Isotopic and conventional techniques to improve the irrigation practice in order to enhance agriculture production under water limiting conditions in morocco

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PLAN

Problematic

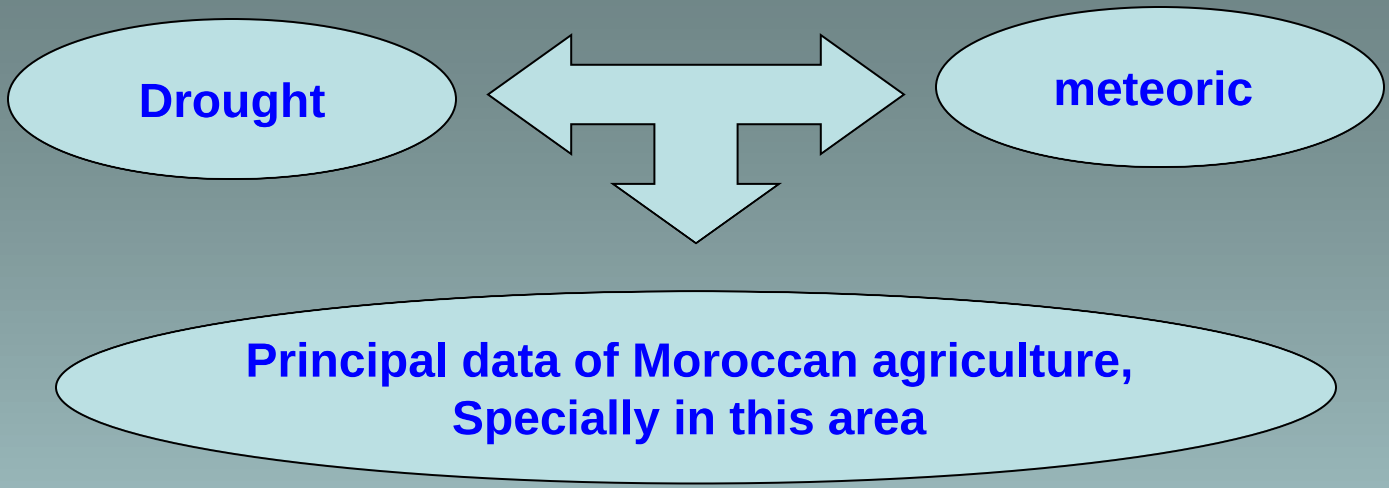
Study site

Field installation

Laboratory works

Results

Conclusions



The irrigation of agriculture remains the only possible way to improve the production.

The evapotranspiration and deep percolation constitute the most important factor of water losses, whose, its determination is capital for a well control for water resources management.

Objectives

Quantification of loss by deep percolation.

Determination of evapotranspiration components flow by using isotopic methods (Keeling plot) ;

Validation of use isotopic techniques in our conditions

Tow studies cases

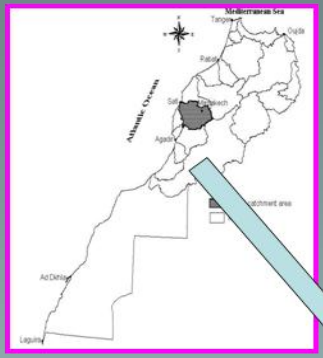
Orange tree

Drip irrigation

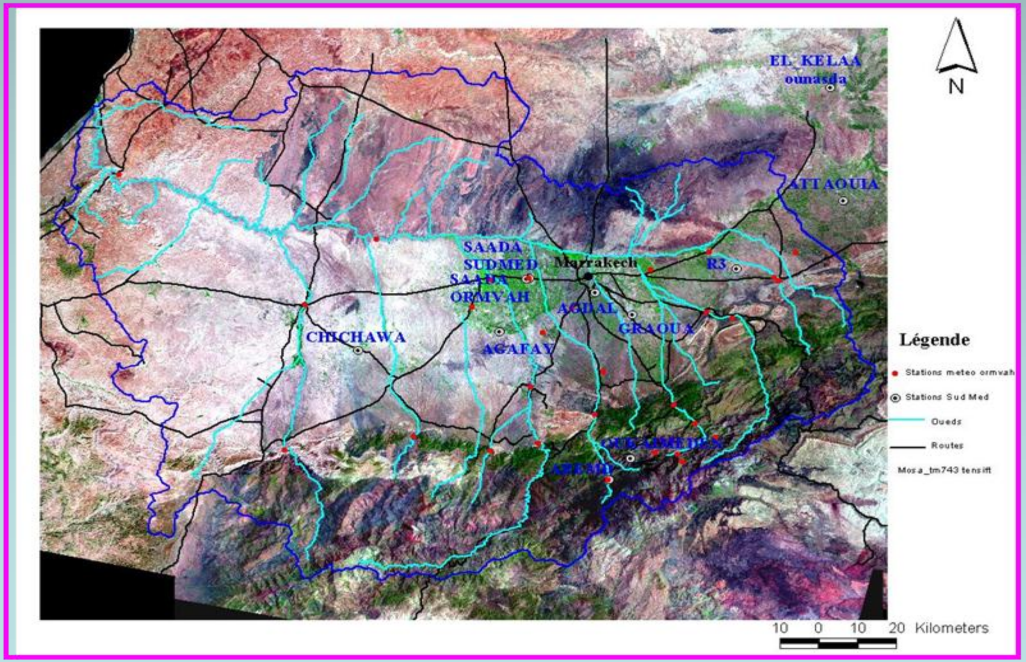
Wheat crop

Flood irrigation

Study site



The study area, Tensift catchment (N9.30, N7.15 and W30.45, W32.15) lying in the middle of Morocco. Tensift has a semiarid climate; with 253 mm average annual precipitation falls during winter and spring (November–April). Very little precipitation falls between May and October. The principal economic activity is agriculture and it’s based on irrigation practices



study site equipped with :

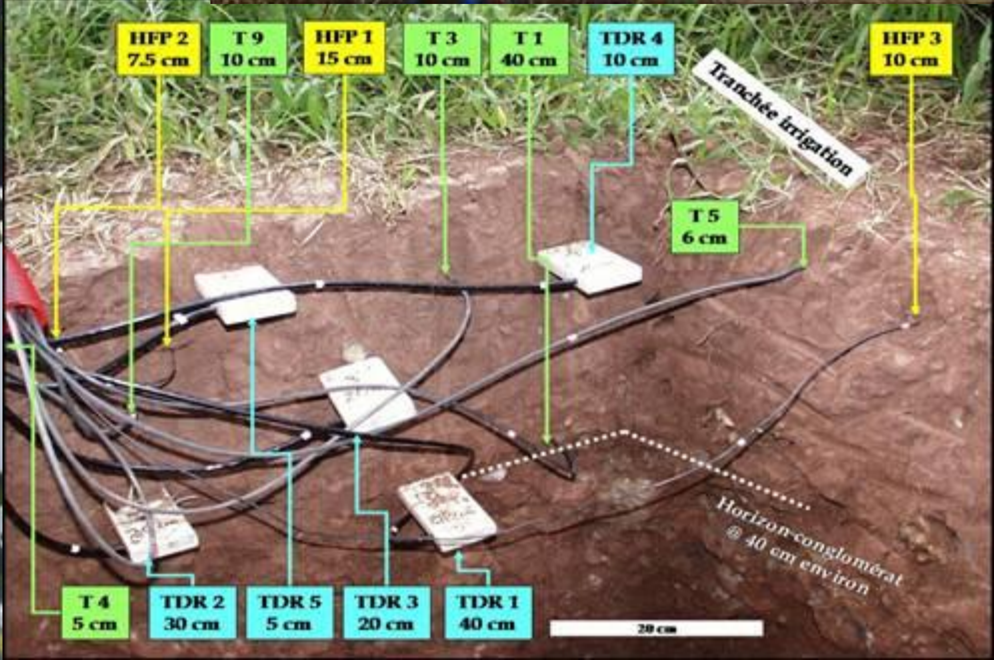
Standard meteorological instruments to measure:

-Wind speed and direction ;

-**Air temperature and humidity ;**

-**ET by Eddy covariance system ;**

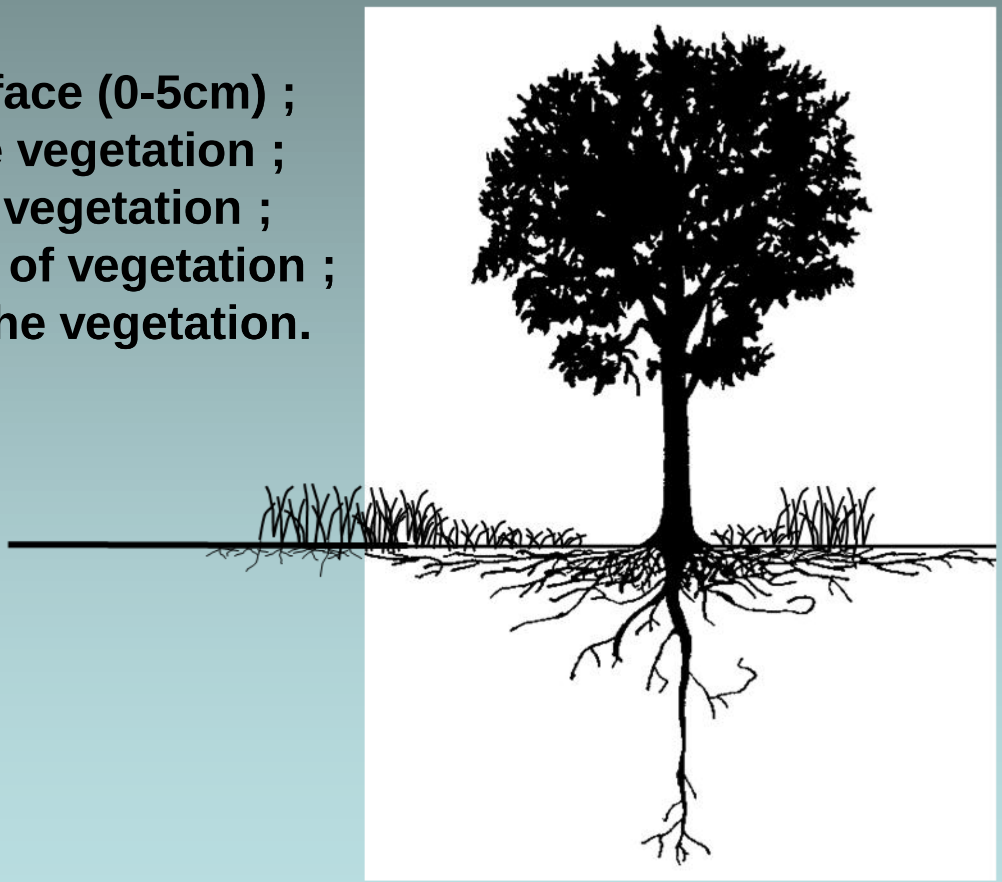
-**Soil humidity was measured at different depth.**

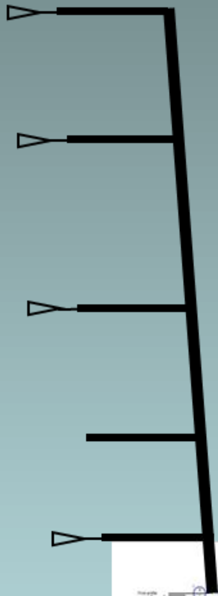


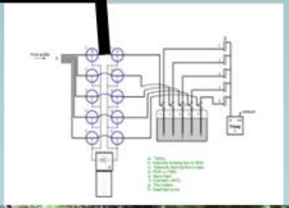
Sampling

Water vapor **was collected from 5 heights at same time. For each group vapour was collected during 1hour with a flow rate of 250 ml min-1 using a vacuum pump**

- **Soil Surface (0-5cm) ;**
- **¼ of the vegetation ;**
- **½ of the vegetation ;**
- **Maximal of vegetation ;**
- **1 m up the vegetation.**







Soil and vegetation

Using a hand-auger, soil was sampled from the surface to 80 cm. In the objective to determine the evaporation front

Stem water extracted by hand vaccum pump from stem.

Laboratory works

In the laboratory the water of soil and stem are extracted by vacuum distillation, during 2 hours at 100°C

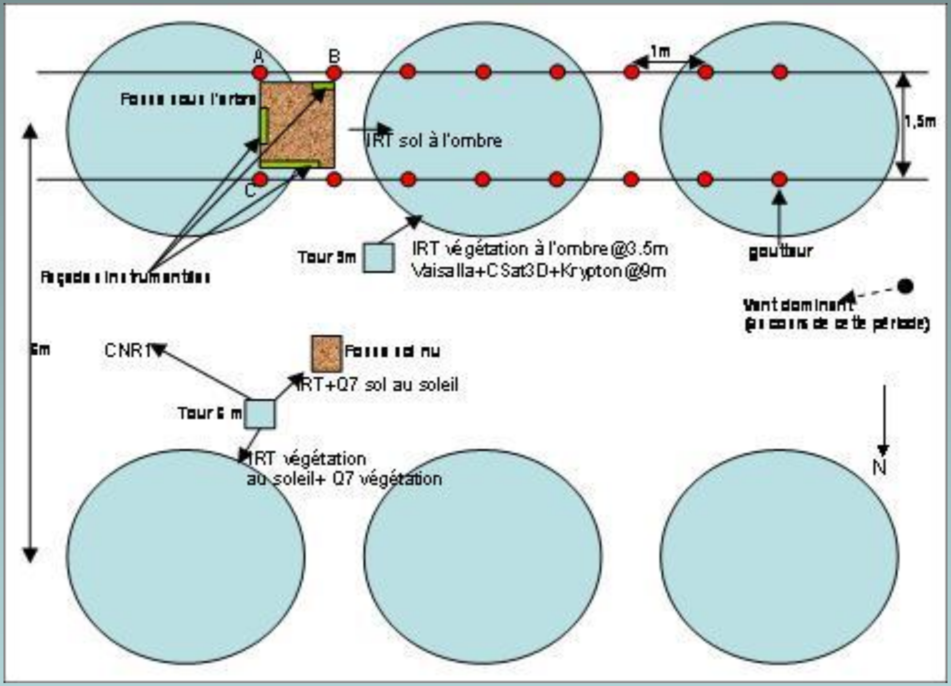
Cryogenic distillation ligne

Stable isotope analysis Uncertainties by LASER (DLT-100) (± 1 standard deviation)

- **$\delta^{18}O$ ~ 0.2 ‰ SMOW**
- **δD ~ 1 ‰ SMOW**

Orange study

The crop planted since 2000 with medium density and irrigated with drip irrigation system, the distance between dripper is 1 m

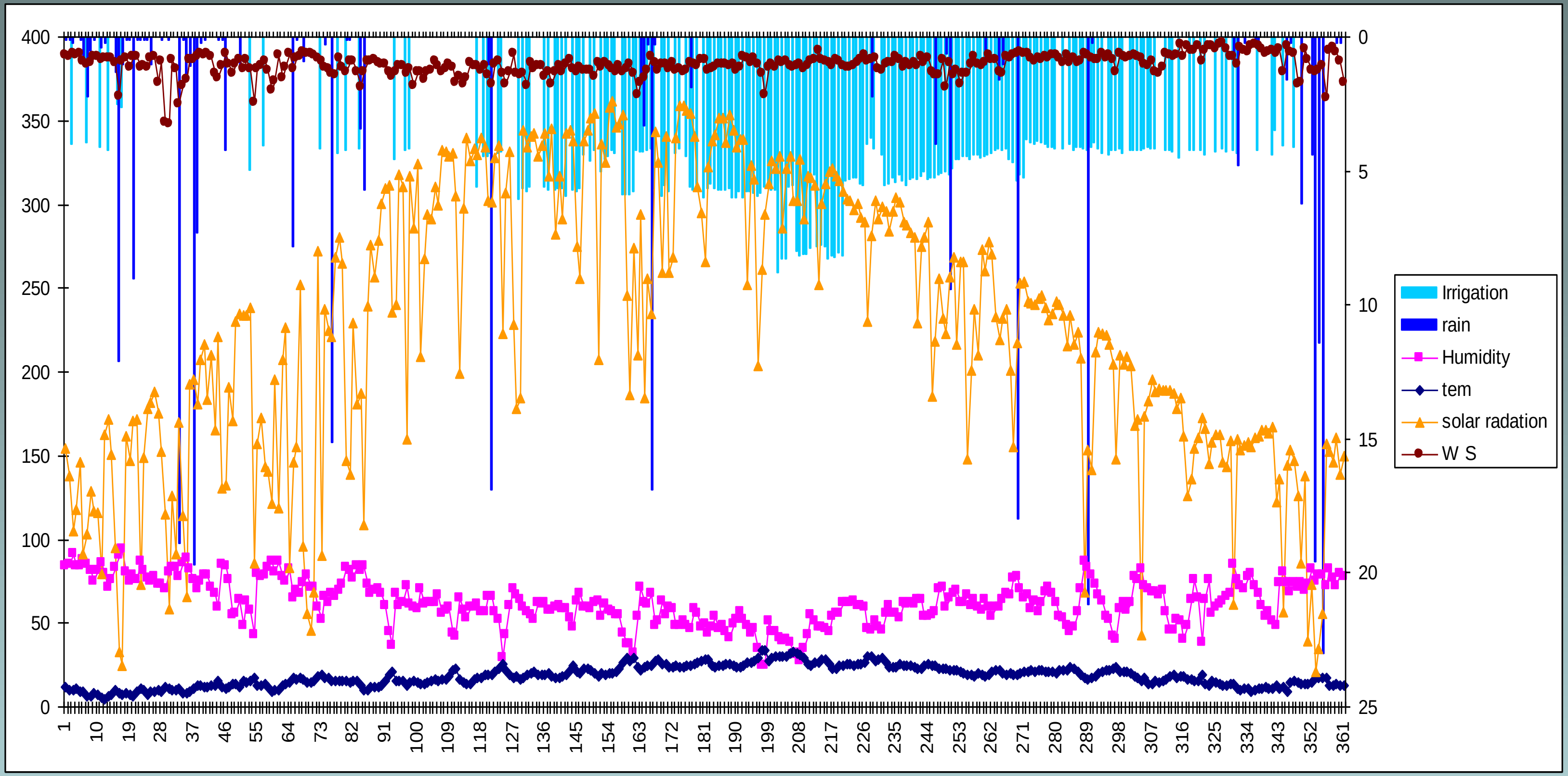


<u>Soil type :</u> **The soil has high sand and low clay contents (18% clay, 32% silt, and 50% sand).**

Flux meter installation

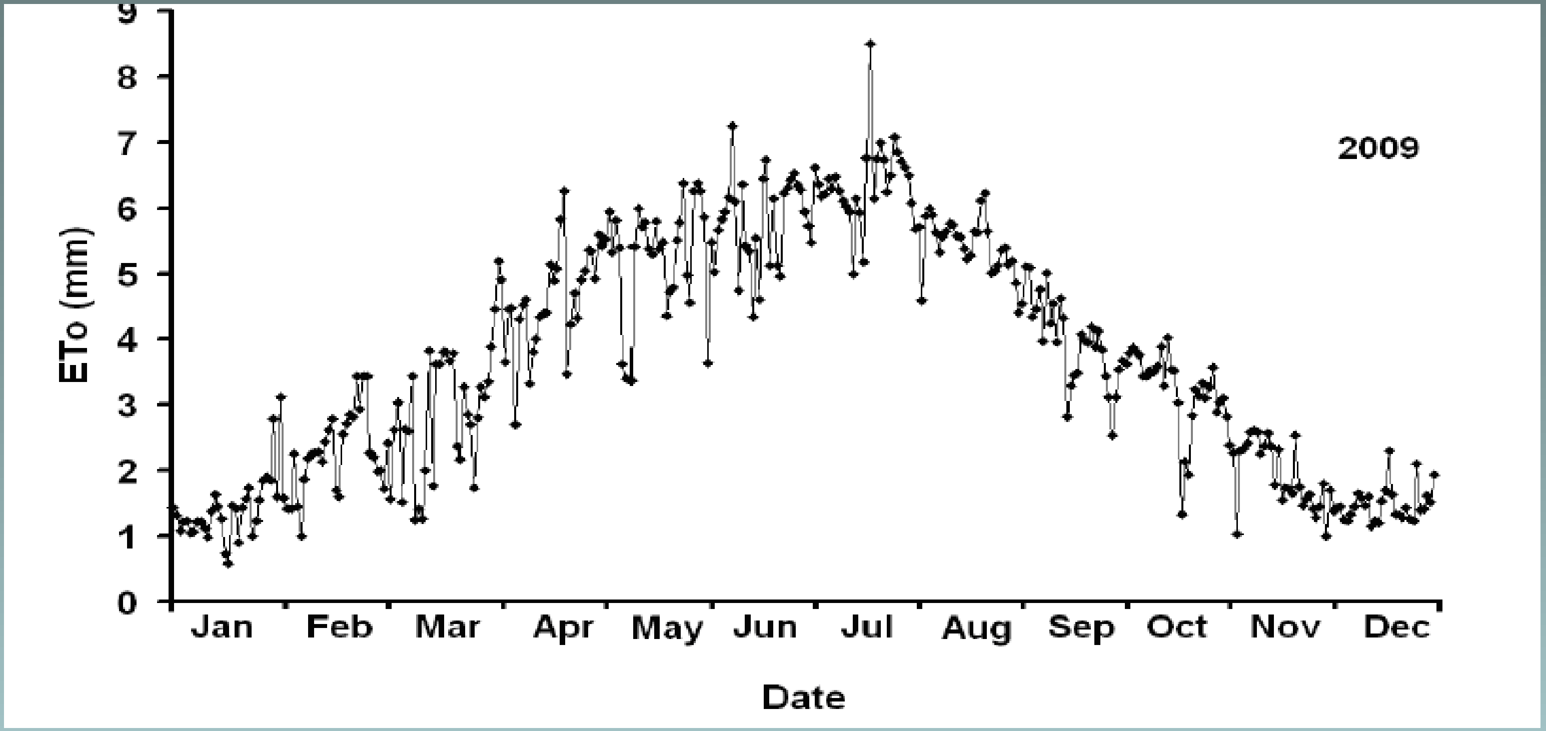
- Flux meter is Installed at 80 cm depth, under the ground which correspond to the roots zone.

Results



The environmental condition during the growing season of 2009

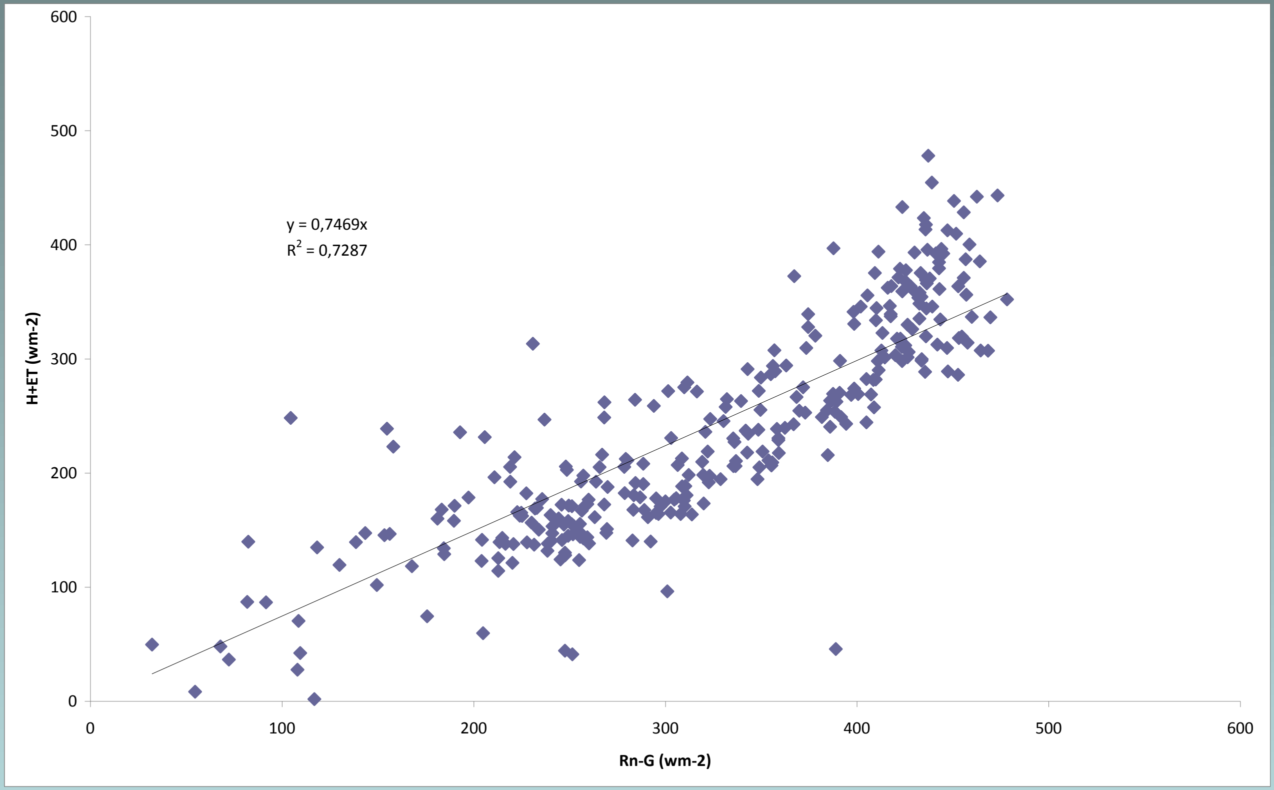
Precipitation temporal patterns over the growing season of citrus trees were characterized by low and irregular rainfall events, with a total precipitation amount of about 295 mm. The amount and timing of irrigations applied by the farmer are presented also in this figure



ET0 of well-watered grass calculated following the FAO-Penman-Monteith equation during 2009

This Figure shows the seasonal variations of the reference Evapotranspiration ET0 of well-watered grass calculated using the The FAO Penman–Monteith equation for the meteorological forcing parameters collected over our study site. The ET0 pattern is characteristic of semi-arid continental climates. with an average accumulated annual ET0 of 1355 mm. The lowest values of ET0 occurred during the winter and autumn (0.05 mm/day) and the highest values occurred in the summer (11.07 mm/day).

The energy balance closure is an important indicator of the performance of an Eddy Covariance system.

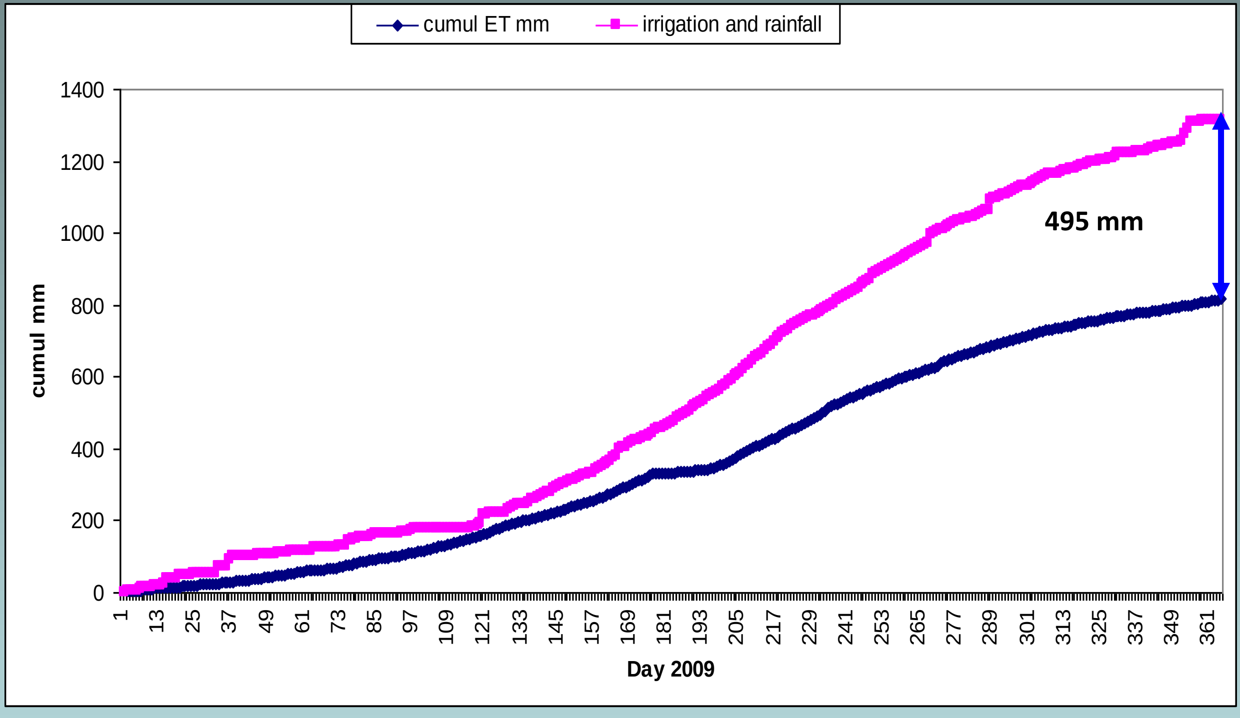


Validation of EC data

This figure presents a cross plot between measured (*Rn*-*G*) and the sum of the turbulent fluxes (*H*+*ET*). We can concluded that the ET measured by EC was acceptable with a slope 0,74 and R2 0,728.

Water balance

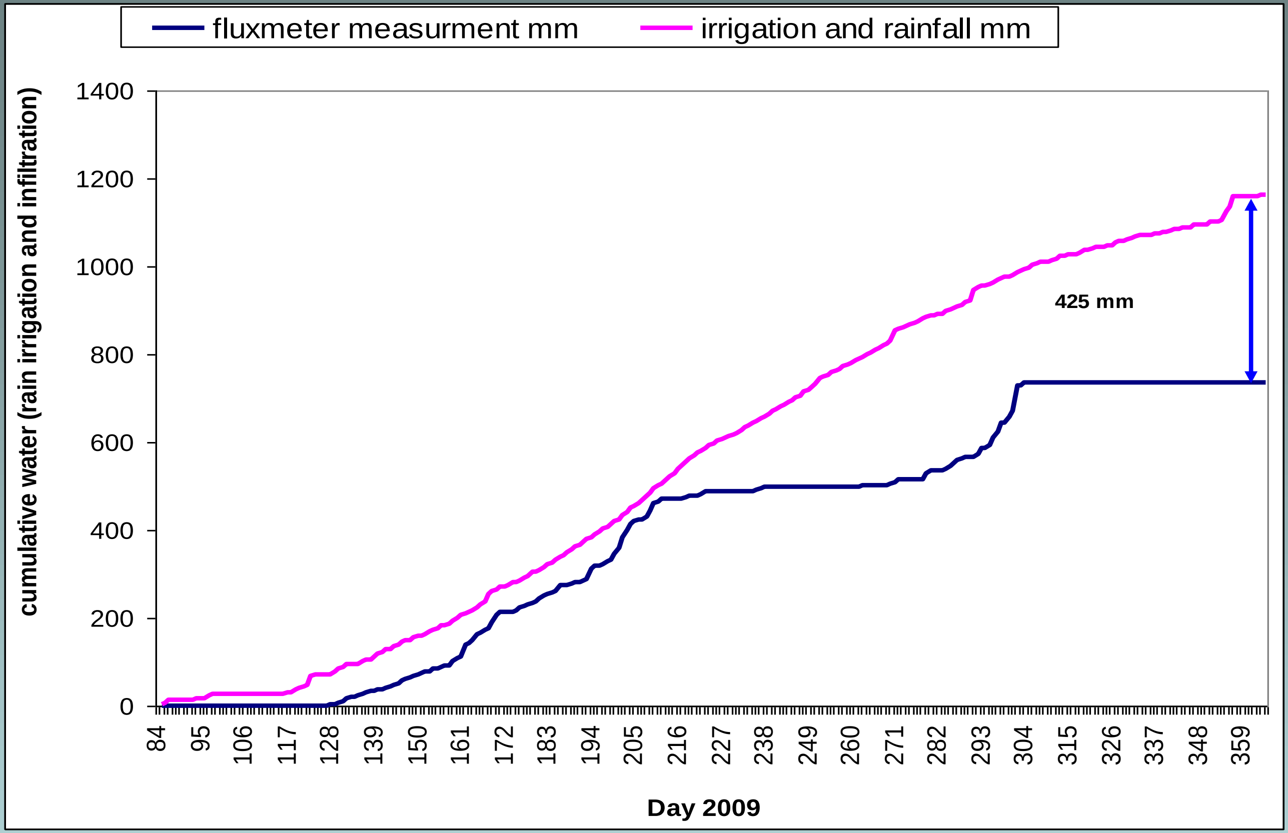
The use of water balance equation allows to determine the rate of infiltration



Cumulative Evapotranspiration (ET) measured by Eddy covariance, compared to sum cumulative precipitation (mm) and irrigation amount (mm).

For this case the difference between cumulative ET and the sum of cumulative irrigation and rain is about 495 mm corresponding to 38% of amount irrigation and rain

Direct measurement (fluxmeter)

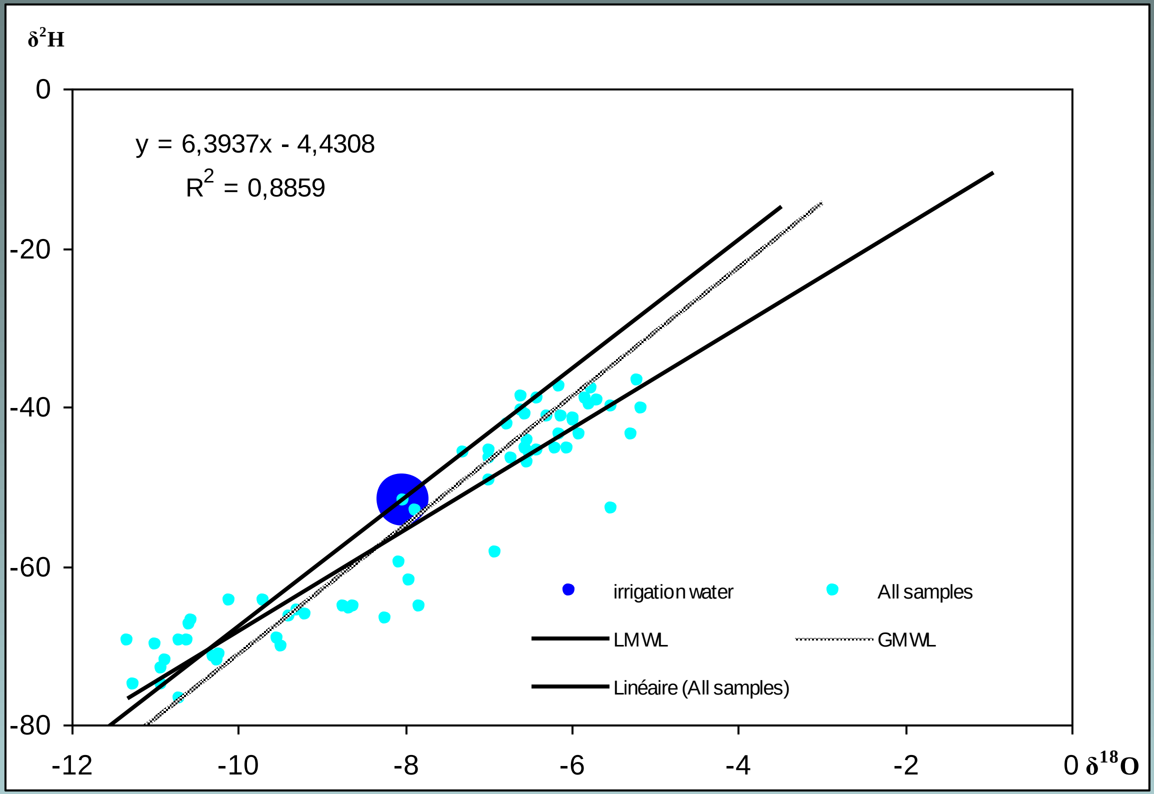


Cumulative drainage compared to sum cumulative precipitation (mm) and irrigation amount (mm)

425 mm represented 32% of the sum of cumulative rain and irrigation. This result confirms the obtained result by using the water balance equation

The difference between direct measurement of percolation and that derived from the water balance can be explained by Surface runoff of rain

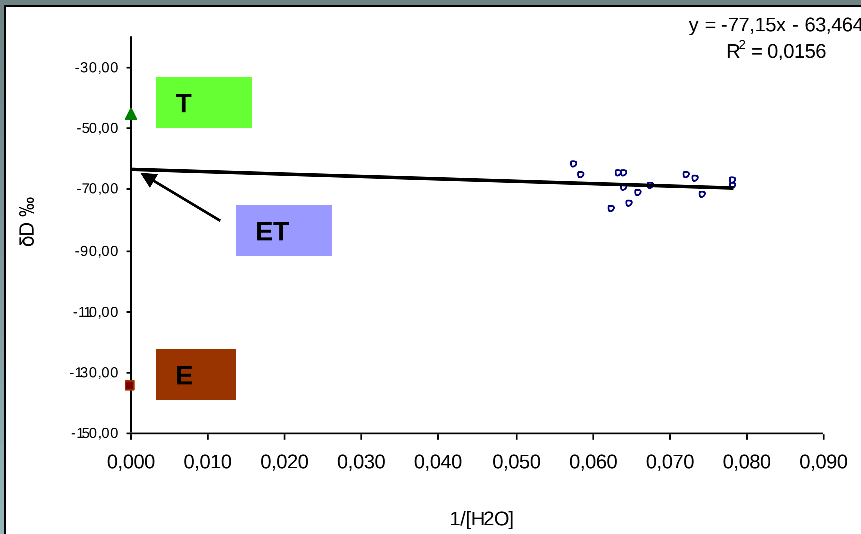
Isotopic data

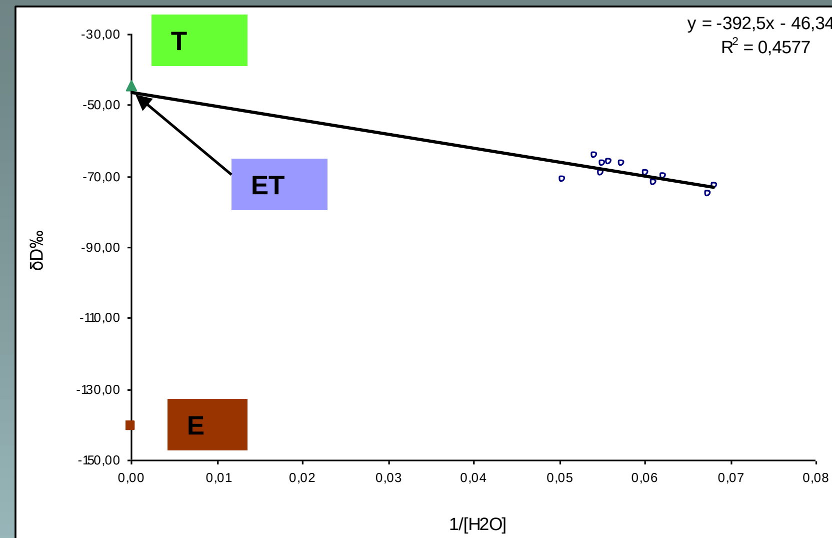


δ18 O versus δD in precipitation, atmospheric water vapor, soil water and stem water

All samples (vapor, soil water, stem water, irrigation water) are situated around the LMWL. The regression line of all samples intersect the LMWL at the point that presents the origin of all samples

Keeling plot





	δs	δa	h	T	δT	δ ET	R^2	α	εk	δE	FT
16	-41,4	-65,08	0,43057	29,084	-44,63	**-46,30**	0.457	1,0750	1,0250	-140,50	0,982
17	-46,14	-68,53	0,3363	28,942	-45,15	**-63,464**	0.015	1,0751	1,0250	-134,861	0,795

δ ET intercept of keeling plot

δE calculated by Craig and Gordon model (1965)

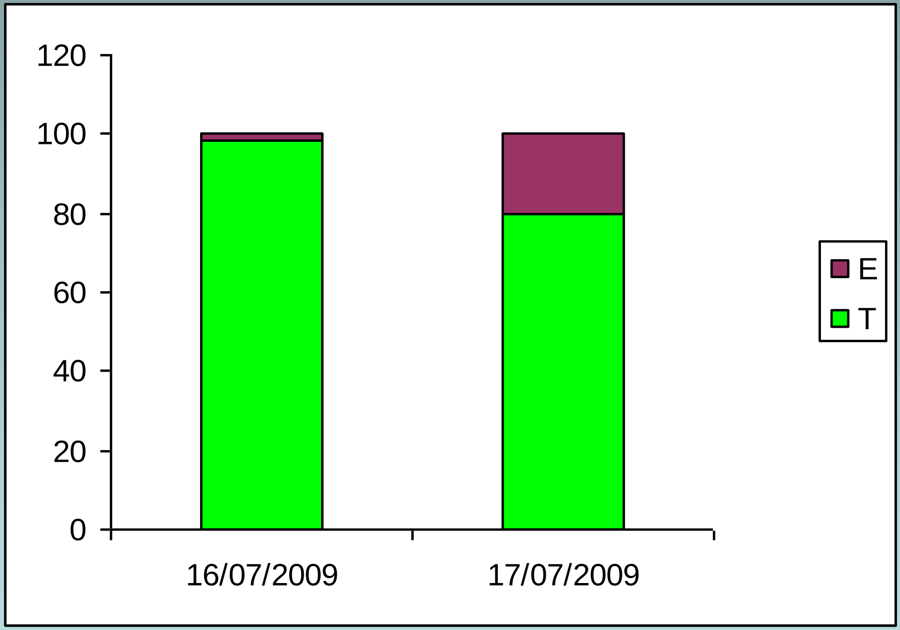
$$\delta_E = \frac{\alpha * \circ \delta_{surface} - h \circ \delta_{atm} - \varepsilon_{eq} - (1-h) \circ \varepsilon_k}{(1-h) + (1-h) \circ \varepsilon_k / 1000}$$

δT measured

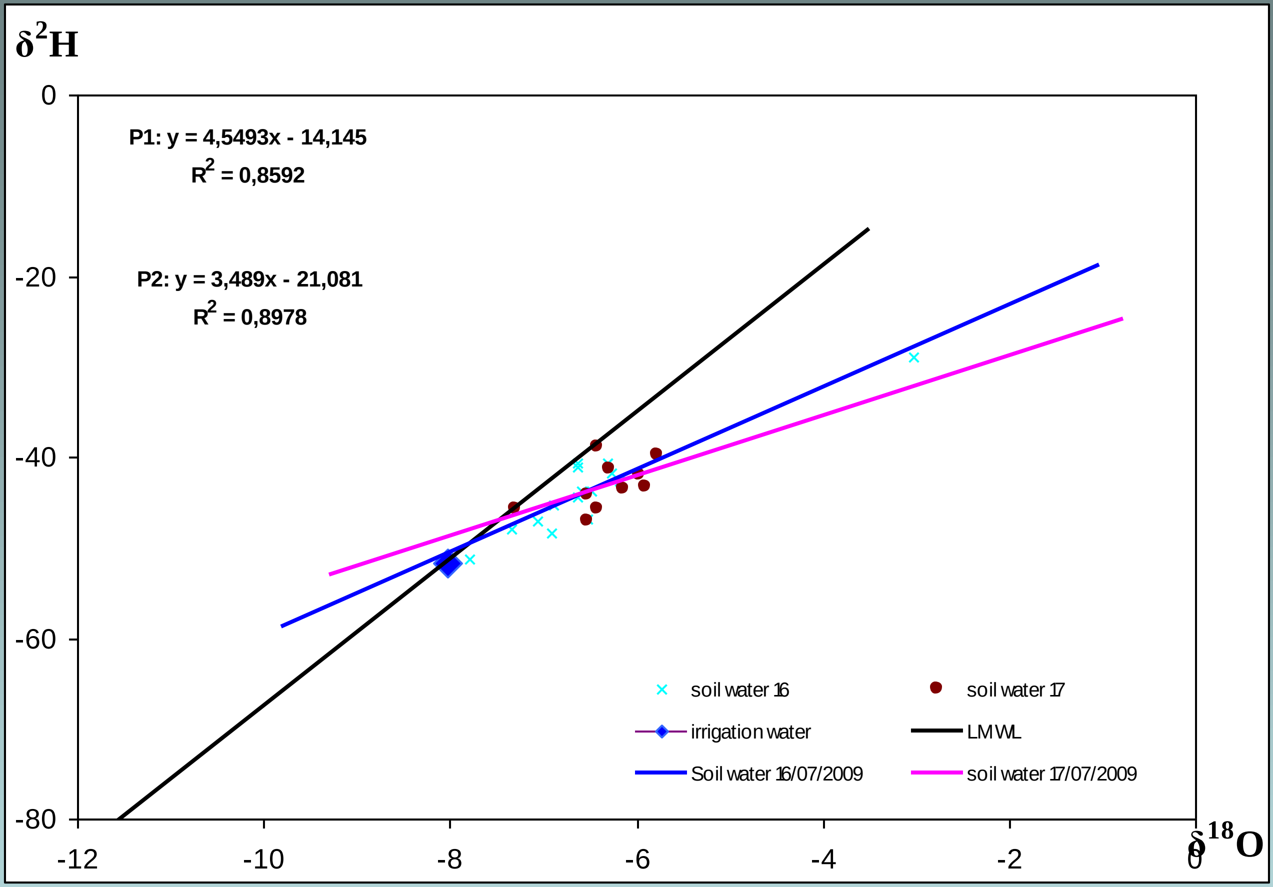
Contibution of transpiration and evaporation on evapotranspiration

The fractional contribution of transpiration to the total ET fluxes (*F*T) were calculated from:

$$F_T = \frac{\delta_{ET} - \delta_E}{\delta_T - \delta_E}$$



Considering orange crop transpiration as one source and soil evaporation as another one, the fractional contribution of plant transpiration to total ET (T/ET) is 79,5% for *δ*D July. Therefore the transpiration dominates the evaporation.



The figure shows that the profile extract at midday on 16/07/2009 have a slope 4.648, but the second profile extracted on 17/07/2009 have a slope 3.489. That shows high evaporation during the second day compared to the first one. That confirms the results obtained by keeling plot.

Wheat study

Wheat study

Superficie : 5ha

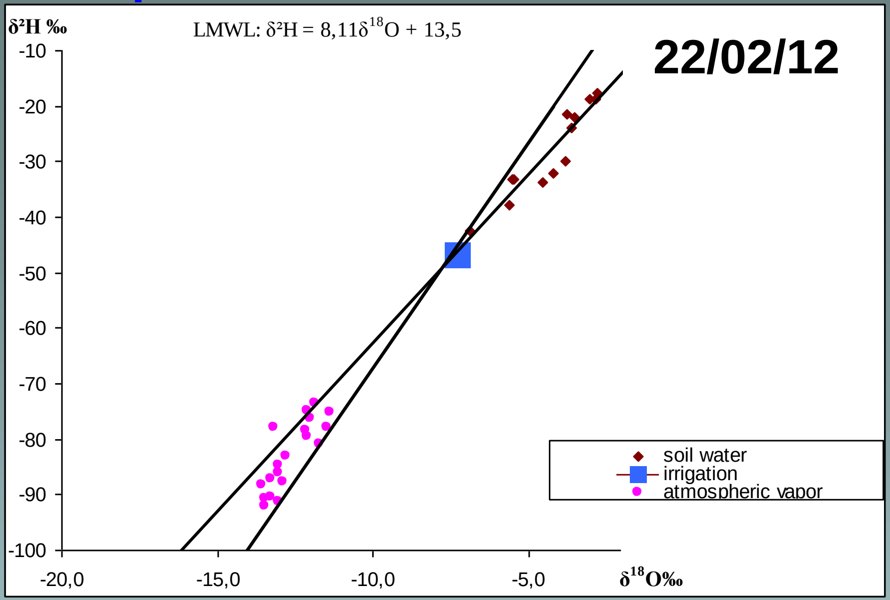
Irrigation type : flood

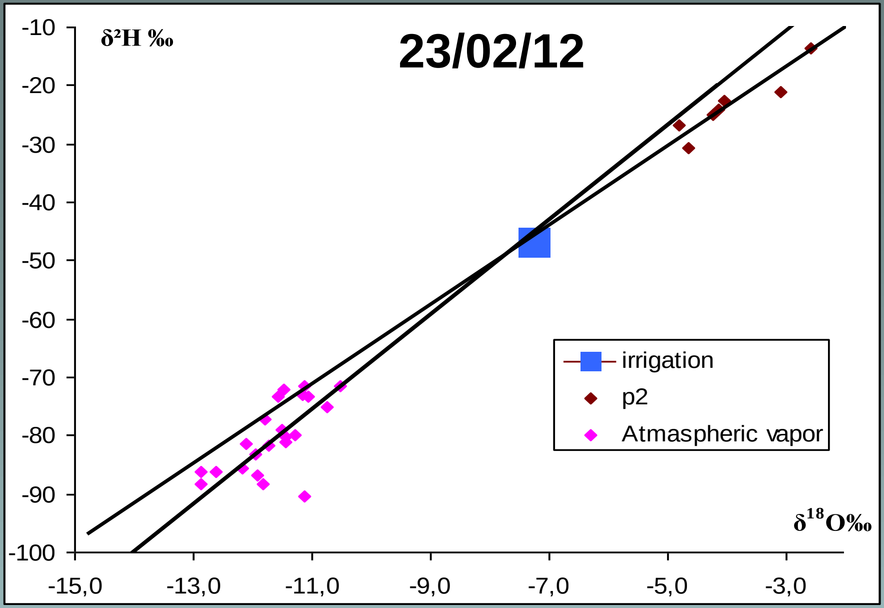
Soil type :

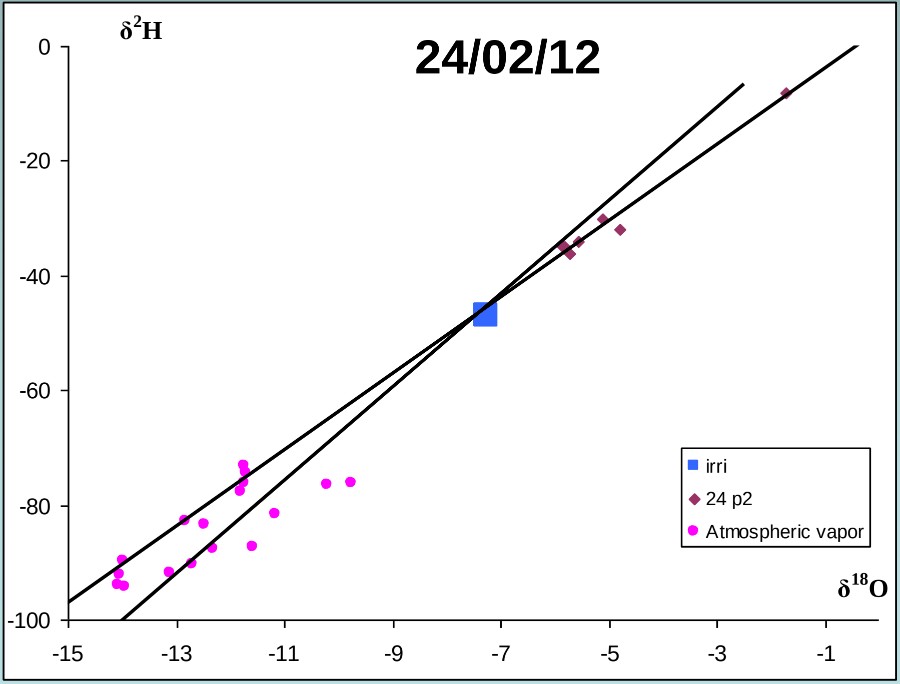
	Clay	Silt	sandy
%	40	42.1	26.9

Wheat study

Isotopic data



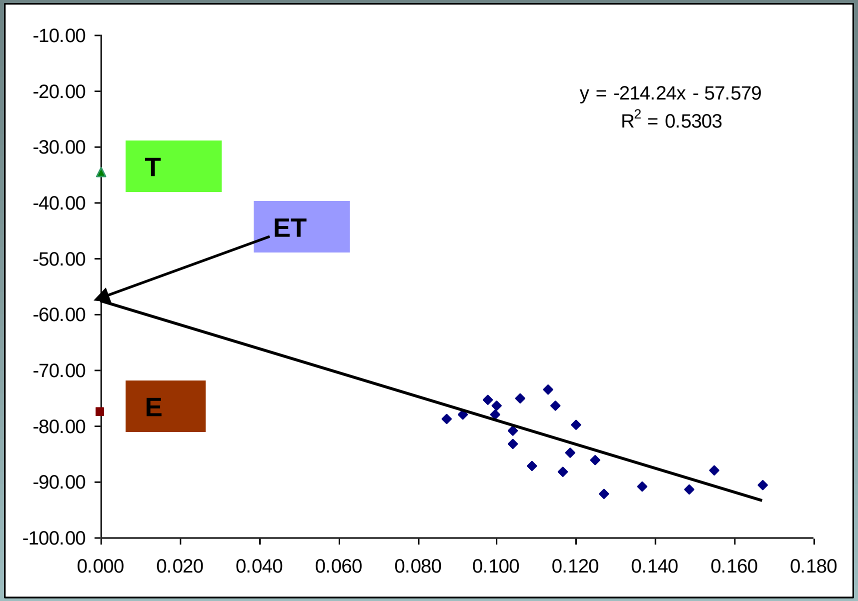


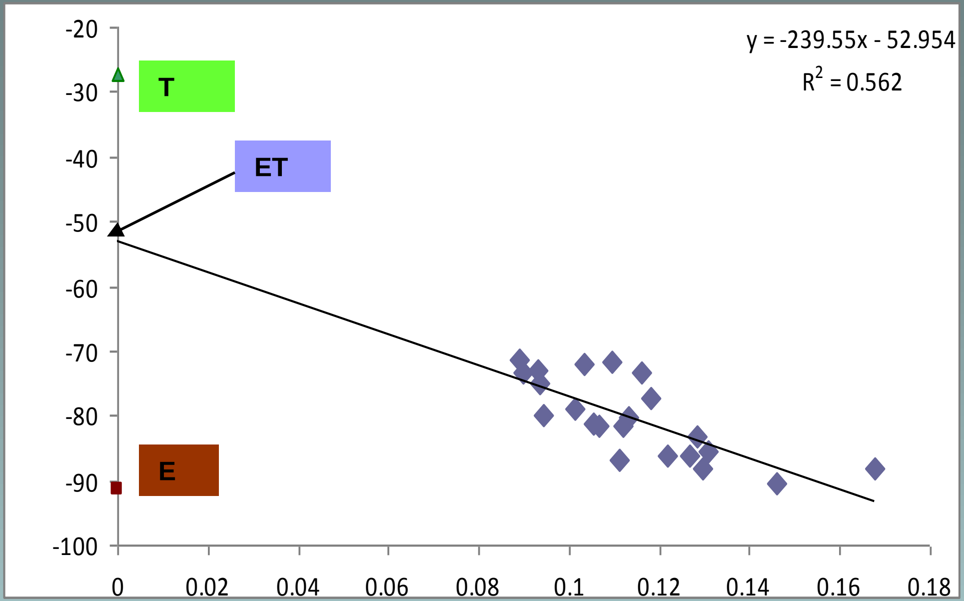


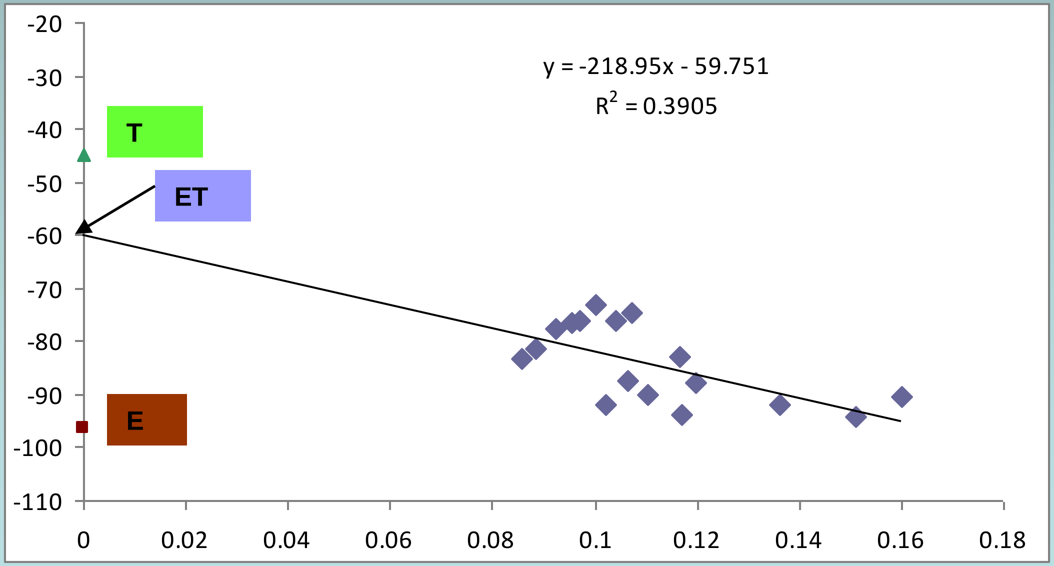
All samples for three day of sampling (vapor, soil water, irrigation water) are situated around the LMWL the regression line of the all samples intersect the LMWL at point that present the origin of all samples

Wheat study

Keeling plot



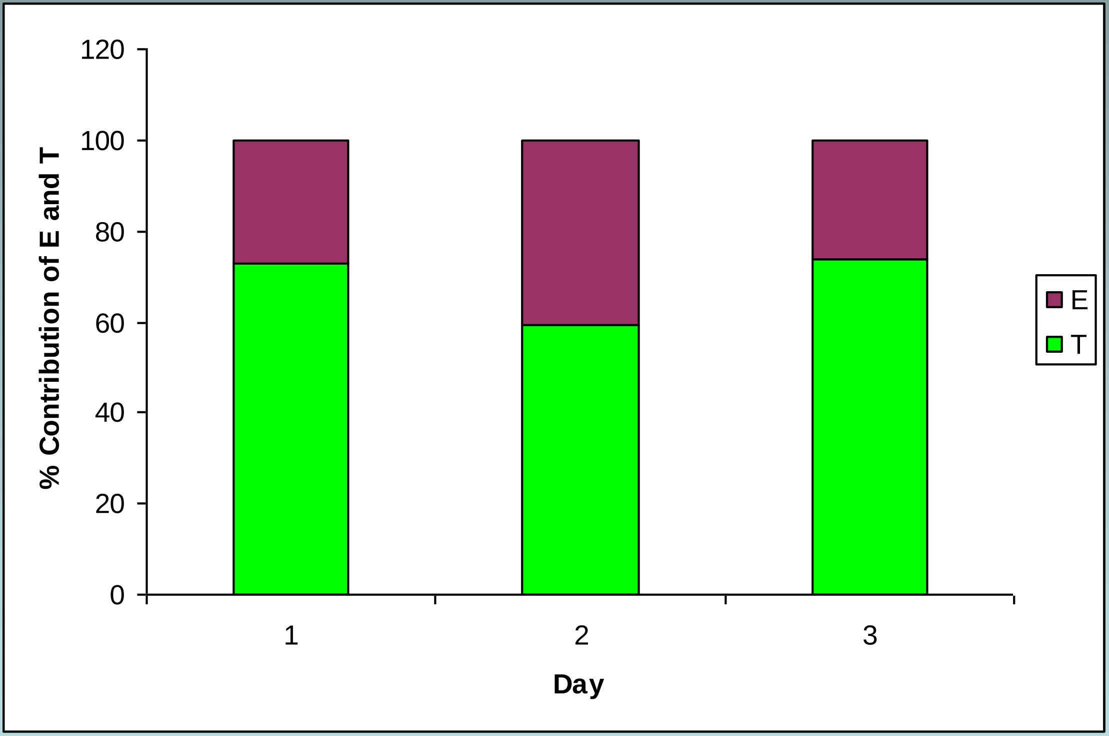




Wheat study

	δs	δa	h	T	δT	δ ET	R^2	α	εk	δE	FT
22/02/12	-27,26	-73,46	0,43	24.11	**-34,55**	**-57,58**	0,530	1,08	1,03	**-119,28**	0,73
23/02/12	-5,72	-68,22	0,46	23.87	**-27,29**	**-52,95**	0,562	1,08	1,03	**-90,09**	0,59
24/02/12	-26,05	-71,36	0,45	23.06	**-37,44**	**-59,75**	0,39	1,08	1,03	**-122,06**	0,74

The fractional contributions of plant transpiration to total ET (T/ET) is 68 % for three day. This may can explain by height canopy cover 77 % at this growing stage.

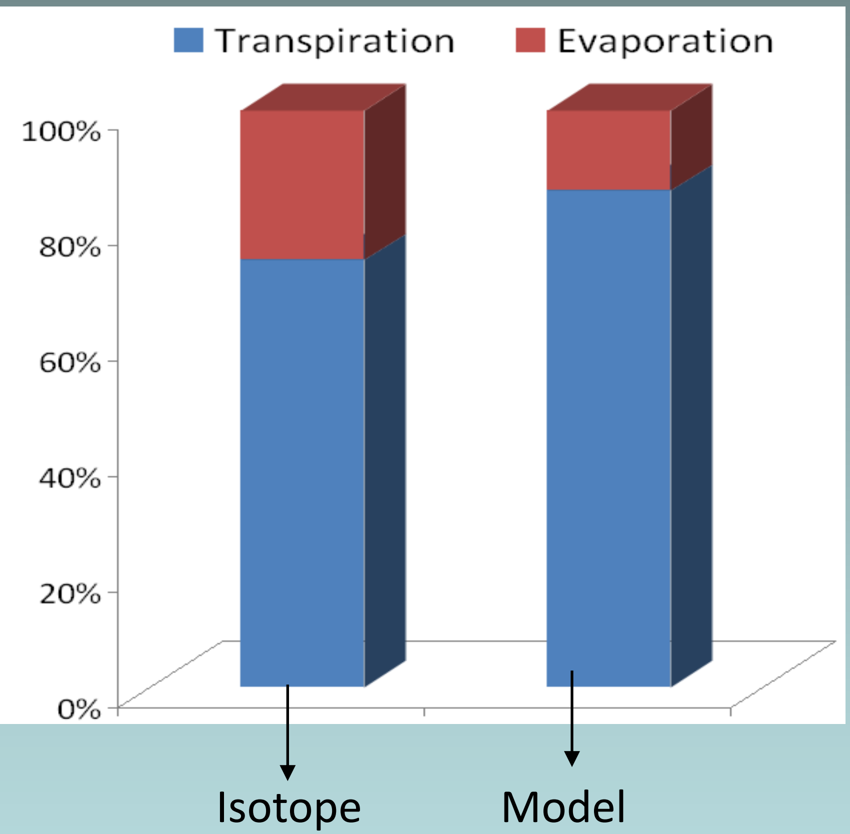


Contribution of transpiration

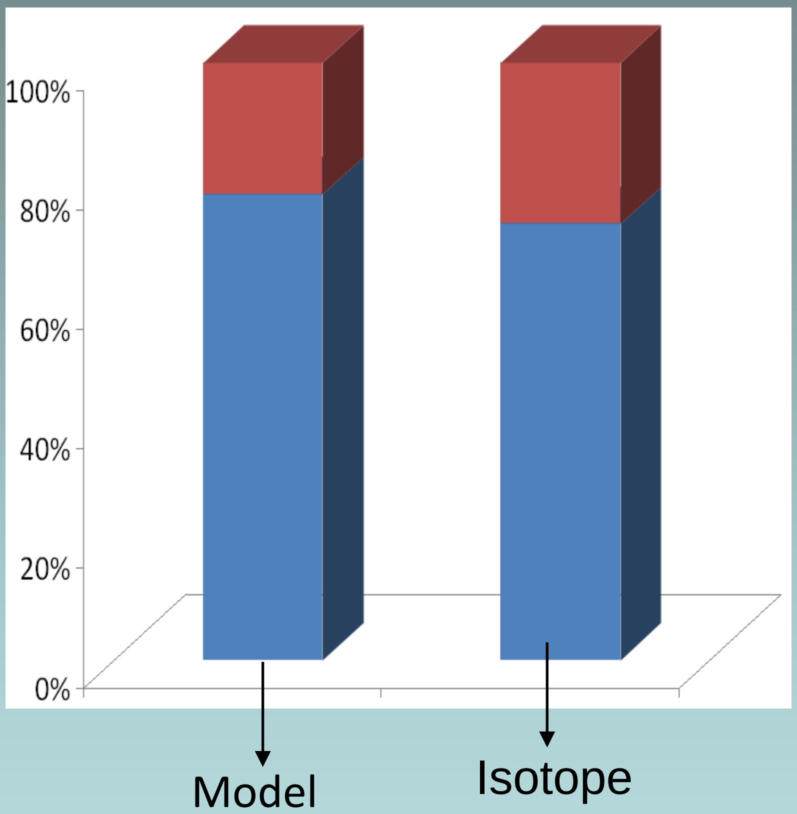
Wheat study

Partitioning of the evapotranpiration components by Aquacrop model

24/02/2012



22/02/2012



By analysing this figure we can conclude that the model gives an acceptable estimate of plant transpiration and soil evaporation. The differences between isotopic and aquacrop estimation, were 5 and 12% for 22/02/2012 and 24/02/2012 respectively.

Wheat study

Estimation of the Yield

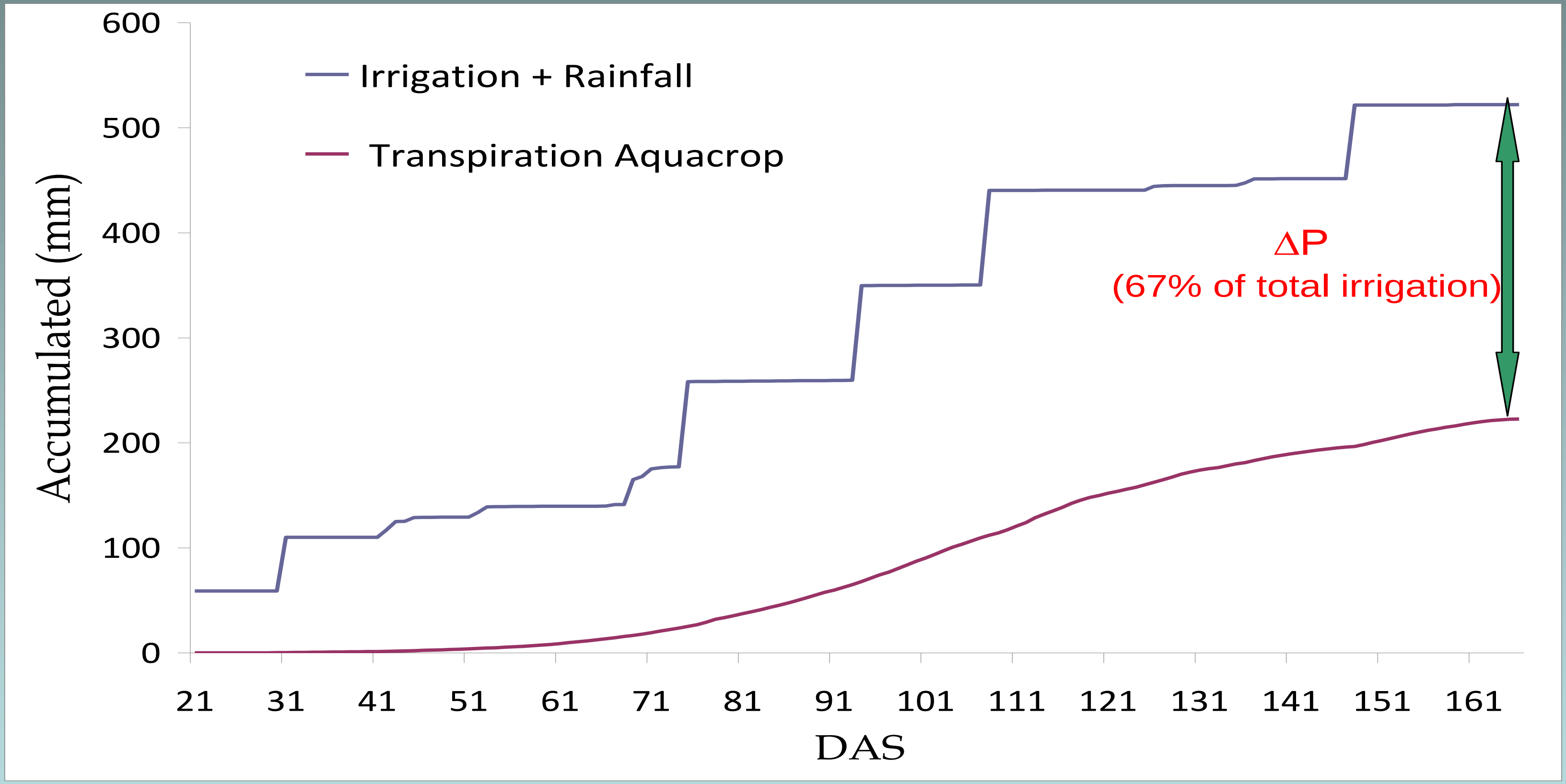
Yield (t/ha)	
Measured	**Simulated**
5,1	4,98

In this table we present a comparison between simulated and measured yield using the quantity of irrigation applied by the farmer. As we show, It's clear that the model simulate reasonably the yield.

We can conclude that the Aqauacrop model still the more accurate model for estimation the Yield under semi-arid climate

Wheat study

Irrigation efficiency assessment



By evaluating the water balance equation using the model outputs, a large quantity of water is lost through soil evaporation and infiltration (67% of total irrigation).

Conclusions

This region Characterised by low and irregular rainfall events. Very little precipitation falls between May and October

This region Characterised by a high climatic demand

The water balance equation and direct measurements (fluxmeter) give the same results for the percolation loss

For the orange crop irrigated with drip irrigation the loss by percolation is 32% of sum amount of irrigation and rain

The loss by surface runoff is 6% of the sum accumulative amount irrigation and rain

Keeling plot technique shows that transpiration dominates the evaporation for orange crop irrigated with drip irrigation system this result is confirmed by analysis of stable isotope profiles

Keeling plot technique for wheat culture give a good result for the partitioning of Evapotranspiration components with high R^2.

The high contribution of transpiration may can explained to high canopy cover

The comparison of % of the contribution of transpiration on ET calculated by isotopic technique and Aquacrop model are similar

Aquacrop model still the more accurate model for estimation the Yield and Irrigation efficiency under semi-arid climate

The comparison between flood irrigation and drip irrigation shows that the losses by evaporation and infiltration is higher for flood irrigation than loss by infiltration for drip irrigation

It was found that the visual observation of the physical conditions of the plant is not sufficient to efficiently manage the irrigation

Acknowledgments

Soil and Water Management and Crop Nutrition (SWMCN) Section of the Joint FAO/IAEA

CRP member

Thank you