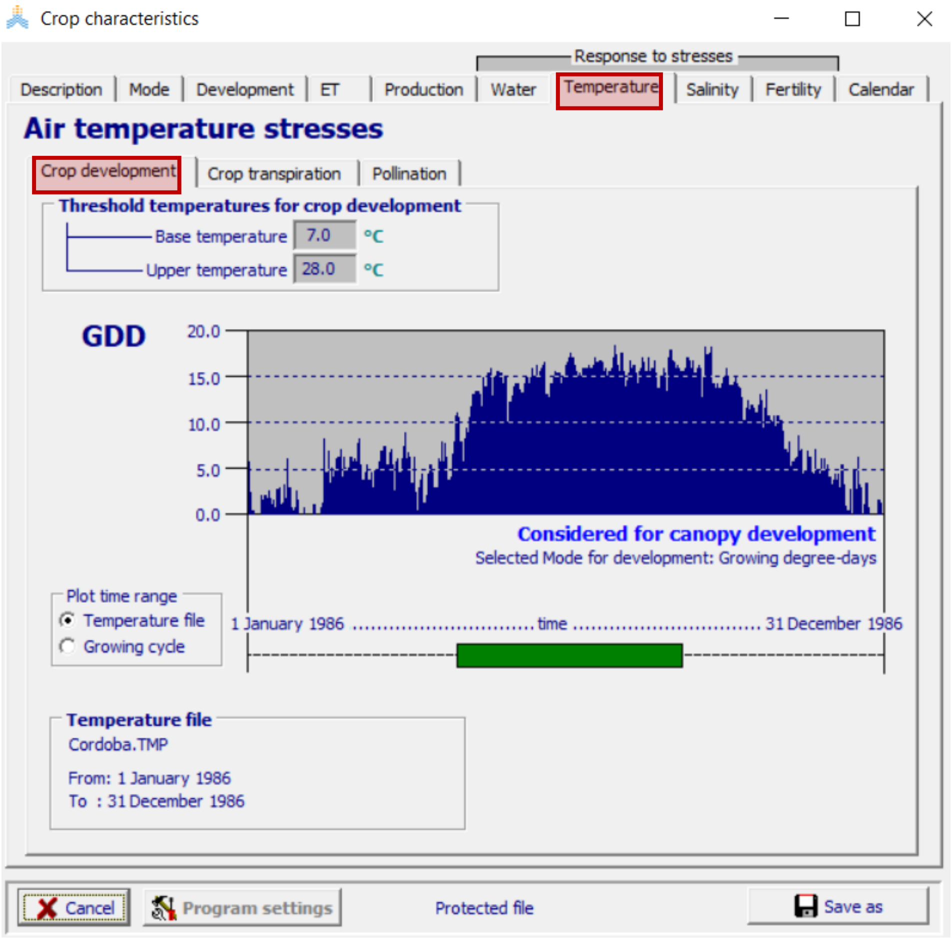
Soil-water balance



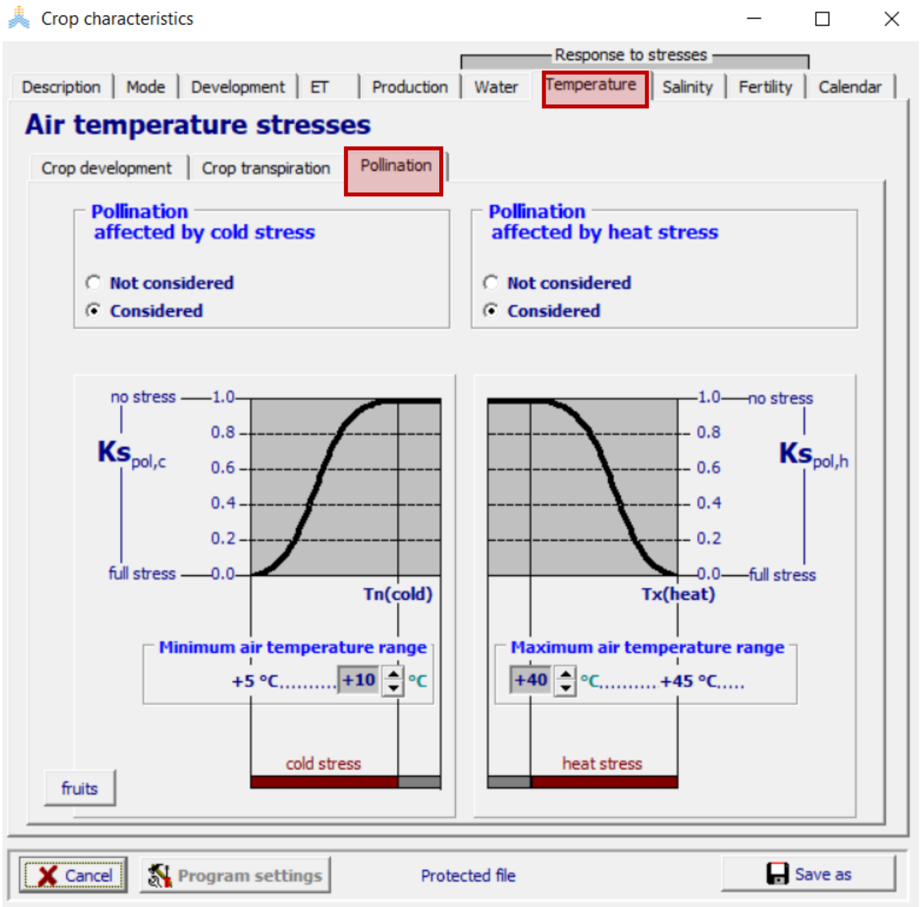
Crop module: temperature stress

Temperature stress: cold temperature stress reduces crop transpiration. Hot and cold temperature stresses inhibit pollination and reduce the harvest index (HI)

Step 1: click on **temperature** and then click on **crop development**



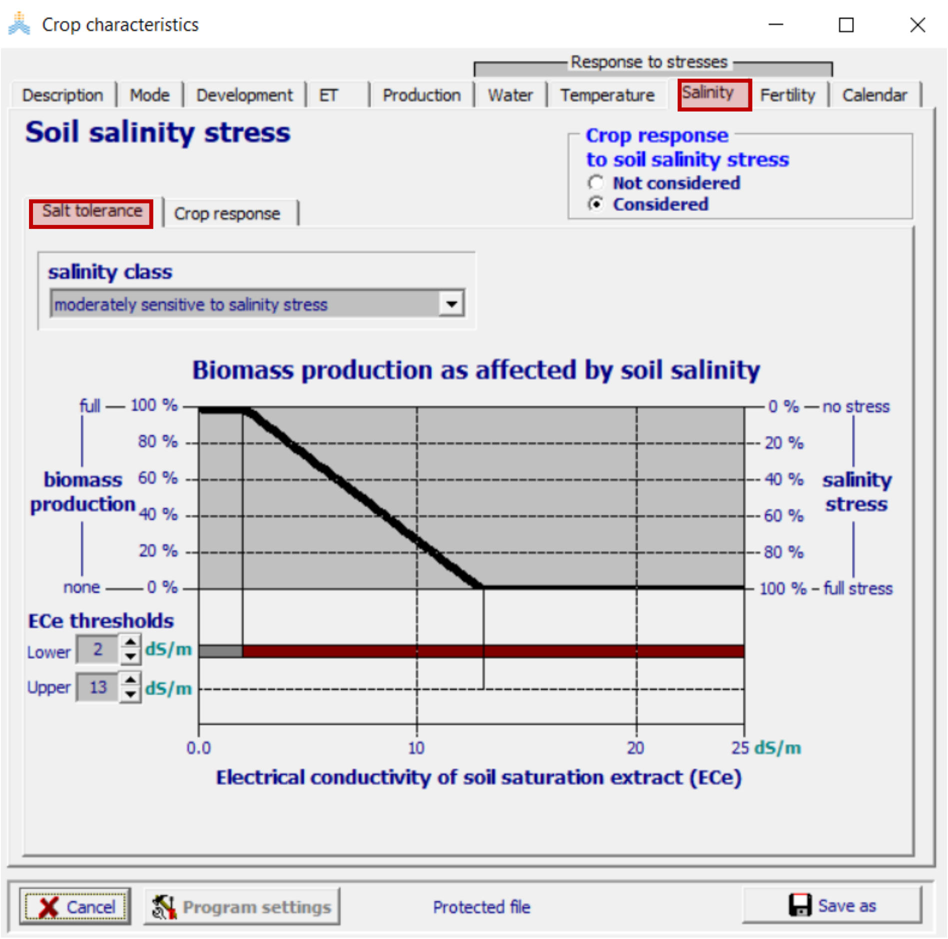
Step 2: click on **temperature** and then **pollination**



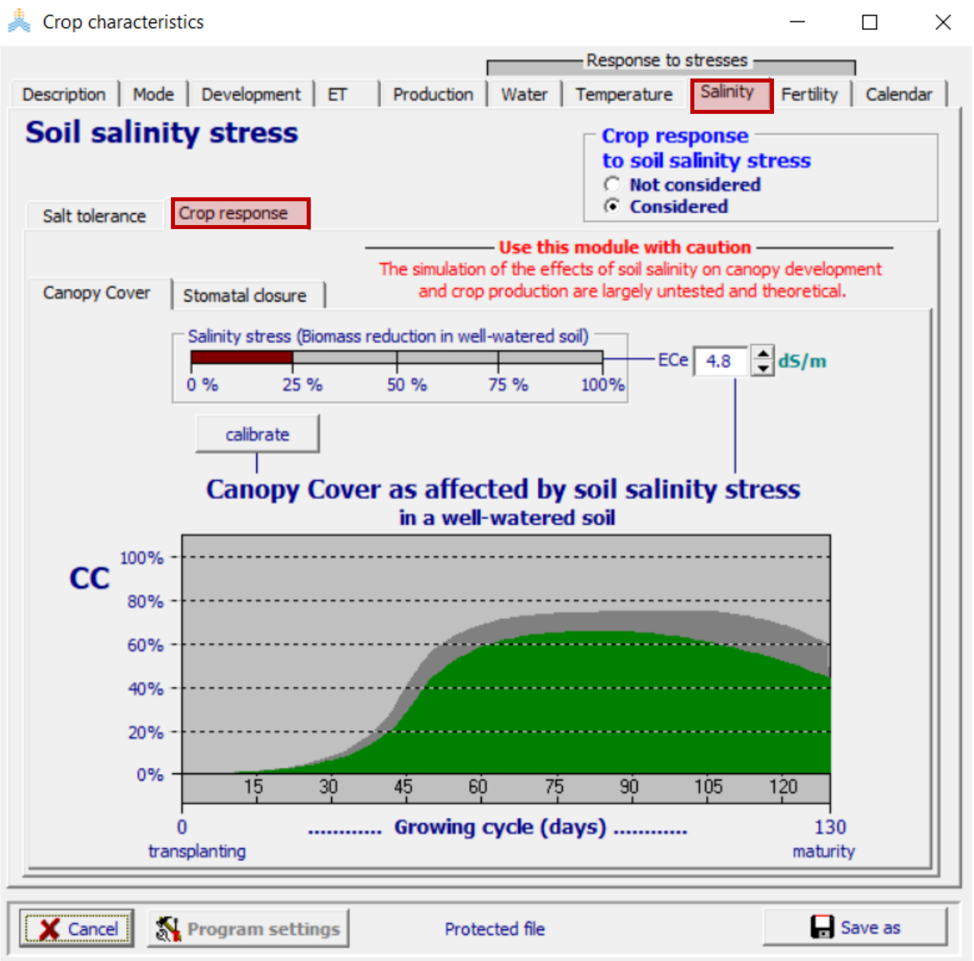
Crop module: salinity stress

Salinity stress: since soil salinity reduces the availability of the water in the root zone reservoir, the presence of dissolved salts increase the effect of soil water stress.

Step 1: click on **salinity** and then click on **salt tolerance**

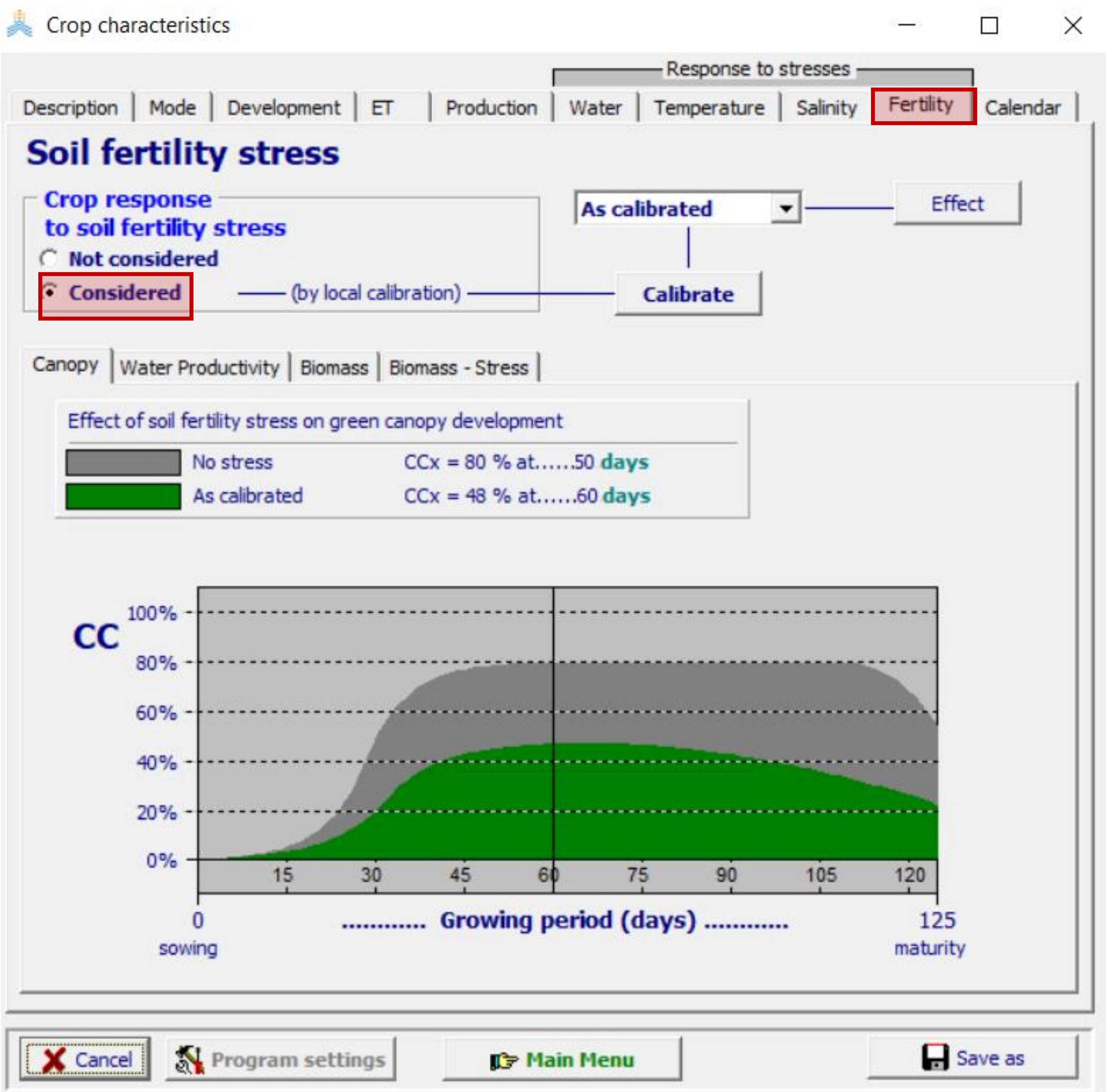


Step 2: click on **salinity** and then click on **crop response**



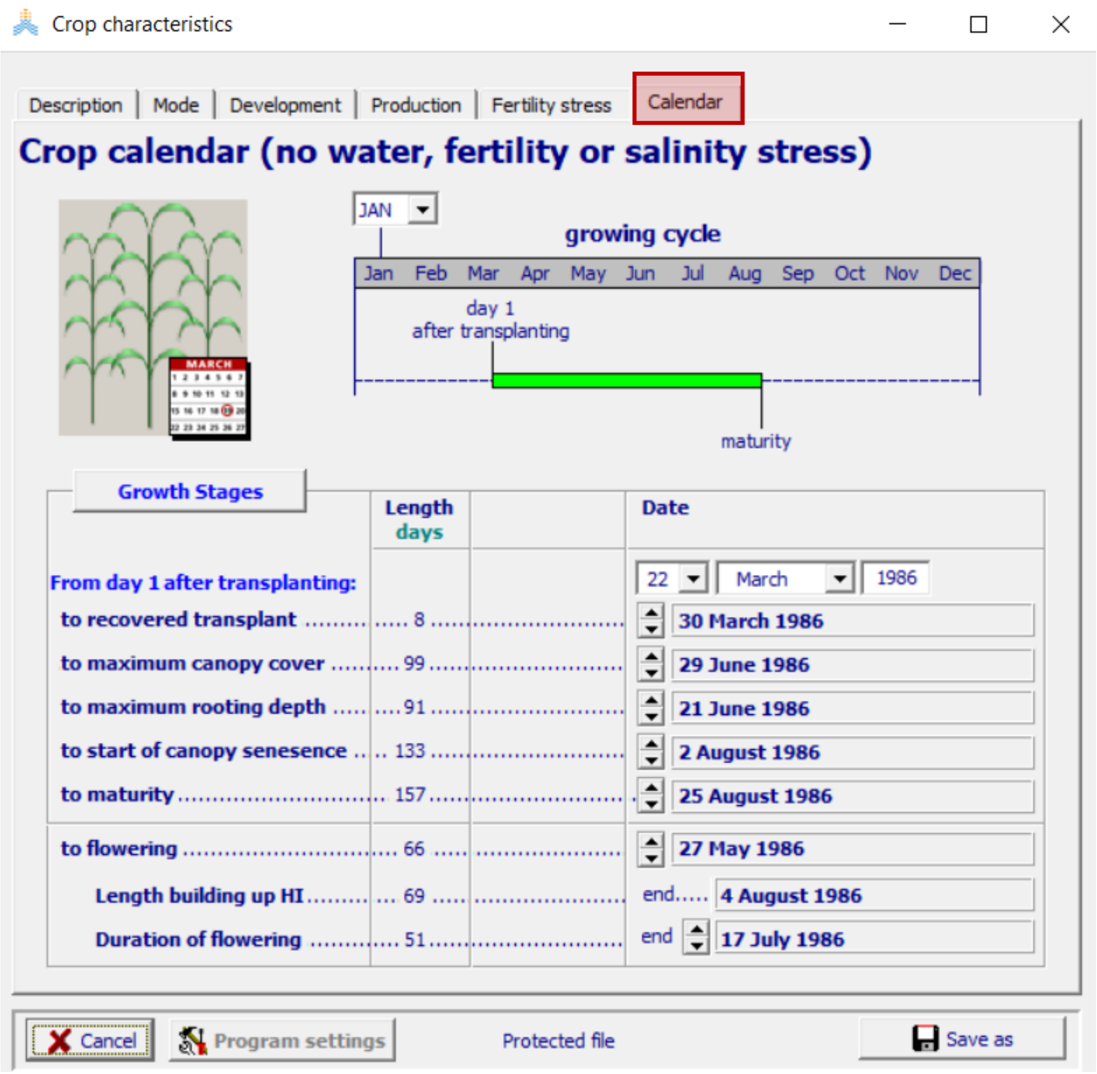
Crop module: soil fertility stress

Step 1: click on **fertility** and then on **considered**



Crop module: calendar information

Step 1: click on **calendar**



Take away messages

- Crop models are essential tools for climate change adaptation.
- Crop models are a simplified representation of the reality.
- The higher the inputs the better the outputs. However, more time consuming and higher processing power required.
- AquaCrop calculates crop ET in four steps: (i) crop development, (ii) crop transpiration, (iii) biomass production, and (iv) yield formation.
- AquaCrop has 4 modules of input requirements: climate, crop, management and soil
    - Climate: rainfall, ETo, temperature and CO_2
    - Crop: planting method/density, plant phenology, production and abiotic stresses (temperature, water and soil fertility/salinity)

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Useful documents

- AquaCrop training handbook: link
- Reference manual version 7:
  - Chapter 1: link
  - Chapter 2: link
  - Chapter 3: link
  - Chapter 4: link
  - Chapter 5: link
  - Annexes: link

- 43 YouTube tutorials on how to use the model: link
- The AquaCrop model – 10 years of enhancing crop water productivity: link