Water and
Environment Support
in the ENI Southern Neighbourhood region

**WES Activity**
**Trainings of Trainers for Palestinian pilot farmers' associations on optimal irrigation management and practices**
2-6 October 2022, Jordan

# Practical applications with AquaCrop

## Simulations worked out during the AquaCrop training workshop at the Dead Sea (Jordan)


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LDK Consultants Global EEIG

In the frame of the AquaCrop training, several practical applications were worked out with the Palestinian participants.

1. Simulation of rainfed winter wheat in the Ramallah region
2. Evaluation of an irrigation strategy to improve the WUE and production of winter wheat in the Ramallah region
3. Assessment of risk on soil salinization
4. Development of an irrigation schedule for cucumber

The main objective of the simulations was to show how practical applications with AquaCrop can be worked out for rainfed agriculture and irrigation strategies and this for several crops cultivated in a particular environment.

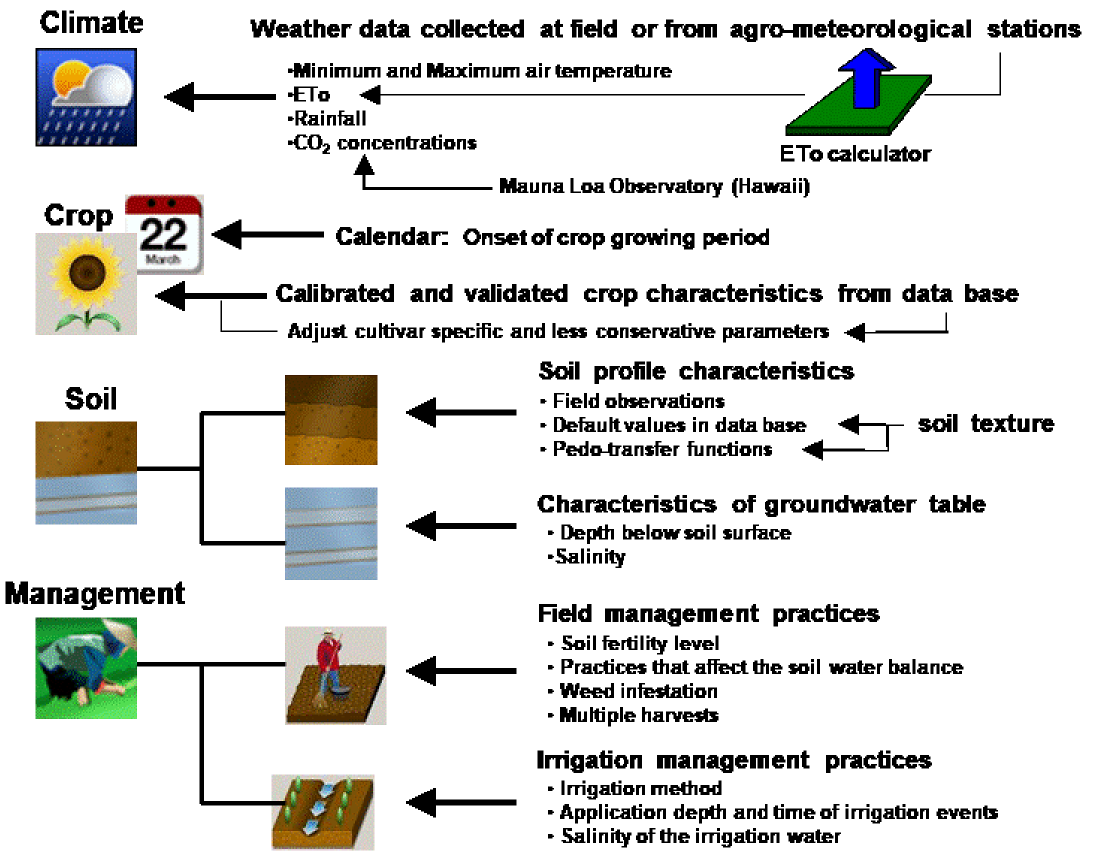
**Warning**

***The quality of the results strongly depends on the quality of the input and the calibration of the crops. In the absence of observed climatic data, the simulations were carried out with generated climatic data. Since field data was missing for crop calibration, the results should be considered with reservation. Nevertheless, it is believed that the simulated trends are valid.***

# 1 Simulation of rainfed winter wheat in the Ramallah region

## 1.1 Input

The environment in which the crop develops, is specified by the user as input. It consists of the crop characteristics and planting/sowing data, characteristics of the soil profile, field management and irrigation management practices. Also, the conditions at the upper boundary (weather conditions) and lower boundary (depth and quality of the groundwater table if present), and the initial soil water conditions in the soil profile at the start the simulation, need to be specified.




*Input data defining the environment in which the crop develops*

In the absence of a long series of observed daily climatic data, historical daily climatic data for 31 years was obtained from NASA Power on Internet (https://power.larc.nasa.gov/data-access-viewer/). Solar and meteorological data sets in support of renewable energy, building energy efficiency and agricultural needs, are made worldwide available by NASA through its POWER ("Prediction Of Worldwide Energy Resources") project.

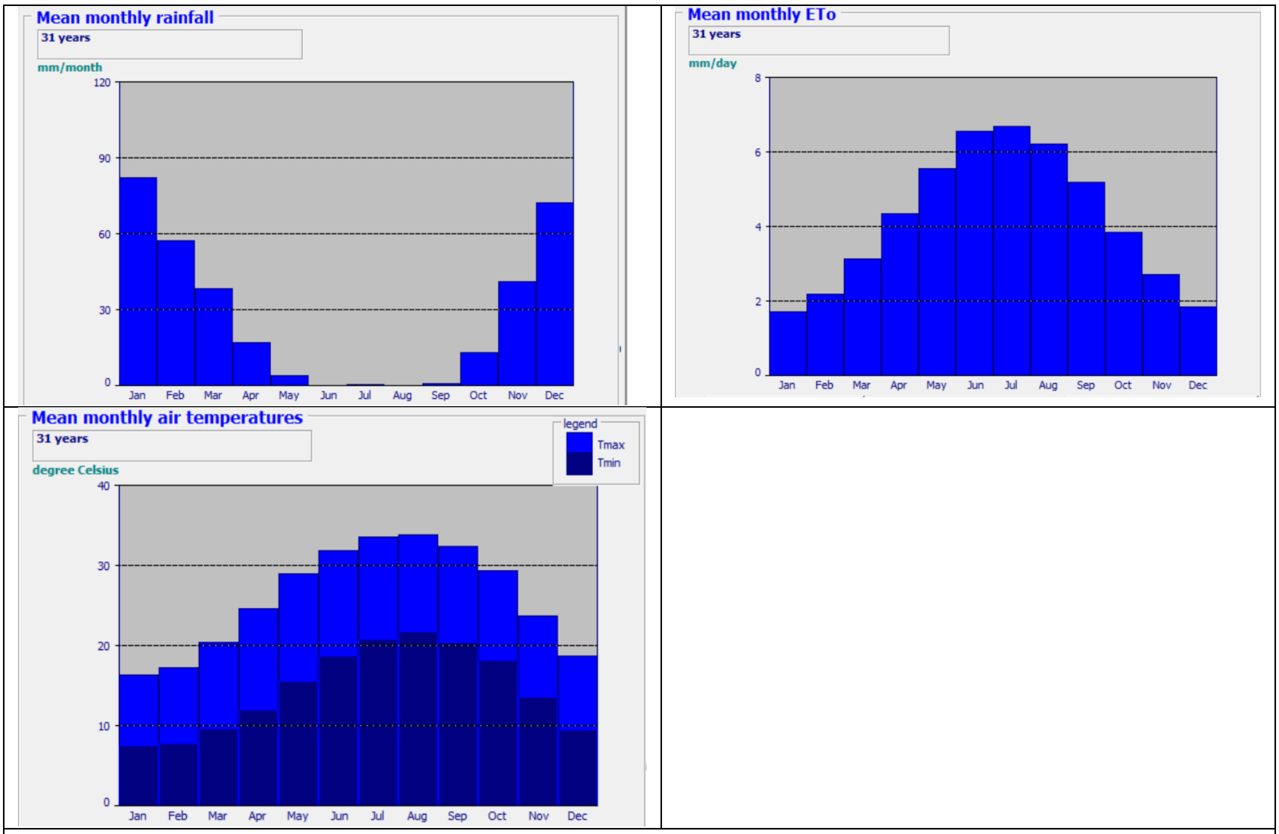
The following daily data from 1 January 1990 to 31 December 2020, were collected for Ramallah:

- all sky surface shortwave downward irradiance (incoming solar radiation),
- maximum and minimum temperature at 2m,
- relative humidity at 2m,
- precipitation and

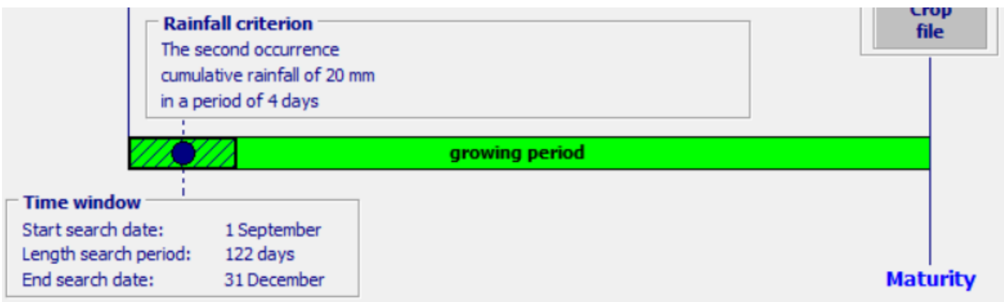
- wind speed at 2m.

The data was imported (ASCII file) in AquaCrop.

- The reference evapotranspiration (ETo) was calculated (with the incorporated ETo calculator in AquaCrop) by considering the solar radiation, minimum and maximum air temperature, air humidity and wind speed.
- The Minimum and Maximum Air Temperature data, ETo data and Rainfall data were extracted and stored in corresponding temperature, ETo and rainfall files.
- The Ramallah.CLI file was created

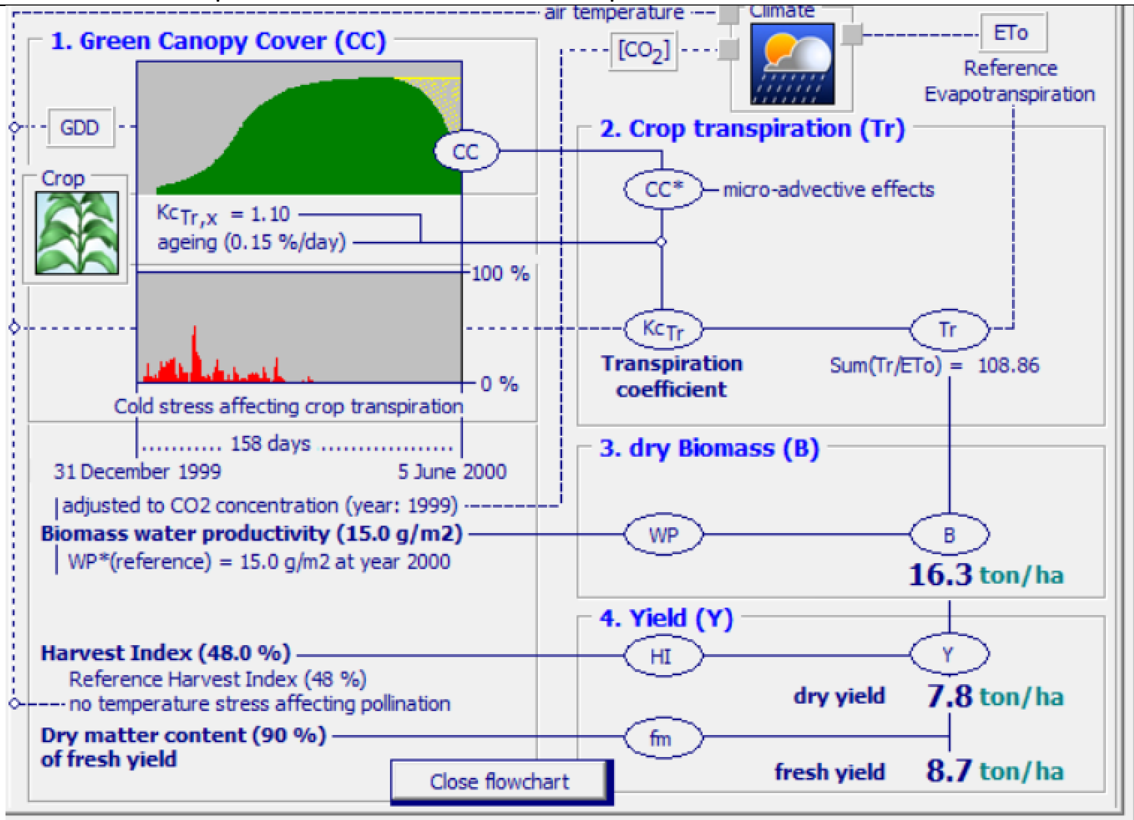



***Mean monthly Rainfall, ETo and Maximum and minimum air temperature for the 31 years of daily climatic data (1 January 1990 to 31 December 2020)***

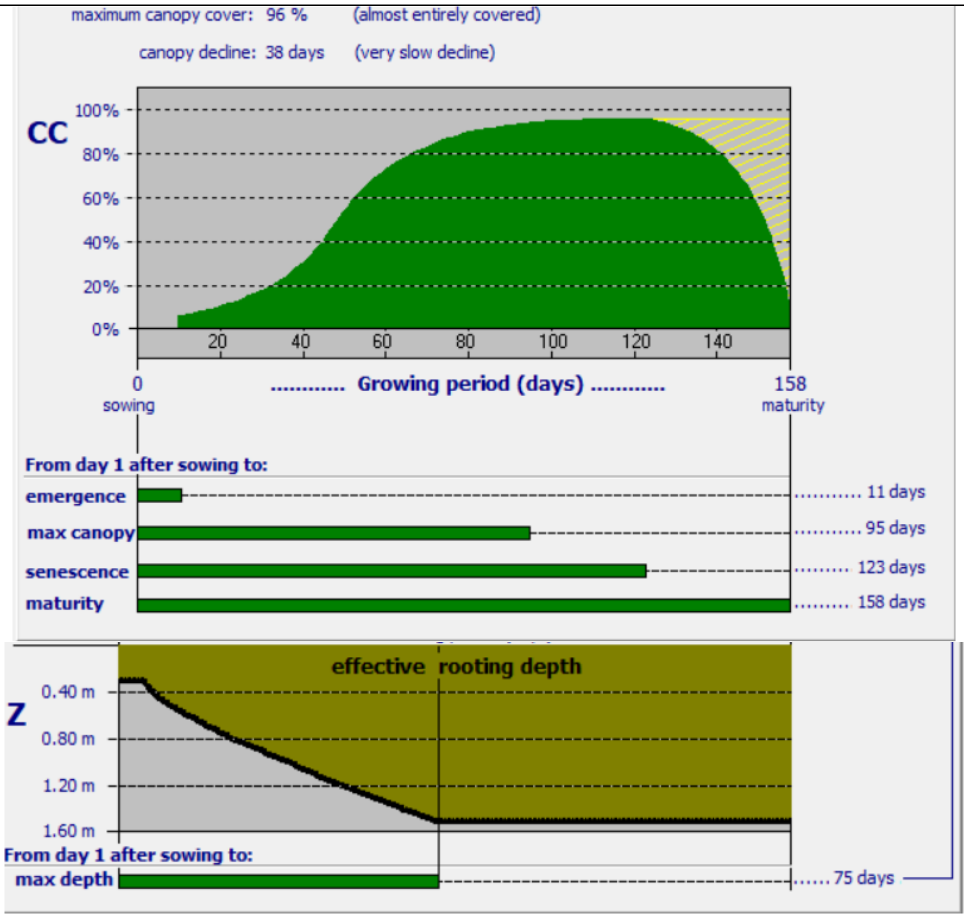


*The winter wheat was assumed to be sown at the 2nd occurrence of 20 mm of rain in a 4-day period (in the time window: 1 September - 31 December).*
*Calendar file: WWRamallah.CAL*

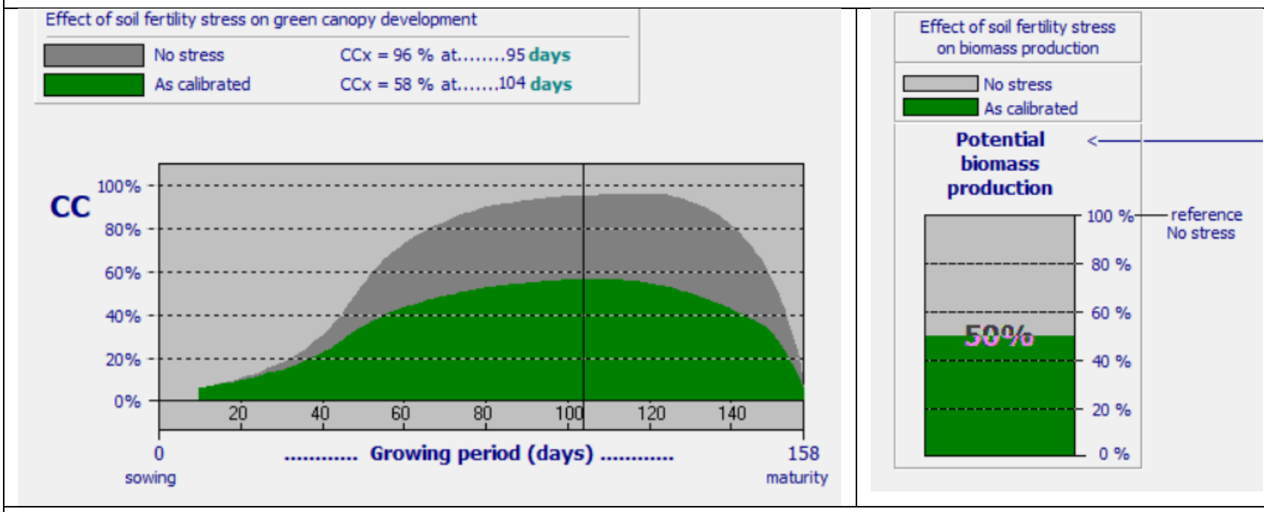
The default Winter Wheat characteristics of the WheatGDD.Cro file from the AquaCrop database were considered as relevant for the Ramallah region. Given that the potential production is about double of the actual observed production, the crop was calibrated for soil fertility by considering a 50% relative biomass production. The calibrated crop was saved as WWRamallah.CRO file.



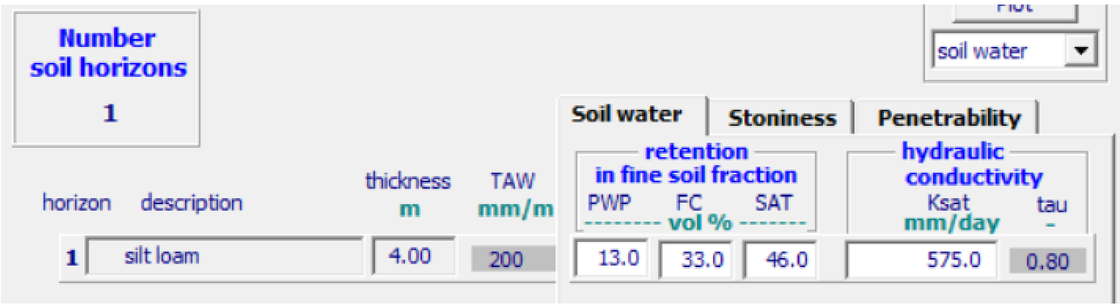

*Potential Biomass and Grain yield of the winter wheat in Ramallah in the absence of water, soil fertility and soil salinity stress (Planting date: 31 December 1999)*




*Crop canopy development and corresponding rooting depth of winter wheat in Ramallah in the absence of water, soil fertility and soil salinity stress (Planting date: 31 December 1999)*




*Calibration for soil fertility by considering half biomass production, resulting in a biomass production of 50% of the production under unlimited conditions.*

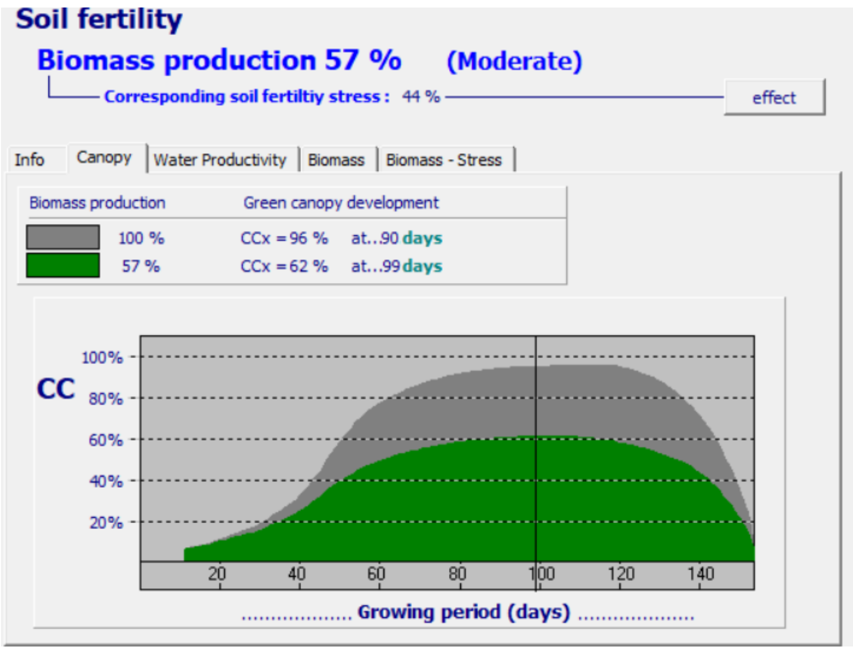



*The characteristic of the default Silt Loam soil (available in the Database of AquaCrop) were considered as representative for the physical soil characteristics in the region.*

*The Total Available soil Water (TAW) is 200 mm/m*

It is assumed that field surface practices do not affect the surface run-off, that surface mulches are not applied, and the weed management is perfect. The simulations were run for 2 soil fertility management levels:

- Optimal (unlimited soil fertility)
- Moderate soil fertility




*Moderate soil fertility (ModerateSF.Man)*

Since the initial soil water content at the start of the growing period (end of the calendar year) is unknown, the simulation period started on 15 August in full summer. This period is characterized by a high ETo and low rainfall. From the interpretation of the climatic conditions, it is safe to assume that in the summer period (August), with none to low rainfall, the soil water content will be very low. In an initial soil water content (SiltLoam10TAW.SW0), with only 10% of the Total Available soil Water (10% TAW) was assumed at 15 August, which is close to Permanent Wilting Point (0% TAW).

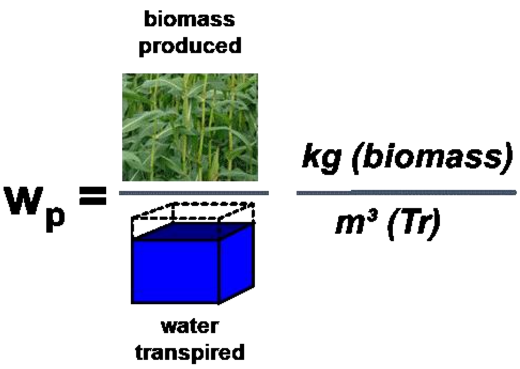
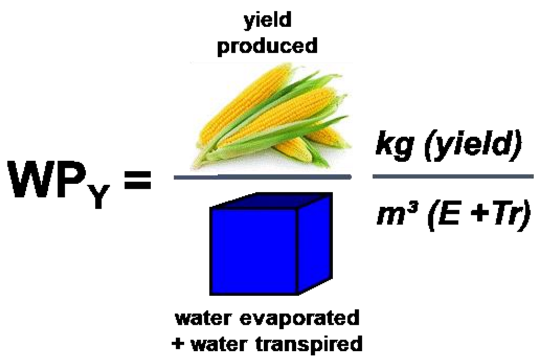
| ***The simulation of rainfed winter wheat for the Ramallah region was done for 20 successive years (1999- 2020) with the following input*** | |
|---|---|
| **Environment and crop** | **File** |
| Climate file | Ramallah.CLI |
| Calendar (planting) | WWRamallah.CAL |
| Crop file | WWRamallah.CRO |
| Irrigation management file | (none) |
| Field management file | • ModerateSF.MAN – moderate soil fertility<br>• (None) – unlimited soil fertility |
| Soil profile | SiltLoam.SOL |
| Groundwater | (None) |
| **Simulation** | |
| Simulation period | Starting at 15 August for 20 successive years |
| Initial conditions | SiltLoam10TAW.SW0 |

### 1.2 Output

AquaCrop estimates the biomass and crop yield that can be expected in the specified environment. With the help of the biomass water productivity (WP), AquaCrop estimates the biomass production from the sum of water transpired by the crop. The biomass water productivity (WP) expresses the aboveground dry matter (g or kg) produced per unit land area ($m^2$ or ha) per unit of water transpired (mm). WP is a conservative crop parameter, which is 15 $g/m^2$ for winter wheat when normalized for climate and for a $CO_2$ concentration of 369.41 ppm for the reference year 2000.

The Water Use Efficiency (WUE) is another output of AquaCrop when running simulations. It is an indicator which assesses the performance of the system in the specified environment. The Water Use Efficiency (WUE) or also called the yield-ET water productivity ($WP_Y$ or $WP_{ET}$), expresses the yield (kg yield) that was produced per unit of water lost by evapotranspiration ($m^3$ water) during the crop cycle. The Water Use efficiency differs from the biomass water productivity (WP) which refers to the amount of biomass that can be obtained with a certain quantity of water transpired, and which is a conservative crop parameter. The WUE uses 'Yield' (instead of biomass) since it is often the output in which one is most interested in. 'Evapotranspiration' (ET) instead of crop transpiration is used since soil evaporation needs to be considered at field level, since water will evaporate from the crop and soil surface each time the soil is wetted by rainfall or irrigation.

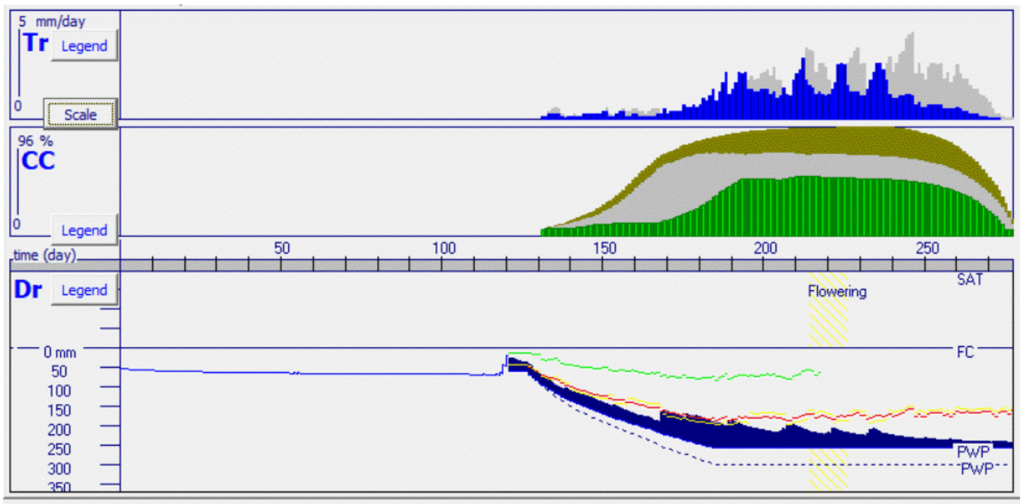
| | |
|---|---|
| A constant relationship between biomass production and transpiration | A performance indicator of the crop system |

| | |
|---|---|
|  |  |
| **Biomass water productivity** | **Yield water productivity ($WP_Y$) or Water Use Efficiency (WUE)** |

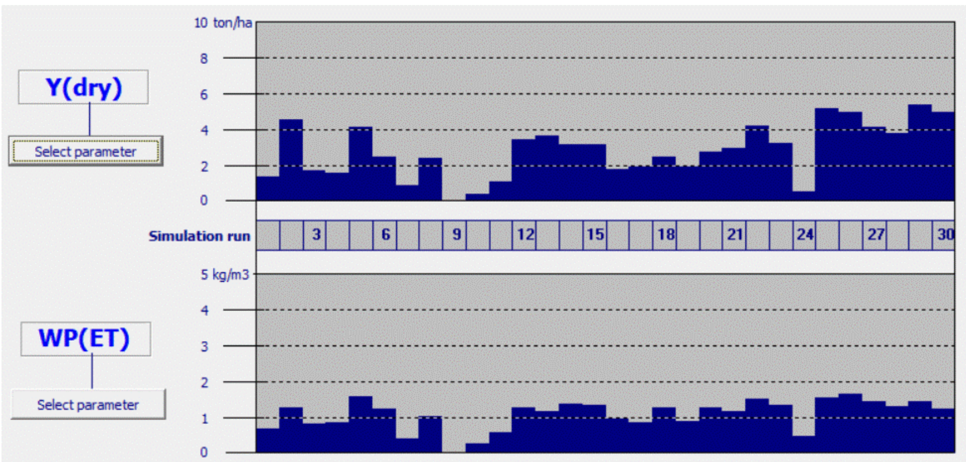
*The biomass water productivity (wp) vs yield water productivity ($WP_Y$)*

Indicative values for the yield water productivity of wheat are given by Zwart et al. (2010). In the global research, the authors found that the water productivity for rainfed and irrigated wheat varies from approximately 0.2 to 1.8 kg of harvestable wheat per cubic meter of water consumed (DOI:10.1016/j.agwat.2010.05.018)

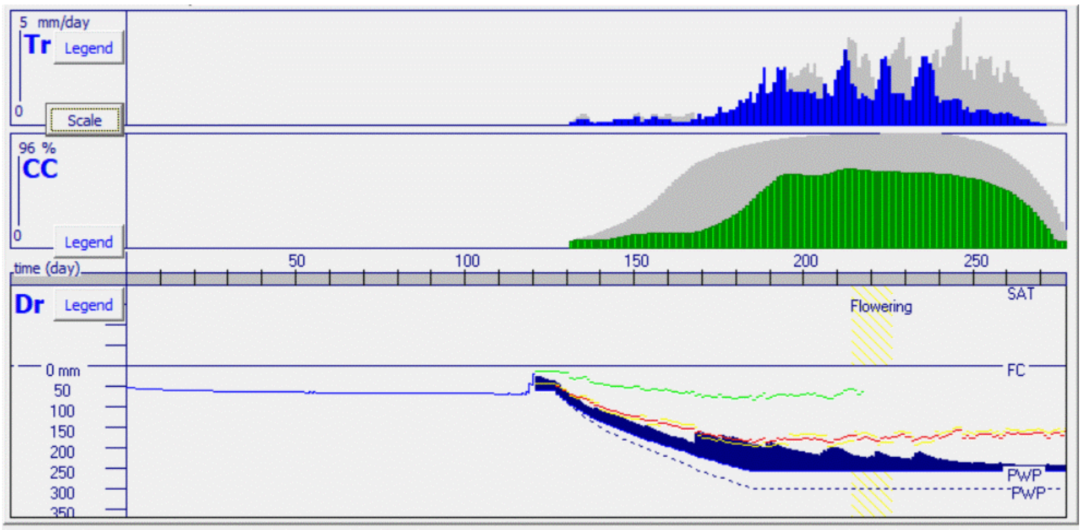
## 1.3 Simulation results



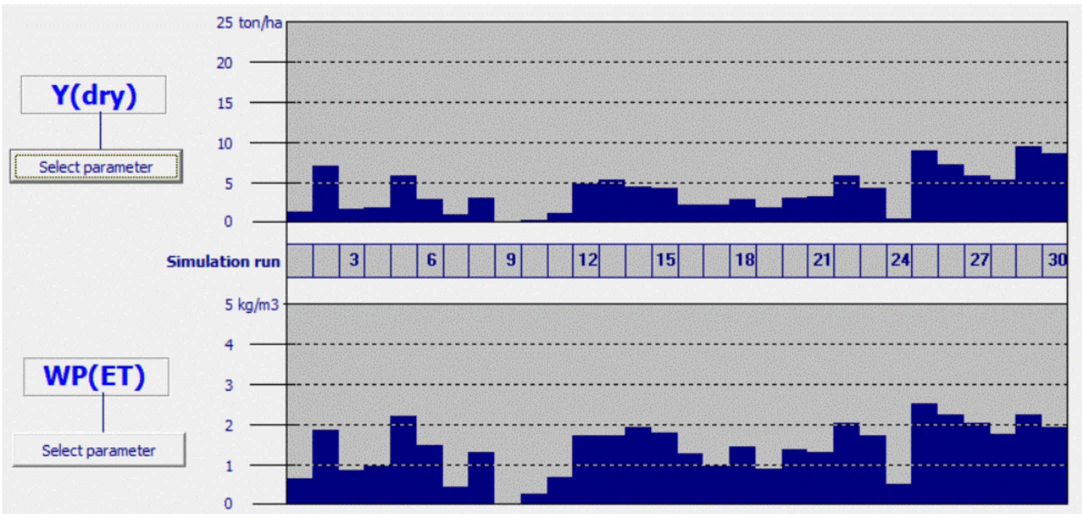

***Simulation results with moderate soil fertility for the year 2010-2011 with indication of the crop transpiration (Tr), the green canopy cover (CC) and the root zone depletion (Dr) in function of time (Day 1 is 15 August 2010, the start of the simulation)***



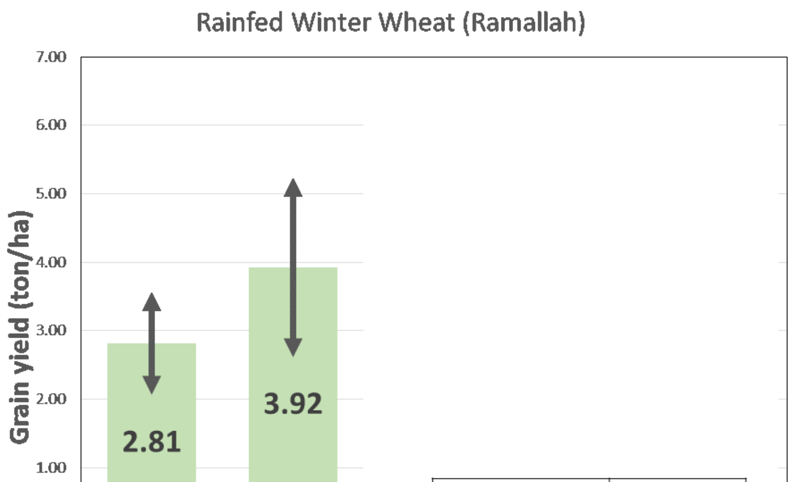

***The simulated dry yield (Ydry) and Water Use Efficiency (WP(ET)) for the 30 years (1990-2020) with moderate soil fertility***



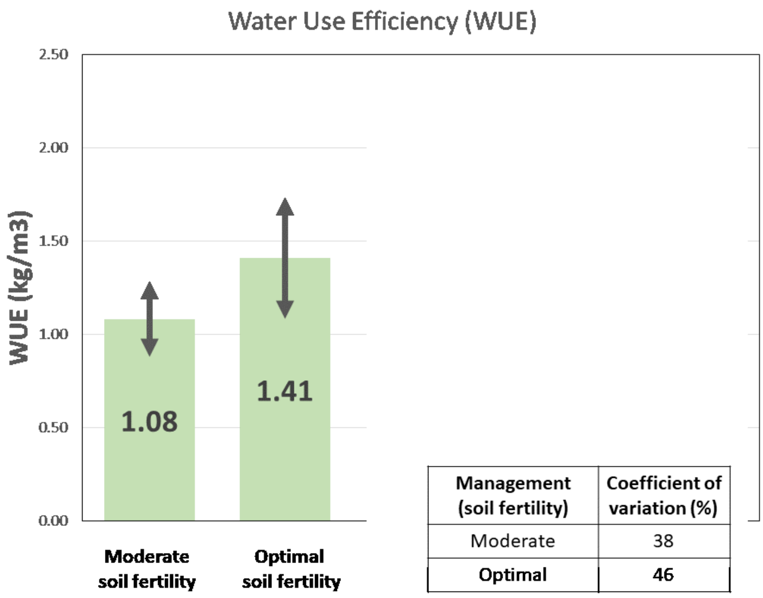

*Simulation results with unlimited soil fertility for the year 2010-2011 with indication of the crop transpiration (Tr), the green canopy cover (CC) and the root zone depletion (Dr) in function of time (Day 1 is 15 August 2010, the start of the simulation)*




*The simulated dry yield (Ydry) and Water Use Efficiency (WP(ET)) for the 30 years (1990-2020) with unlimited soil fertility*




| Management (soil fertility) | Coefficient of variation (%) |
|---|---|
| Moderate | 53 |
| Optimal | 67 |




| Management (soil fertility) | Coefficient of variation (%) |
|---|---|
| Moderate | 38 |
| Optimal | 46 |

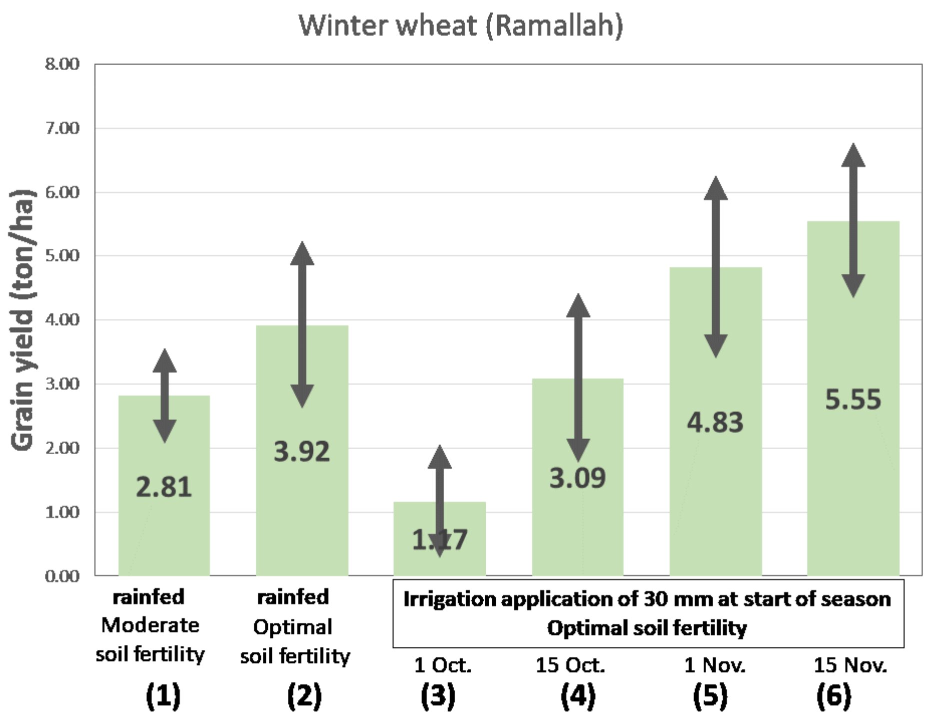
With optimal soil fertility the average grain yield of rainfed winter wheat is 40% higher than with moderate soil fertility (3.92 versus 2.81 ton/ha). In a good rainy year, the production under optimal conditions (unlimited soil fertility) can rise to more than 5 ton/ha, but in a year with limited rainfall the production will be less than 3 ton/ha. With moderate soil fertility the variation between the grain yield over the years is less.
Under optimal conditions the WUE is very good (1.41 kg/m³). However, the actual WUE might be lower since it is very difficult to obtain optimal conditions in farmers field, due to the quality of the seeds, weed infestation, not optimal field surface practices, etc.

## 2 Evaluation of an irrigation strategy to improve the WUE, and production of winter wheat in the Ramallah region

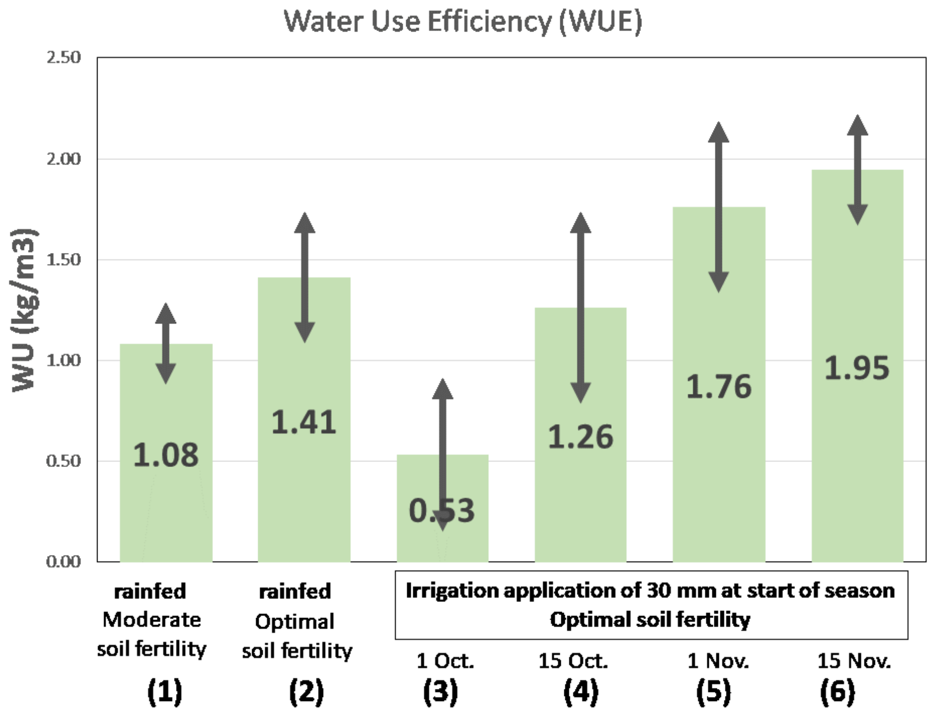
To increase the grain yield and Water Use Efficiency (WUE) of winter wheat in Ramallah, an irrigation application at the start of the growing period (fixed at a specific date) was evaluated.

### 2.1 Irrigation application of 30 mm at sowing

An irrigation application of 30 mm was considered with different fixed sowing dates: 1 and 15 October, and 1 and 15 November. Optimal soil fertility was assumed in the simulations with irrigation.




| Strategy | Coefficient of variation (%) |
|---|---|
| (1) | 53.4 |
| (2) | 66.8 |
| (3) | 151.7 |
| (4) | 85.7 |
| (5) | 59.1 |
| (6) | 43.9 |

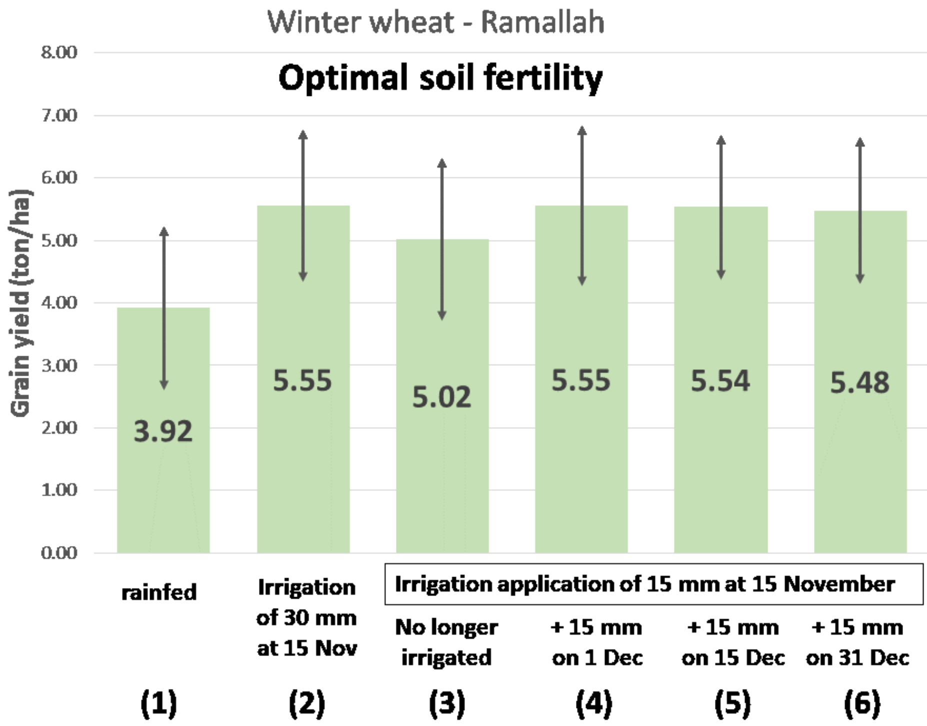



| Strategy | Coefficient of variation (%) |
|---|---|
| (1) | 37.7 |
| (2) | 46.3 |
| (3) | 143.6 |
| (4) | 75.4 |
| (5) | 48.3 |
| (6) | 28.3 |

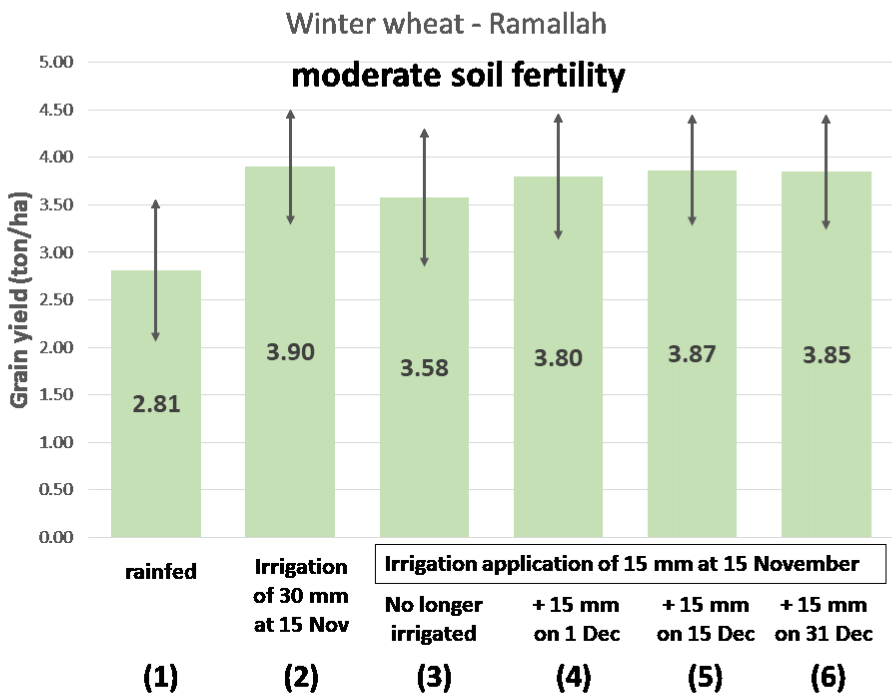
The best results were obtained by starting the season on 15 November. The irrigation application of 30 mm at sowing, guaranteed a good germination of the crop, and with the winter rains that are already relevant in most of the years in that period, the crop was able to develop well. By sowing on 15 November, the crop matures around the end of April. This is also the moment when rainfall becomes insignificant in most of the years.
Thanks to the irrigation, the average grain yield under optimal field management was 40% higher than under rainfed conditions (5.55 versus 3.92 ton/ha). Additionally, the grain yield was more stable over the years (coefficient of variation of 43.9% versus 66.8% under rainfed). This resulted in a very high WUE of 1.95 kg/m³. However, the actual WUE might be lower since it is very difficult to obtain optimal conditions in farmers field, due to the quality of the seeds, weed infestation, not optimal field surface practices, etc.

## 2.2 Irrigation application of 15 mm at sowing, followed by another irrigation of 15 mm later in the season

In the graphs below the result of other irrigation strategies and with optimal and moderate soil fertility management are presented. The irrigation strategy consists in applying 15 mm of water at the 15 November and eventually another application of 15 mm on 1, 15 or 31 December. The grain yield remains high, and the results do not vary that much from previous results.




| Strategy | Coefficient of variation (%) |
|---|---|
| (1) | 66.8 |
| (2) | 43.9 |
| (3) | 51.9 |
| (4) | 46.1 |
| (5) | 41.9 |
| (6) | 43.2 |

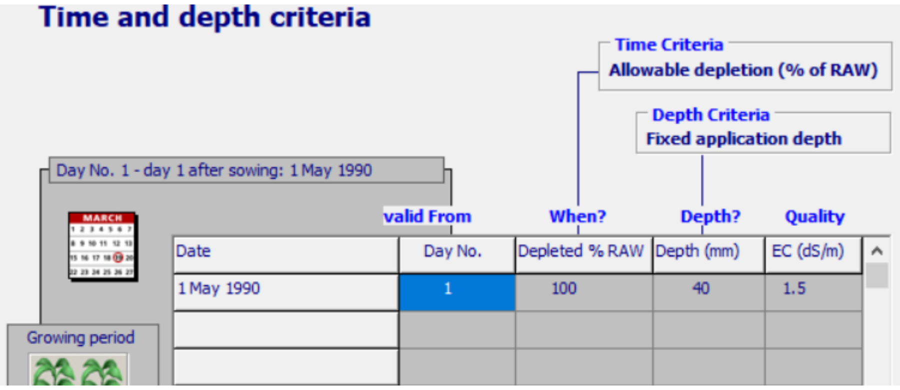



| Strategy | Coefficient of variation (%) |
|---|---|
| (1) | 53.4 |
| (2) | 31.2 |
| (3) | 40.6 |
| (4) | 35.2 |
| (5) | 30.3 |
| (6) | 31.7 |

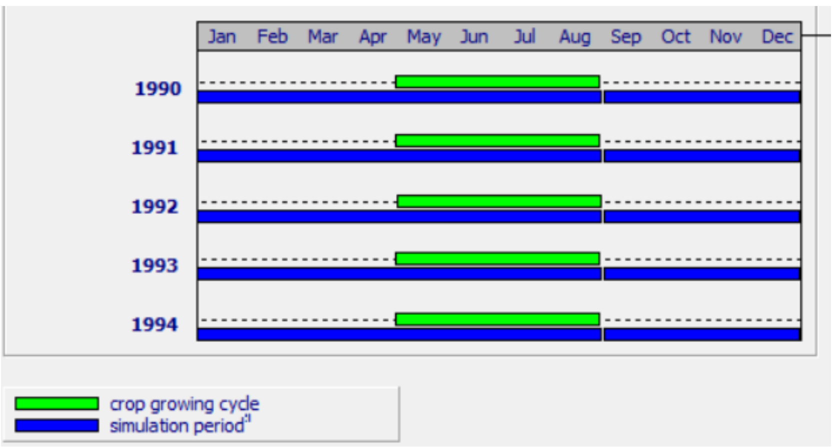
# 3 Assessment of risk on soil salinisation

## 3.1 Simulation

By assuming an irrigation water quality (ECe) of 1.5 dS/m, the risk on soil salinisation was estimated by AquaCrop. The simulations were run for a crop which is moderate sensitive to salinity stress (such as Squash, peppers, Lettuce, Potato, Maize, Cabbage, Spinach, Radishes, Cucumber, Broccoli, Tomato, Alfalfa, cauliflower, Berseem). The crop (with a crop cycle of 125 days) was sown/planted on 1 May, on a loamy soil.




*An irrigation of 40 mm was applied, each time 100% of RAW (Readily available soil water) was depleted from the root zone by furrow irrigation (80% of the soil surface wetted). A constant water quality (ECe) of 1.5 dS/m was assumed throughout the season*



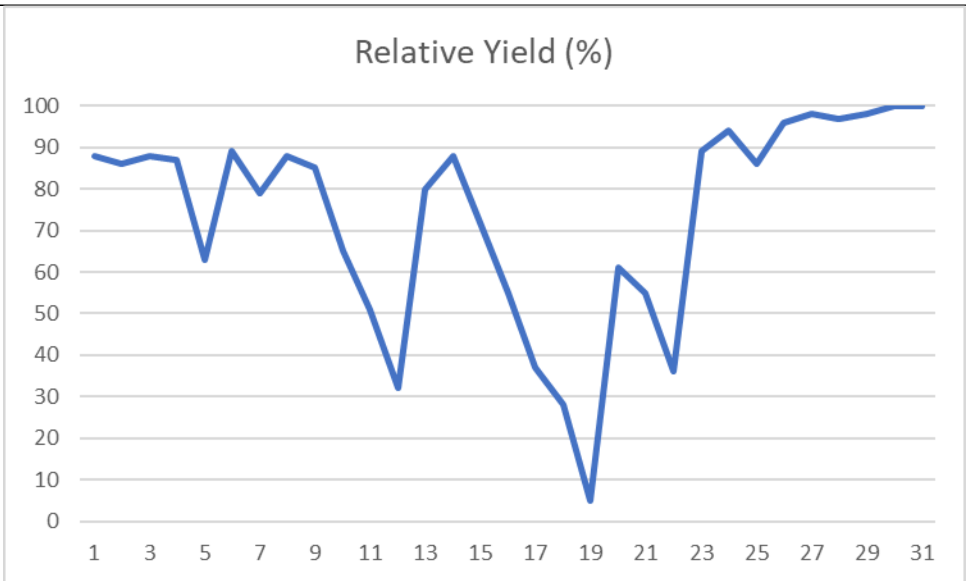

*Simulations were run for the 31-years of available daily climatic data for Ramallah. The initial conditions (soil water and salt content in the soil profile) at the start of a simulation run consisted of the conditions at the end of the previous run (linking of the simulation runs). As such, the leaching effects of the winter rain could be considered.*

### 3.2 Results

The results are presented in the next tables and figures for a particular year (1994 – 1995), and for the 31 simulated years.

The results indicate that due to salinity stress, the yield is on average 73% of the potential yield without salinity stress. However, the yield varied very strongly between the years:

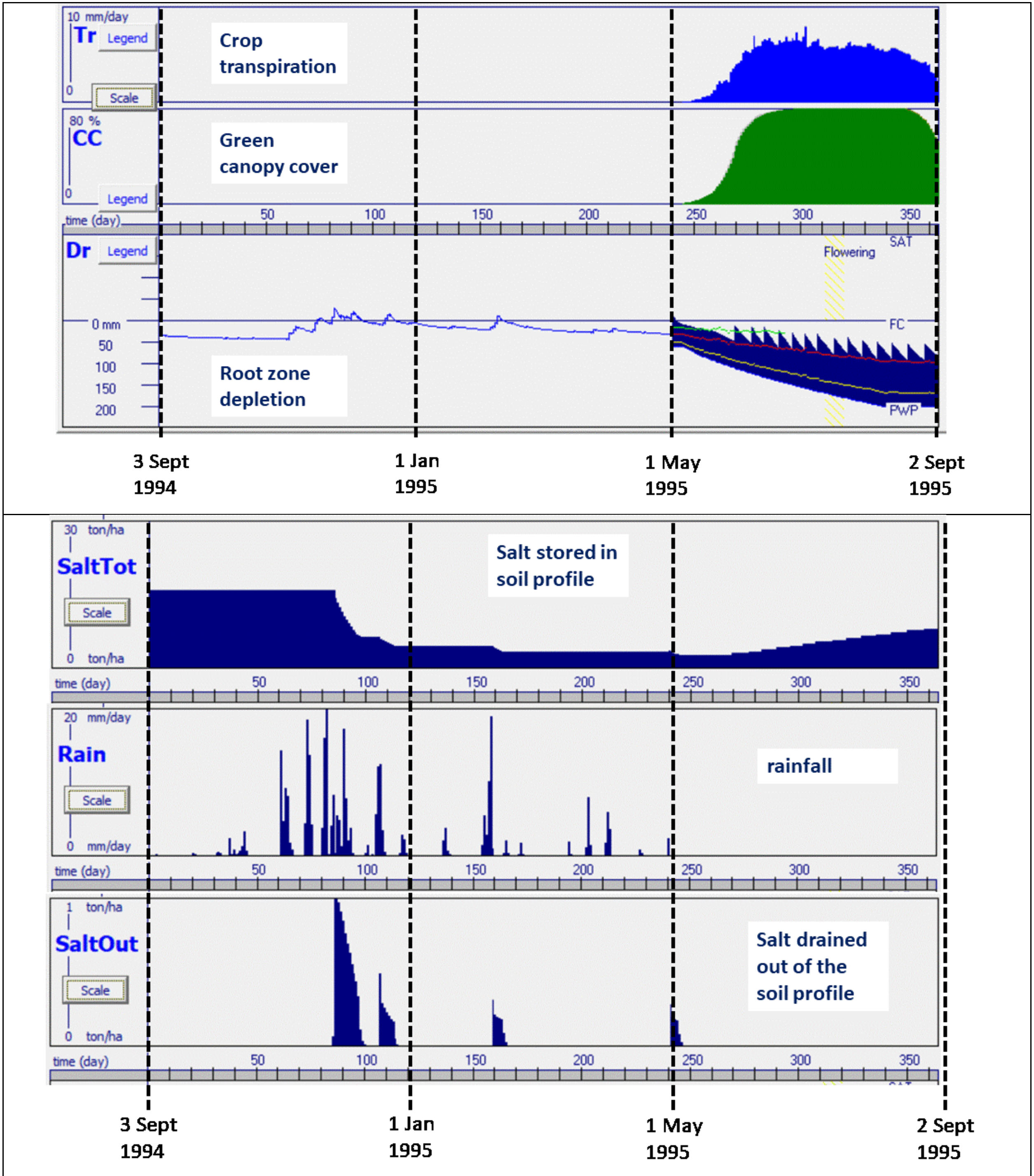
- At the end of the 31-year simulated period, there was no longer a salinity stress thanks to the abundant rainfall in the winter period of the previous years;
- On the other hand, due to the gradually building up of salts in the root zone during 5 successive years (in the middle of the time series, from year 15 up to 19), the cultivation of crops became very problematic as a result of the high salinity stress (Yield in year 19 is only 5% of the potential yield).




***Variation of the relative yield (%) in the 31-year time series as a result of the building up of salts in the root zone***

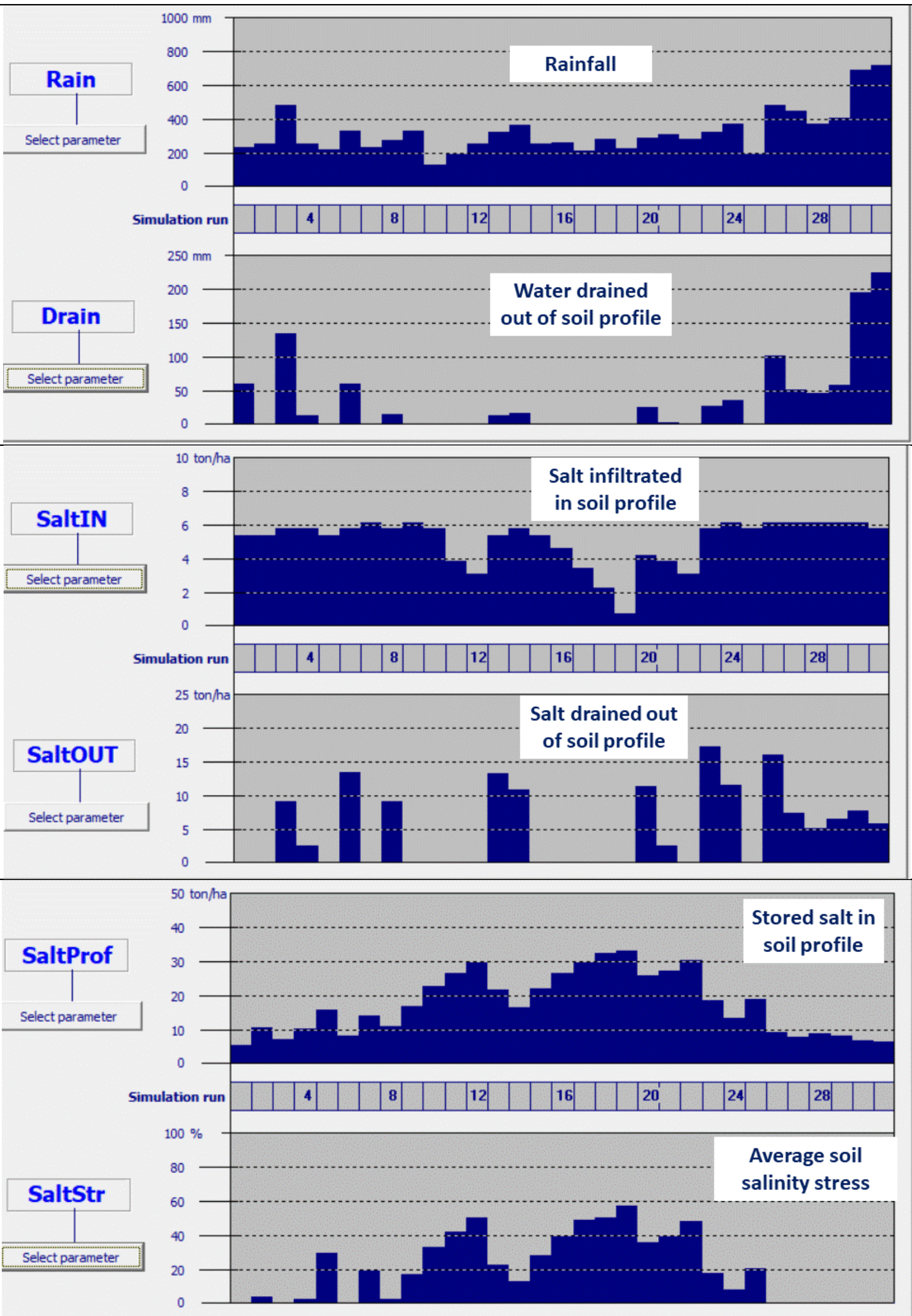
Similar simulations can be run to evaluate the effect of soil salinity for other crops and soil types, and for a different irrigation management strategy. One can for example consider:

- A more or less sensitive crop to soil salinity,
- Crops with a longer growing cycle. As a result, more salts will build up due to a longer period of irrigation,
- A more sandy or clayey soil type. In more clayey soils the slats build up slower, but it also takes up longer to remove salts from the root zone by leaching,
- Over-irrigation during the season (leaching with an excess of irrigation water) to limit the building up of salts in the root zone
- Etc.




*Intermediate results for the year 1994- 1995.*

*The simulation started at the end of the growing cycle on 3 September (1994). During the winter period salts were leached out of the soil profile thanks to the winter rains. During the next growing cycle in the summer period (1 May – 2 September 1995) salts build up in the root zone, due to the absence of rainfall*




*Elements of the soil water and salt balance of the soil profile for the 31 years: From year 1 (1990) up to year 31 (2020)*

***Variation of Rainfall (Rain), Irrigation (Irri), surface runoff (Runoff), Deep percolation losses (Drain), Salt infiltrating in the soil profile (SaltIN), drained out of the soil profile (SaltOut) and stored in the soil profile (SaltProf), the salinity stress (SaltStr) and relative yield (Yrel) for the 31 years***

| Run | Rain | Irri | Runoff | Drain | SaltIn | SaltOut | SaltProf | SaltStr | Yrel |
|---|---|---|---|---|---|---|---|---|---|
| | mm | mm | mm | mm | ton/ha | ton/ha | ton/ha | % | % |
| **1** | 236 | 560 | 12 | 61 | 5.4 | 0.0 | 5.4 | 0 | 88 |
| **2** | 255 | 560 | 18 | 0 | 5.4 | 0.0 | 10.8 | 4 | 86 |
| **3** | 485 | 600 | 64 | 135 | 5.8 | 9.1 | 7.4 | 0 | 88 |
| **4** | 254 | 600 | 8 | 14 | 5.8 | 2.6 | 10.5 | 3 | 87 |
| **5** | 218 | 560 | 0 | 0 | 5.4 | 0.0 | 15.9 | 30 | 63 |
| **6** | 328 | 600 | 20 | 61 | 5.8 | 13.5 | 8.1 | 0 | 89 |
| **7** | 235 | 640 | 3 | 0 | 6.1 | 0.0 | 14.3 | 20 | 79 |
| **8** | 274 | 600 | 7 | 16 | 5.8 | 9.2 | 10.9 | 3 | 88 |
| **9** | 328 | 640 | 6 | 0 | 6.1 | 0.0 | 17.0 | 17 | 85 |
| **10** | 133 | 600 | 0 | 0 | 5.8 | 0.0 | 22.8 | 33 | 65 |
| **11** | 193 | 400 | 15 | 0 | 3.8 | 0.0 | 26.6 | 42 | 51 |
| **12** | 252 | 320 | 7 | 0 | 3.1 | 0.0 | 29.7 | 50 | 32 |
| **13** | 321 | 560 | 15 | 13 | 5.4 | 13.3 | 21.7 | 23 | 80 |
| **14** | 367 | 600 | 17 | 18 | 5.8 | 10.8 | 16.7 | 13 | 88 |
| **15** | 256 | 560 | 9 | 0 | 5.4 | 0.0 | 22.0 | 28 | 72 |
| **16** | 263 | 480 | 8 | 0 | 4.6 | 0.0 | 26.6 | 39 | 55 |
| **17** | 215 | 360 | 1 | 0 | 3.5 | 0.0 | 30.1 | 49 | 37 |
| **18** | 285 | 240 | 8 | 0 | 2.3 | 0.0 | 32.4 | 50 | 28 |
| **19** | 229 | 80 | 8 | 0 | 0.8 | 0.0 | 33.2 | 57 | 5 |
| **20** | 289 | 440 | 15 | 26 | 4.2 | 11.4 | 26.0 | 36 | 61 |
| **21** | 310 | 400 | 15 | 3 | 3.8 | 2.7 | 27.1 | 40 | 55 |
| **22** | 281 | 320 | 6 | 0 | 3.1 | 0.0 | 30.2 | 48 | 36 |
| **23** | 324 | 600 | 15 | 27 | 5.8 | 17.3 | 18.7 | 18 | 89 |
| **24** | 369 | 640 | 51 | 37 | 6.1 | 11.5 | 13.3 | 8 | 94 |
| **25** | 197 | 600 | 10 | 0 | 5.8 | 0.0 | 19.0 | 21 | 86 |
| **26** | 486 | 640 | 42 | 101 | 6.1 | 16.0 | 9.2 | 1 | 96 |
| **27** | 446 | 640 | 31 | 51 | 6.1 | 7.4 | 8.0 | 1 | 98 |
| **28** | 372 | 640 | 57 | 46 | 6.1 | 5.2 | 8.9 | 1 | 97 |
| **29** | 405 | 640 | 36 | 58 | 6.1 | 6.6 | 8.4 | 1 | 98 |
| **30** | 692 | 640 | 120 | 194 | 6.1 | 7.7 | 6.8 | 0 | 100 |
| **31** | 718 | 600 | 101 | 225 | 5.8 | 5.9 | 6.7 | 0 | 100 |
| | | | | | | | | | |
| **Mean** | **323** | **528** | **23** | **35** | **5** | **5** | **18** | **21** | **73** |
| **Stdev** | **131** | **141** | **29** | **57** | **1** | **6** | **9** | **19** | **25** |
| **Var%** | **41** | **27** | **122** | **163** | **27** | **117** | **51** | **94** | **34** |

# 4 Development of an irrigation schedule for cucumber

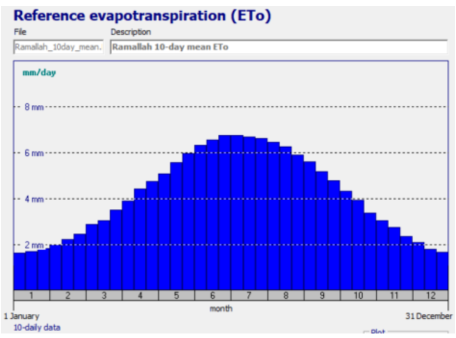
As a demonstration for the development of an irrigation schedule, an example was worked out for irrigated cucumber in the region of Ramallah (Palestine autonomous region).

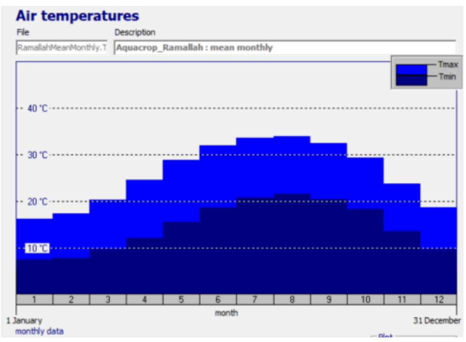
***Input for the development of an irrigation schedule for cucumber in the Ramallah region***

| **Environment and crop** | **File** |
|---|---|
| Climate file | Ramallah_mean |
| Calendar (planting) | 1 April |
| Crop file | Cucumber.CRO |
| Irrigation management file | Fixed irrigation interval of 1 day with a net irrigation application changing during the season |
| Soil profile | SiltLoam.SOL |
| Groundwater | (None) |
| Field management file | (None) – optimal conditions |
| **Simulation** | |
| Simulation period | Starting at 1 April |
| Initial conditions | Initial soil water content at 50% TAW (as a result of pre-irrigation and/or rain |

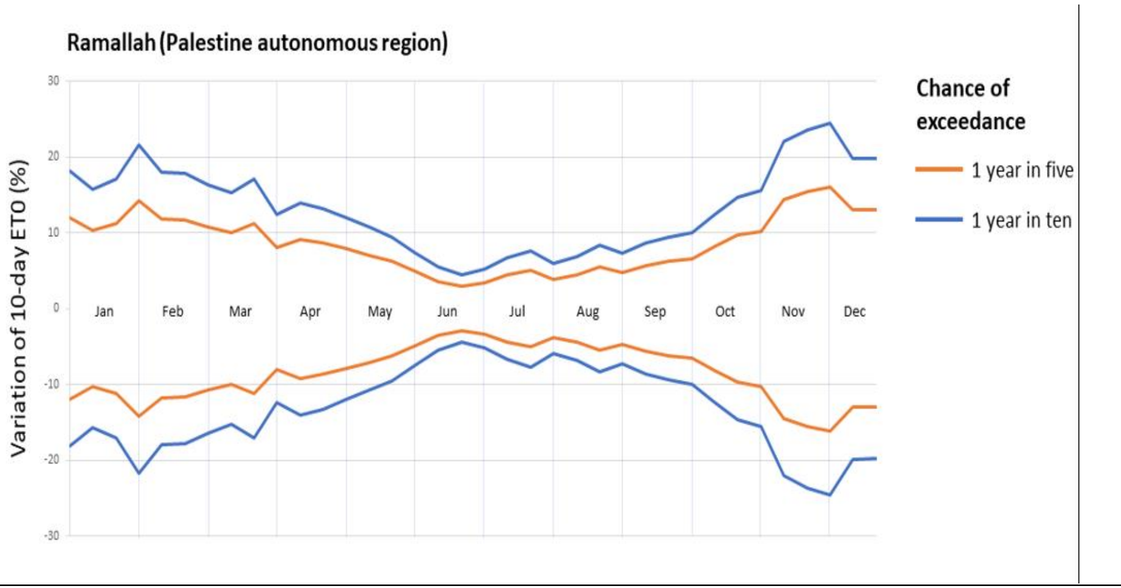
## 4.1 Climate, crop and soil characteristics

Mean 10-daily ETo and mean monthly Minimum and Maximum air temperature for the 31-year time series for Ramallah were calculated. The crop, planted on 1 April, is cultivated on a silty loam soil type and optimal field management conditions are assumed. A crop file for cucumber was created by considering a coefficient for transpiration ($Kc_{Tr,x}$) of 1.0, a moderate sensitive to water stress, a growing cycle of 90 days and a maximum rooting depth of 0.5 m.

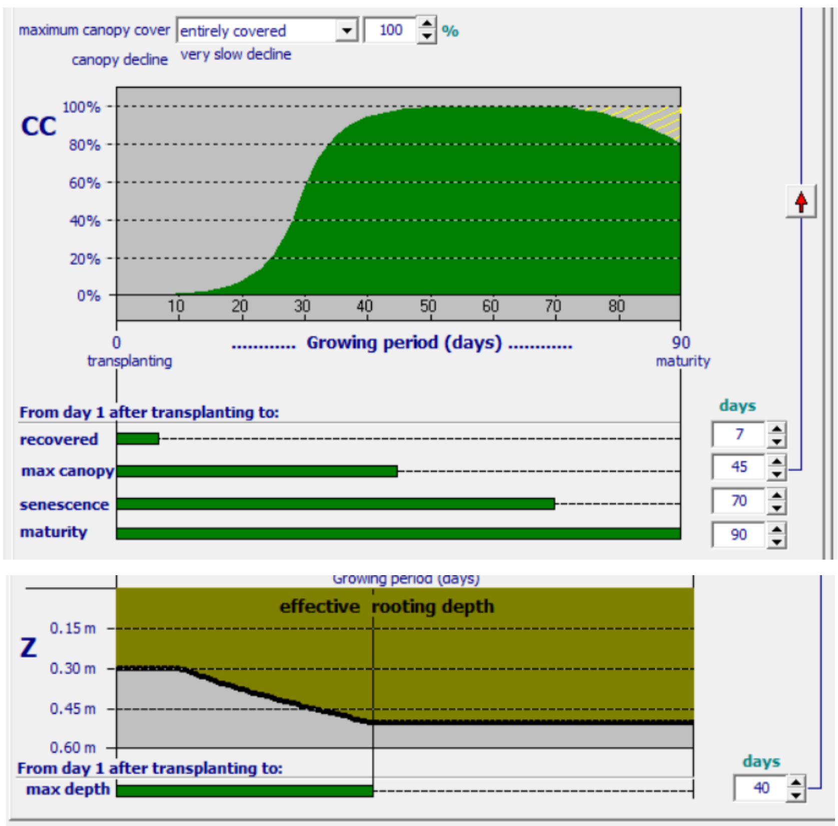



***Mean 10-day ETo and mean monthly Air temperatures for Ramallah (period: 1990 – 2020)***




*A frequency analysis of the reference evapotranspiration (ETo) on the 30-year time series, revealed that the 10-daily ETo varies only slightly between the various years*

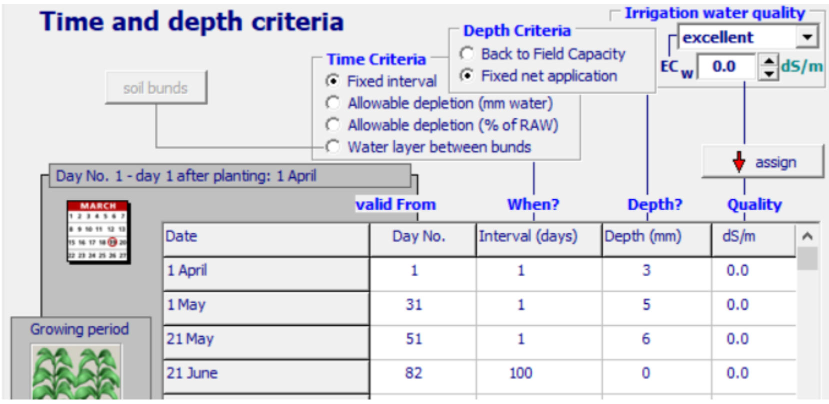



*Canopy and root zone development of cucumber*

## 4.2 Development of the irrigation schedule

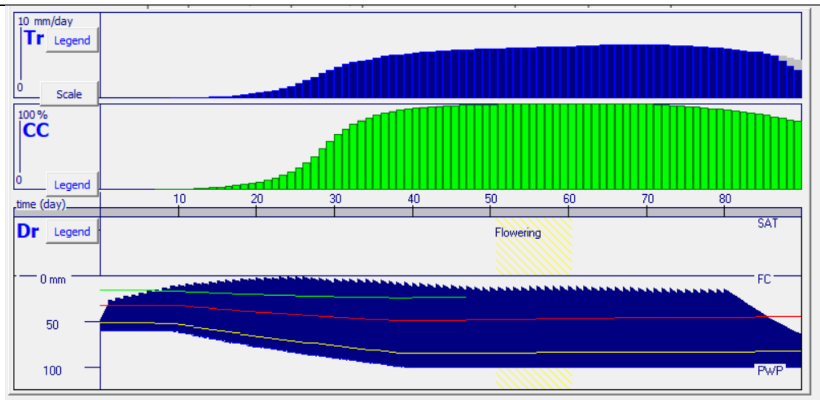
The crop was irrigated by drip irrigation. A fixed interval of 1 day was selected. To develop the irrigation schedule with the mean 10-daily ETo in the absence of rainfall, irrigations were generated with the help of AquaCrop. It consisted of the following steps:

- A fixed irrigation interval of 1 day was assumed and an initial net application (dnet) of 3 mm. Due to the crop development and the increase of the crop transpiration (increase of CC and ETo), the irrigation application of 3 mm could not be maintained during the whole growing cycle. Step by step, adjustments of dnet were worked out by checking after each adjustment if the root zone remains well watered and water stress or overirrigation is avoided.
- In the last decade of the growing cycle, the irrigation was switched off.




| Date | Day No. | Interval (days) | Depth (mm) | dS/m |
|---|---|---|---|---|
| 1 April | 1 | 1 | 3 | 0.0 |
| 1 May | 31 | 1 | 5 | 0.0 |
| 21 May | 51 | 1 | 6 | 0.0 |
| 21 June | 82 | 100 | 0 | 0.0 |

*Generated irrigation schedule for cucumber with a fixed irrigation interval of 1 day. Starting from day 1 (1 April) a constant irrigation application dose (dnet) of 3 mm was assumed. Subsequently dnet was gradually increased to 5 mm (on 1 May) and 6 mm (on 21 May). At the end of the season (starting from 21 June) the crop was no longer irrigated.*




*Crop transpiration (Tr), canopy development (CC) and root zone depletion (Dr) simulate with the generated irrigation schedule for cucumber.*

## 4.3 Irrigation chart

# Irrigation guidelines

**Crop: Cucumber**
**Length of crop cycle (days): 90**
**Planting date: 1 April**
**Soil type: silt loam**
**Irrigation method: Drip**
**Irrigation interval: 1 Day**
**Application efficiency: 90 %**

### $d_{net}$: Net irrigation application dose (in absence of rainfall)

| Month | April | | | May | | | June | | |
|---|---|---|---|---|---|---|---|---|---|
| Decade | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| $d_{net}$ (mm) | 3 mm | | | 5 | | 6 mm | | | |

### Irrigation duration in hours and minutes
### Application efficiency (Ea): 90 %

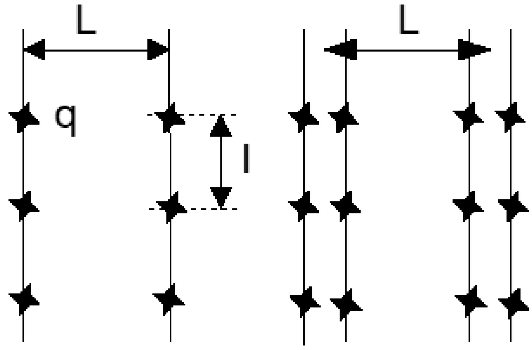
| Discharge per unit surface liter/hour/m² | dnet : Net irrigation application dose (mm) | | | | |
|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 |
| | $d_{gross}$ Gross application dose (mm) with Ea = 90% | | | | |
| | 3.3 | 4.4 | 5.6 | 6.7 | 7.8 |
| 2 | 1h 40’ | 2h 10’ | 2h 50’ | 3h 20’ | 3h 55’ |
| 3 | 1h 05’ | 1h30’ | 1h 50’ | 2h 15’ | 2h 35’ |
| 4 | 0h 50’ | 1h 05’ | 1h25’ | 1h 40’ | 1h 55’ |
| 5 | 0h 40’ | 0h 50’ | 1h 10’ | 1h 20’ | 1h 35’ |
| 6 | 0h 35’ | 0h 45’ | 0h 55’ | 1h 10’ | 1h 20’ |

**Calculation of the discharge per unit surface (litre/hour.m2)**

| | single lateral | double laterals |
|---|---|---|

**Charactersistics of installation :**

l : distance between emitters (m)
L : lateral spacing between laterals (m)
q : emitter discharge (litre/hour)
Type : single/double laterals




**Discharge per unit surface = q/(l x L) | 2q/((l x L)**

| | single lateral | double laterals |
|---|---|---|
| Example: | l = 0.4 m<br>L = 1.6 m<br>q = 2 l/h | l = 1.0 m<br>L = 2.0 m<br>q = 4 l/h |
| Discharge per unit surface : | 2/(0.4x1.6) = 3.1 l/h.m2 | (2x4)/(1.0x2.0) = 4.0 l/h.m2 |

- **Adjusting the irrigation application dose to the varying weather conditions**

In response to crop development and variations in weather conditions, the irrigation application dose (dnet) need to be adjusted during the season. For each decade (10-day period) of the growing period, indicative values for the application dose are presented on the chart in the absence of rainfall.

Below the table the corresponding duration of the irrigation application is presented for various discharges per unit surface by considering an application efficiency of 90%. The discharge per unit surface (liter/hour.m²) varies with the layout of the system (distance between laterals and drippers), the discharge of the emitter, and the number of laterals.

Although a frequency analysis of the reference evapotranspiration (ETo) revealed that the 10-daily ETo varies only slightly between the various years, the irrigation duration can be somewhat increased by about 10% if the weather at a particular moment of the growing period is hotter than normal for the region. Similar, the duration should be decreased by 10% in periods which are cooler than normal for the region.

- **Adjusting the irrigation interval to rainfall**

At days on which the rainfall is equal to the application dose, the crop does not need to be irrigated. For large rainfall amounts (covering the irrigation dose of several successive days), the irrigation can be delayed by more than one day. However, since the soil water content remains close to Field Capacity with drip irrigation, the period should not exceed more than 3 days (unless it rains again on day 3).

On days where the rainfall is only a fraction of the irrigation dose, the irrigation duration can be reduced with that fraction.

- **Adjusting the irrigation interval to rainfall**

Although the considered irrigation interval in the Table is 1 day, farmers may irrigate less frequently. Under such conditions, the chart still provides valid guidelines for irrigation planning as long as the link between the application dose and interval is respected. If a farmer increases the 1-day irrigation interval with a certain percentage, the farmer has also to increase the irrigation dose with that percentage.

Variations of the irrigation interval should remain moderate. If the corresponding applied amount of water is much larger than the listed application dose, a lot of irrigation water will be lost as deep percolation. This will not only spoil water, but valuable nutrients might be flushed out of the root zone.