Assessment of the effects of climate variability on the main components of water balance and crop yield

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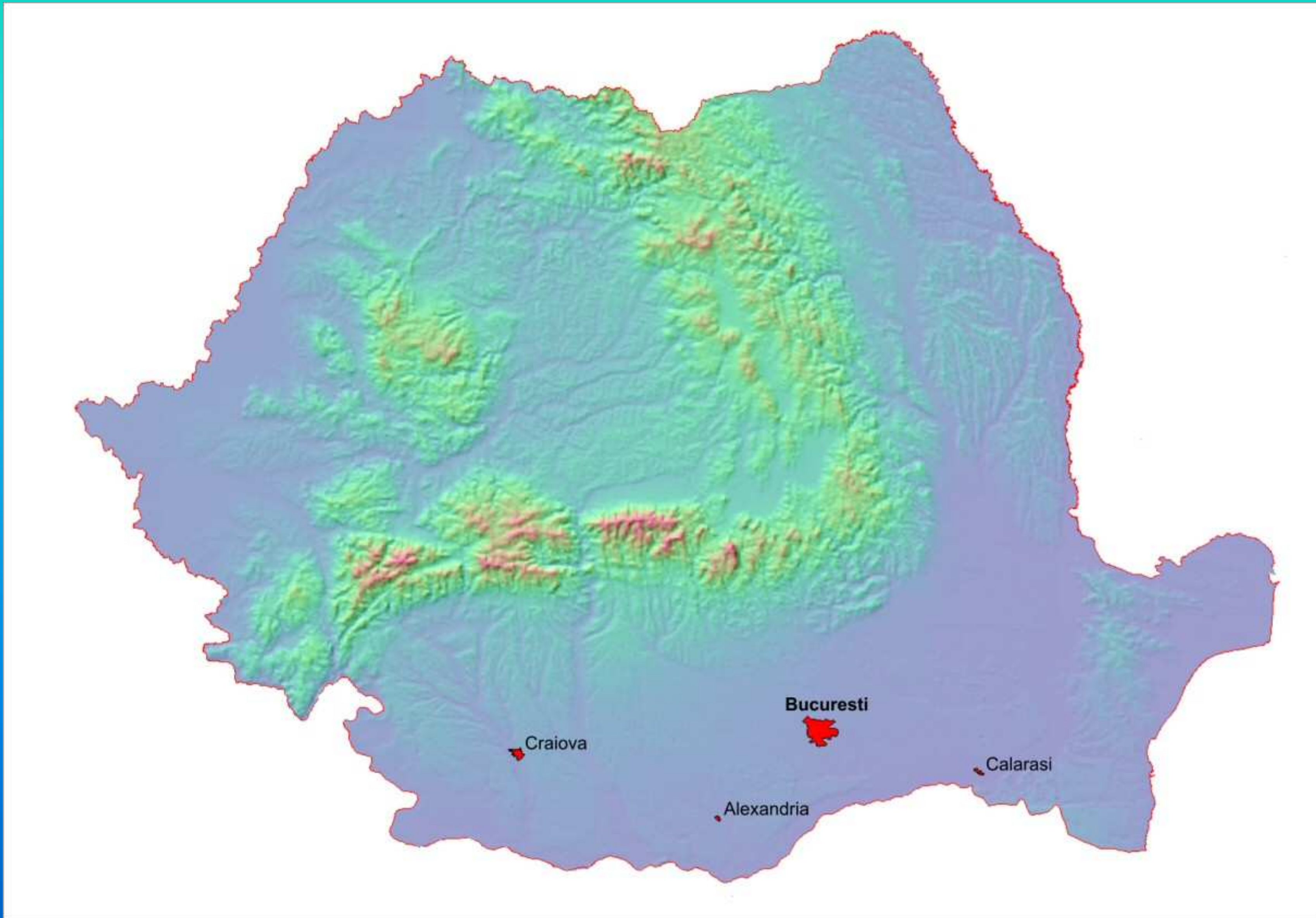
Aim:

- Demonstrate the use of the CROPWAT model in determining the impacts of different climatic conditions on the water balance elements and maize yield.

Objectives:

- Analysis historical rainfall data (1961-2001) and identify extreme climatic years;
- Estimate daily water balance components during maize growing season for a normal year and two extreme years;
- Compare the model results from the wet and dry year simulations with the normal climate;
- Quantify the extreme climatic effects on the main components of water balance;
- Estimate total yield reduction due to crop stress.

Selected site: Calarasi agrometeorological station



CROPWAT for Windows v. 4.3

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DATA	INPUT	OUTPUT
Climatic	• Monthly means of: minimum and maximum air temperature (°C), air relative humidity (%), sunshine duration (hours), wind speed at 2m high (m/s) • Monthly rainfall	• reference evapotranspiration • crop water requirement • irrigation requirement
Crop	• Kc, crop description, max. rooting depth, % area covered by plant	• actual crop evapotranspiration • soil moisture deficit
Soil	• initial soil moisture condition and available soil moisture	• estimated yield reduction due to crop stress
Irrigation	• irrigation scheduling criteria	

Input data used

Climatic data:

- Monthly means of:
  - minimum temperature (°C),
  - maximum temperature (°C),
  - air relative humidity (%),
  - sunshine duration (hours),
  - wind speed at 2m high (m/s)
- Monthly Rainfall

Crop data:

- sowing date: 14 April 2000/ 1 May 1997
- crop coefficient (Kc): standard
- crop yield data (Ky): standard
- depletion fraction (P): standard

Soil data:

- total available moisture: 139 mm/m depth
- initial available soil moisture: 61/71/74 mm/m depth
- maximum root infiltration rate: 35 mm/day
- maximum rooting depth: 0.80 m

Scheduling criteria: rainfed / irrigated at fixed intervals (15 days) and depths (42 and 70 mm)

Model application

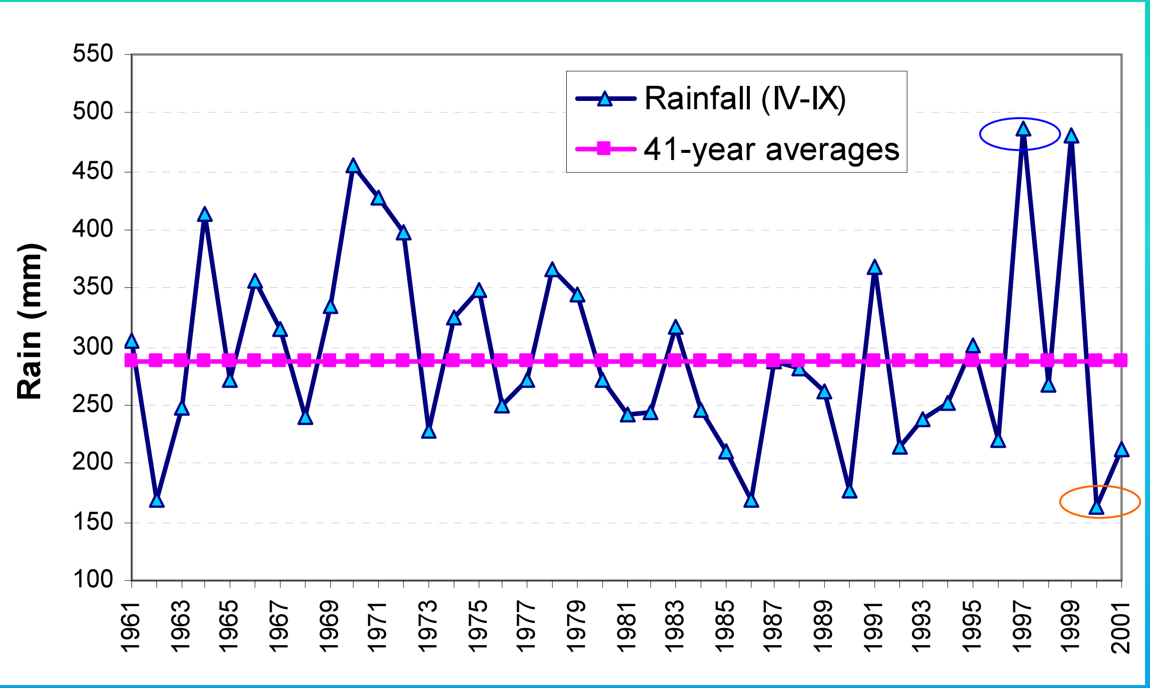
The key steps in the simulations:

• running the CROPWAT model for the maize crop with the mean monthly climatic data (over the interval 1961-2001) and similar for a wet year-1997 and a dry one-2000 in the rainfed conditions;

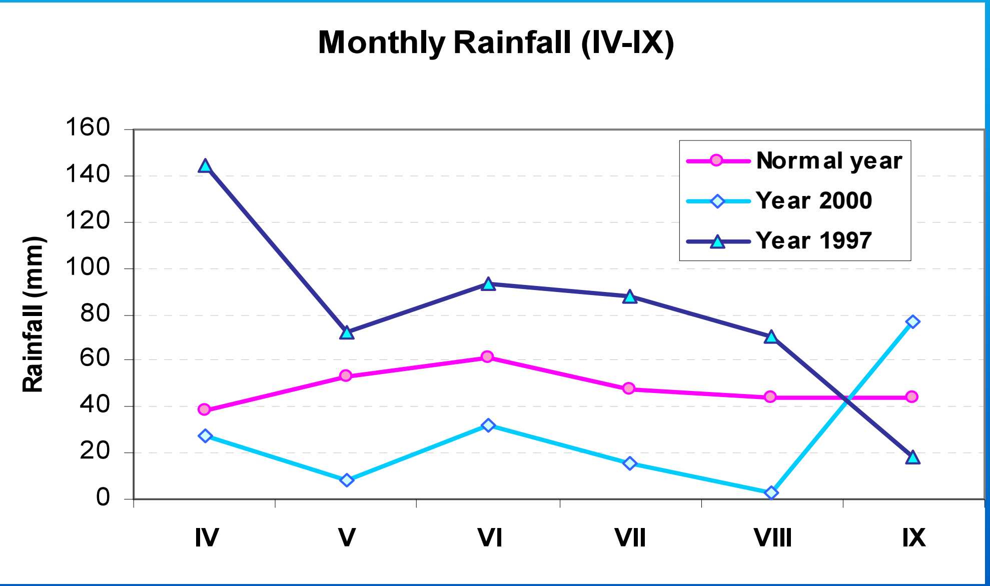
• running the model in the all these 3 years with application of irrigation at fixed intervals and depths;

• quantifying the effects of climate variability on water balance and crop yield reduction by comparing difference between dry and wet year versus normal year of the simulated daily and total water balance components.

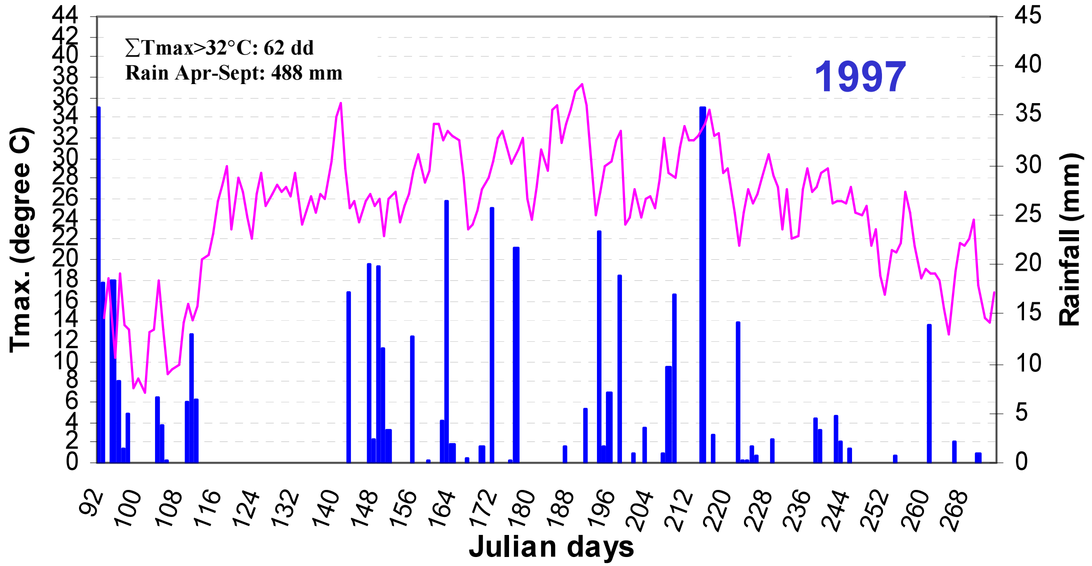
Rainfall variability analysis

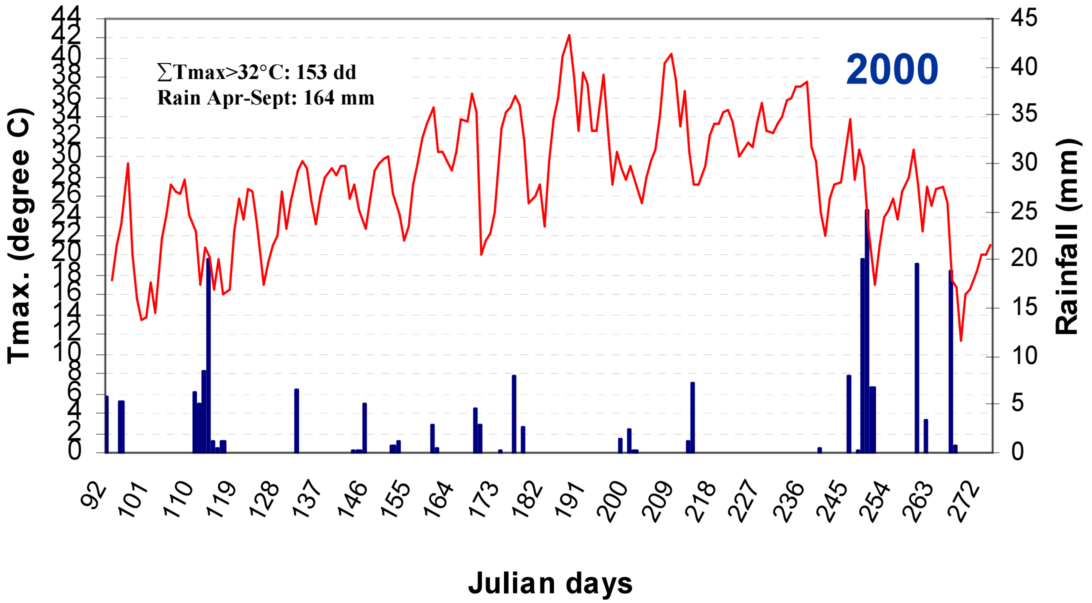


Rainfall variability during maize growing season (April-September) in the period 1961-2001 at the Calarasi station



Variation in the monthly rainfall during maize growing season in the normal year, wet year 1997 and dry year 2000

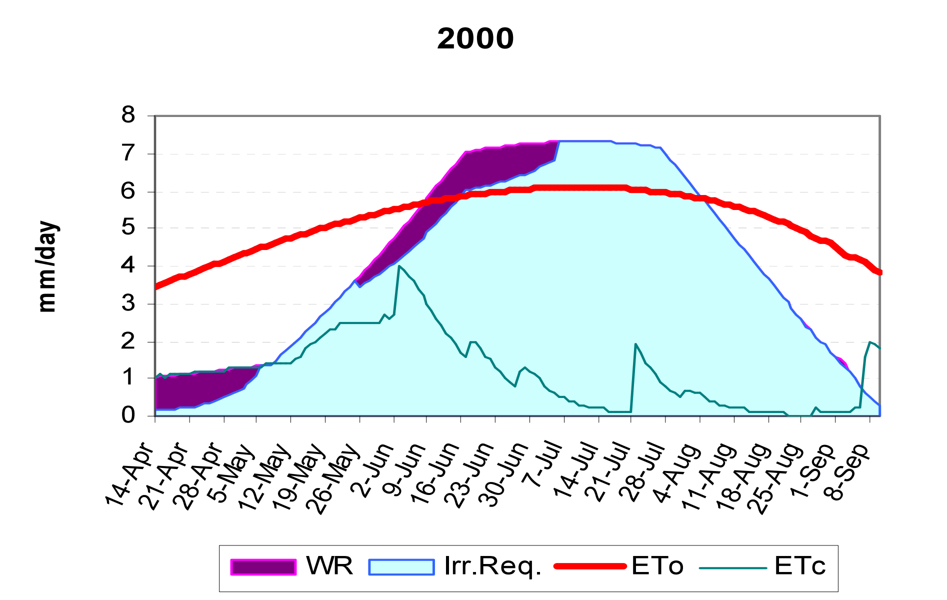


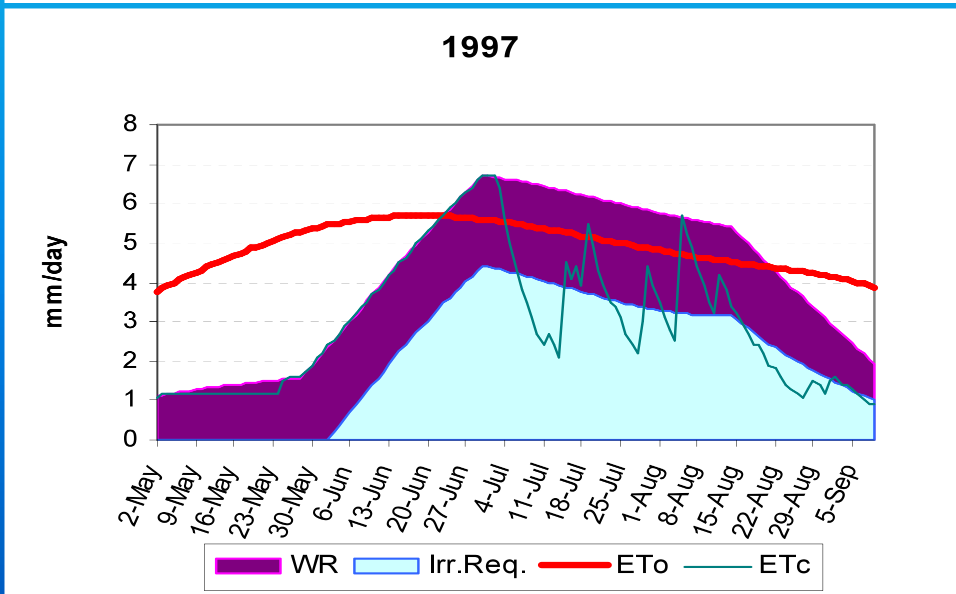


Variation in the daily rainfall distribution and maximum air temperature during 1997 (top) and 2000 (bottom) in the interval April – September, with similar seasonal totals

Results

Effects on evapotranspiration

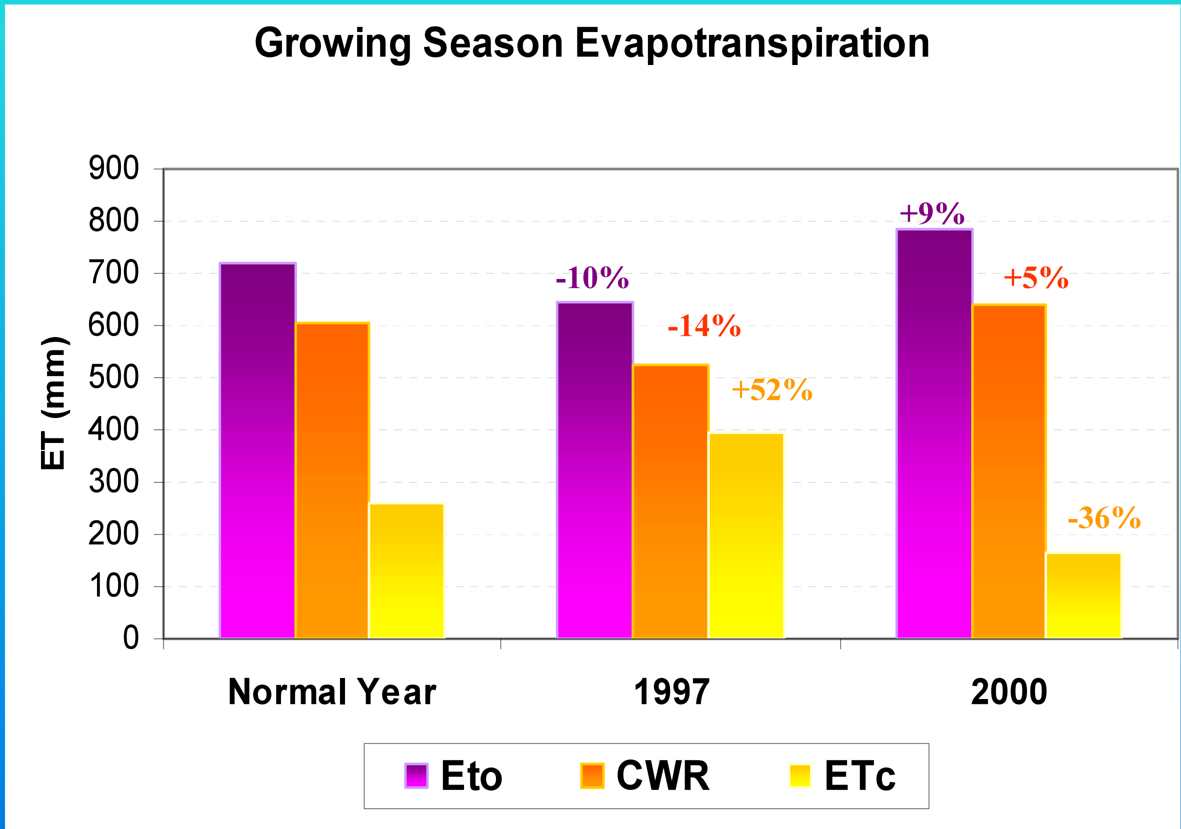




Daily evolution of the reference evapotranspiration (Eto), water requirement (WR), irrigation requirement (Irr.Req.) and actual crop evapotranspiration (ETc) simulated with CROPWAT model during maize growing season, in 2000 and 1997 at Calarasi station

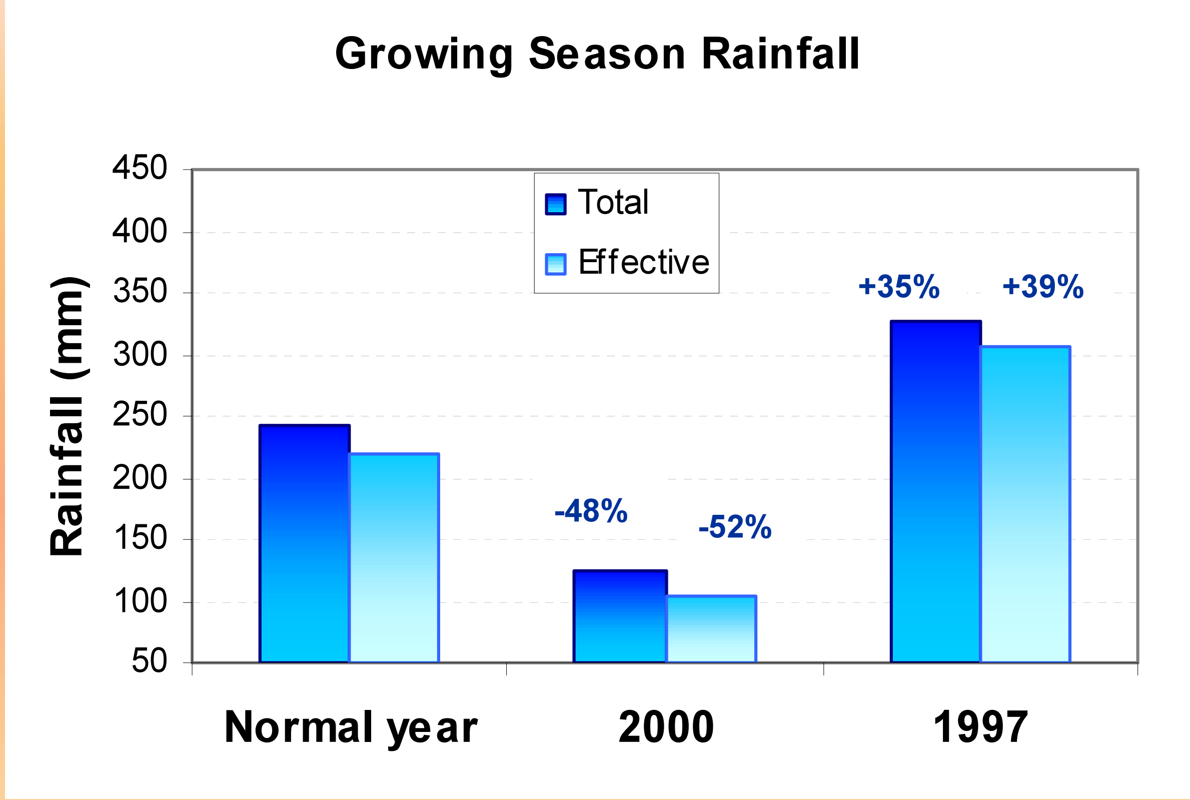
Results

Effects on evapotranspiration



The total amount of the reference evapotranspiration (ETo), *crop water requirement (*CWR) and actual crop evapotranspiration (Etc) simulated with the CROPWAT model, on the whole maize vegetation period, in the all three studied years

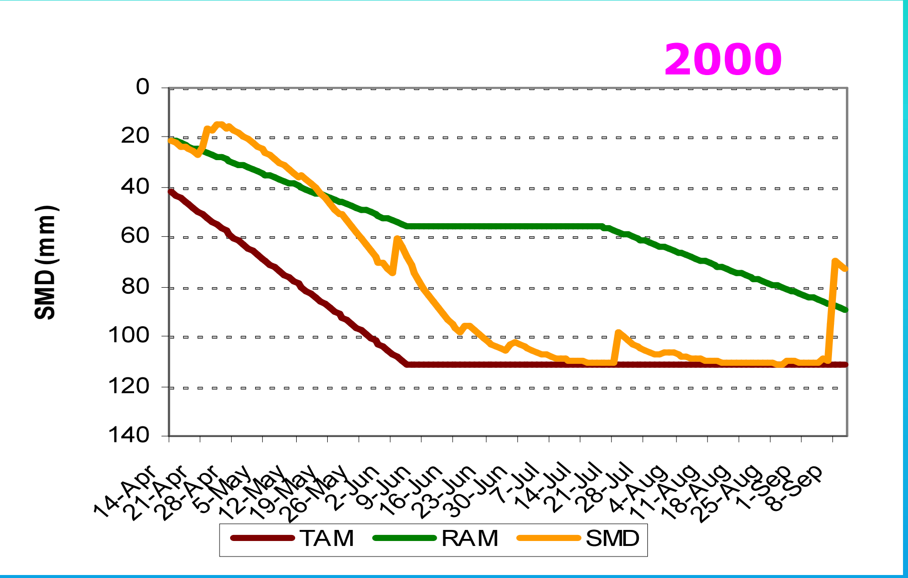
Results

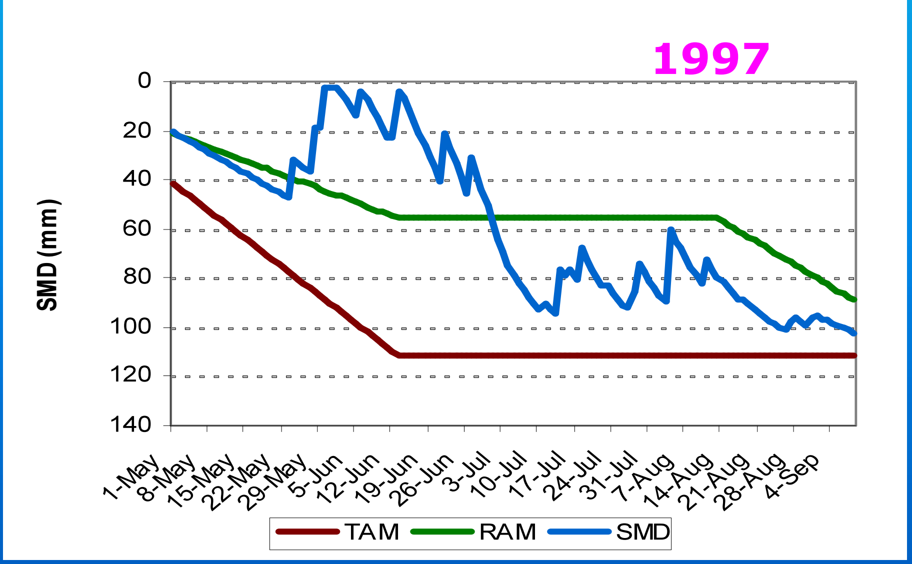


Comparison of the total and effective rainfall during maize growing season in the all three analyzed years

Results

Effects on soil moisture deficit





The dynamics of daily soil moisture deficit at the rooting depth of maize crop simulated with the CROPWAT model during growing season in the dry and wet year

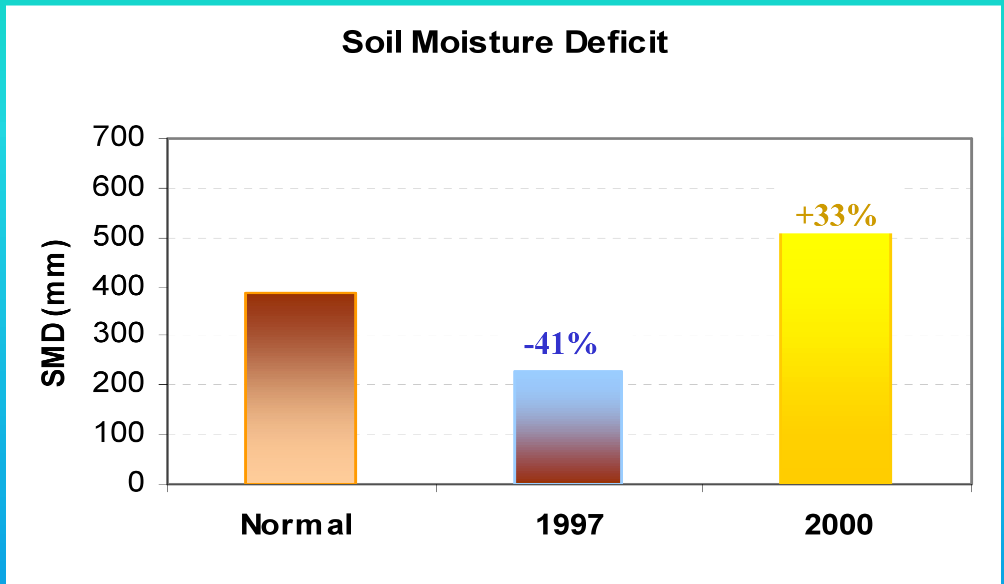
TAM: *Total Available Moisture (Fc-Wp)*

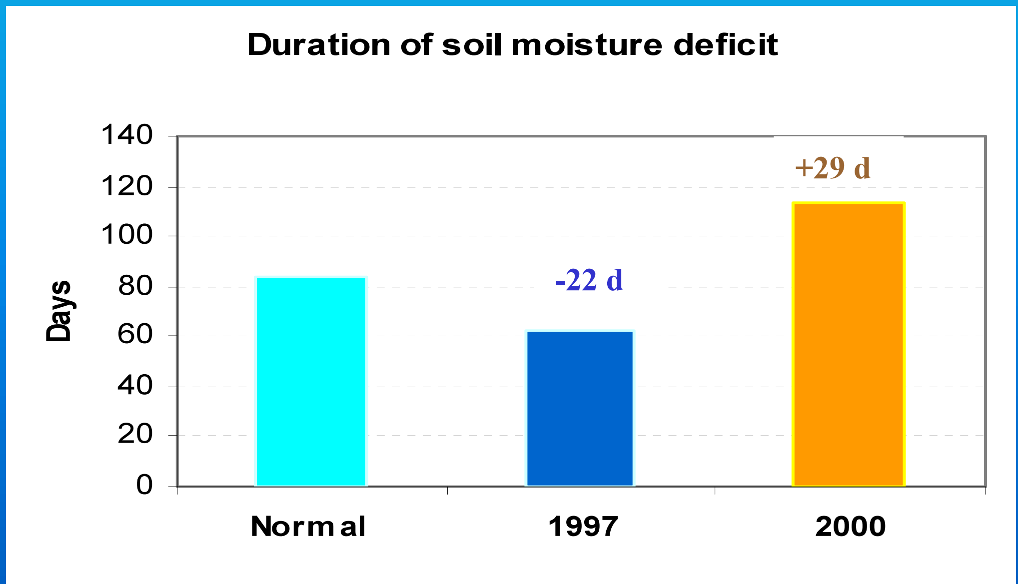
RAM: *Readily Available Moisture (TAM *P)*

SMD: *Soil Moisture Deficit*

Results

Effects on soil moisture deficit





Comparison of the difference in amount (mm) and duration (days) of soil moisture deficit simulated with CROPWAT model in the normal, dry and wet year at Calarasi station

The effect of the rainfed and different irrigation options simulated with CropWat model on estimated total maize yield reduction

(Net Irr.: the irrigation depth applied; Yield red.: the estimated yield reduction due to crop stress)

Years	Management options	Net Irr. (mm)	Yield red. (%)
Normal year	**Raifed** Irr. fixed int.&depth.(3 x 42mm) Irr. fixed int.&depth. (3 x 70mm)	**-** 126 210	**52%** 36% 20%
2000	**Raifed** Irr. fixed int.&depth.(5 x 42mm) Irr. fixed int.&depth. (5 x 70 mm)	**-** 210 350	**90%** 49% 26%
1997	**Raifed** Irr. fixed int.&depth.(1 x 42mm) Irr. fixed int.&depth.(1 x 70mm)	**-** 42 70	**25%** 16% 10%

Conclusions:

- **The CROPWAT model allows assessing climate variability impacts on soil water balance and maize yield;**

- **Climate variability effects depend on the severity of the extreme dry or wet conditions and the crop phonological phases in which hydric and thermic stress occurred;**

- **In rainfed conditions the maize crop suffered from lack of soil water during the growing season in the all three studied years, but with different strengths according to the specific climate conditions of each year;**

Conclusions:

- In the extremely dry year 2000, the maize was the most seriously damaged by soil drought, which occurred as a result of low rainfall relative to crop water requirements associated with the high maximum temperature, and as a consequence in the areas without irrigation the yield loss was considerable (up to 90%);

- The maize being a crop with high water requirements, by application of irrigation the yield losses due to the crop stress can be significantly reduced, especially in extremely dry years.

Summarized results