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CREA
Centro Regional de Estudios del Agua

Groundwater extraction with minimum cost.

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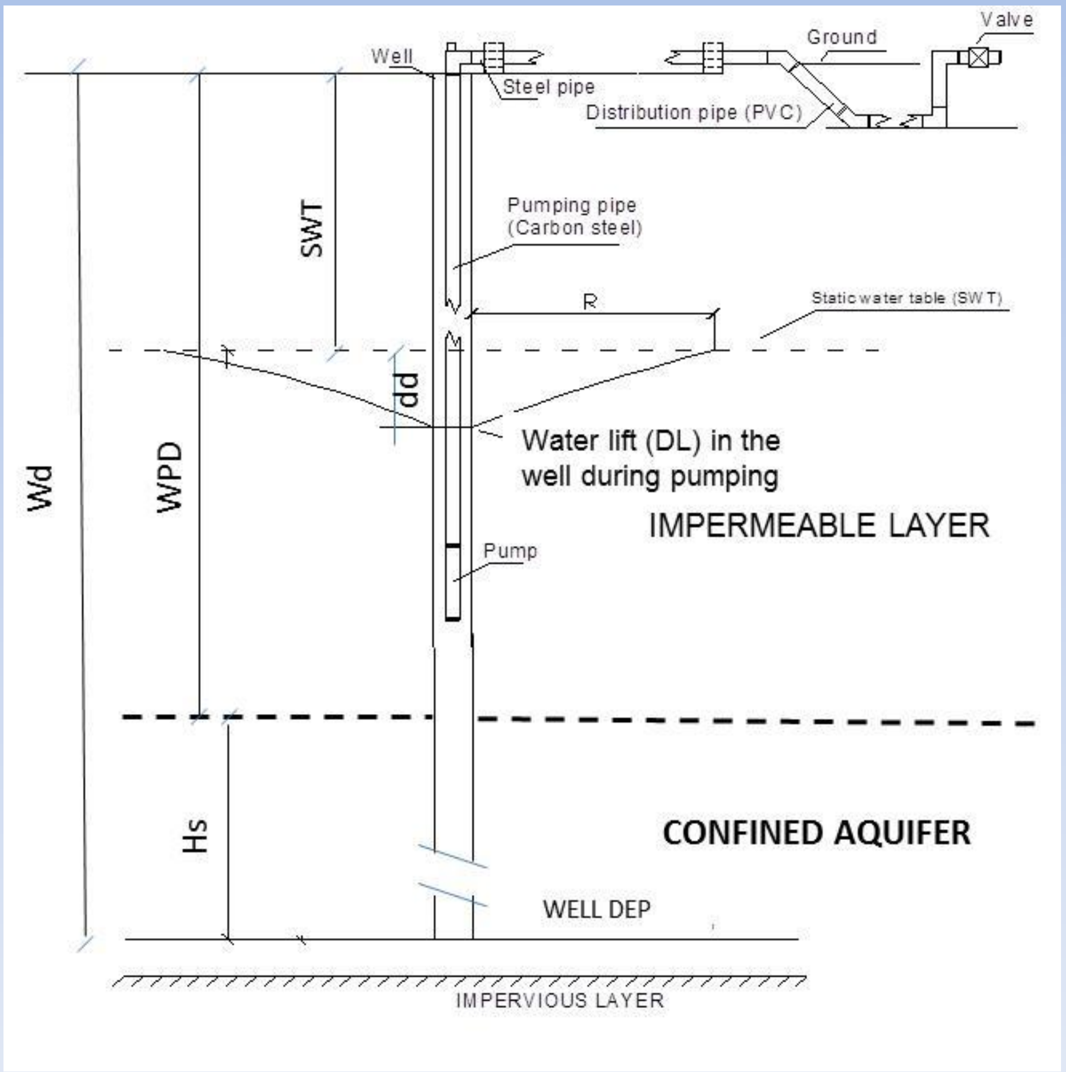
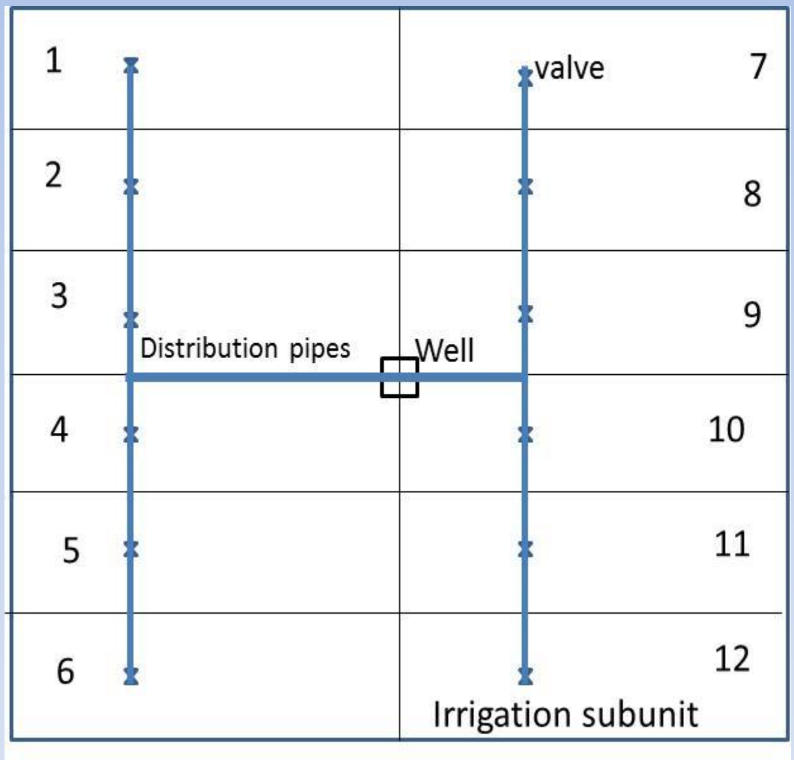
OBJETIVO

- Minimize the total cost (C_T) of water abstraction and application with the irrigation system (investment (C_a) + operation (C_{op}) developing a tool for decision support named DC-WAT (Design of pressurized irrigation), analyzing the irrigation system as a whole, from the water source to the emitter, integrating the main factors implied in the process.
- Apply DC-WAT to sprinkler and drip irrigations using groundwater from two types of aquifer for corn, piper and vineyard crops in Spain.

METHODOLOGY

Diagram of the infrastructure to design



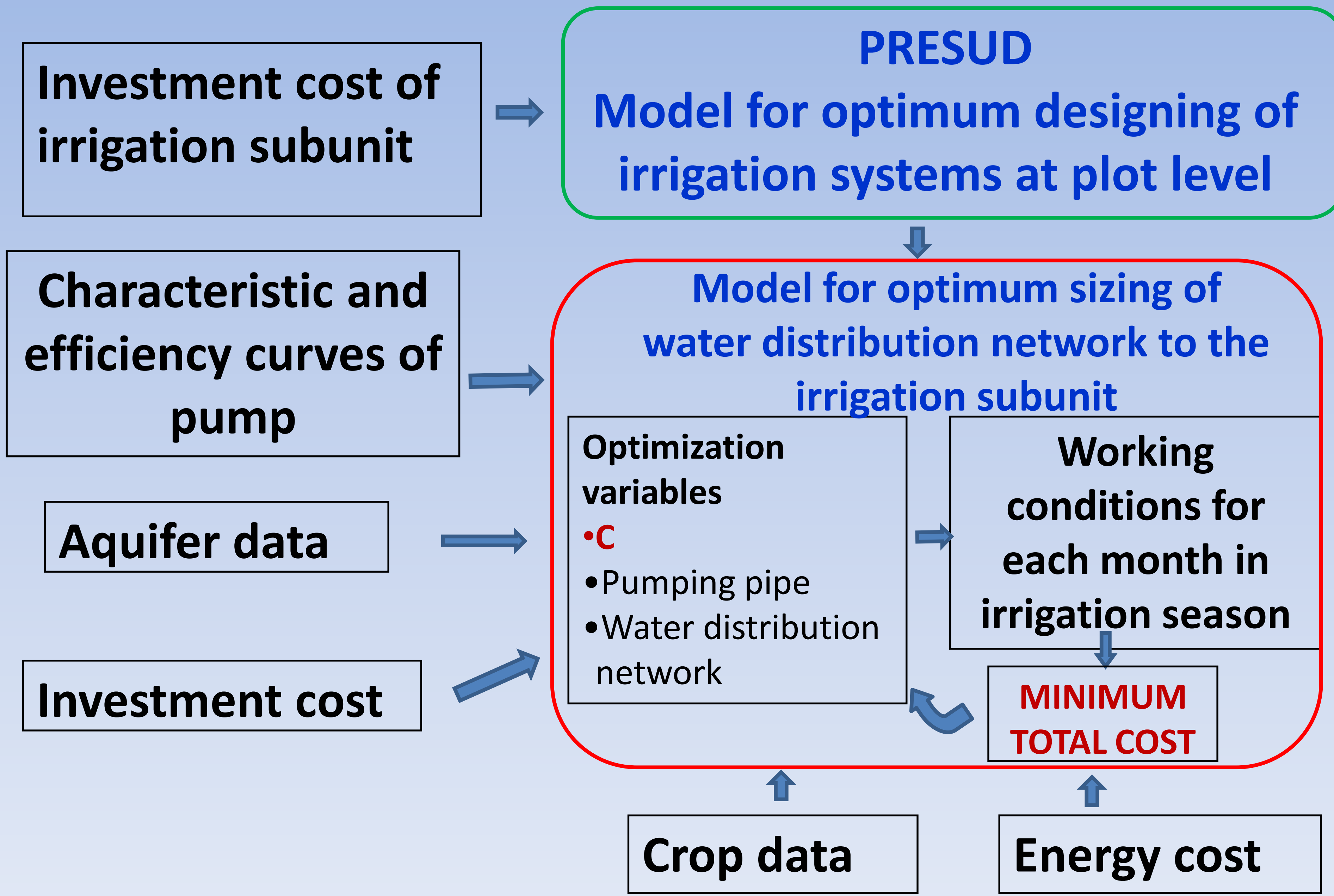


METODOLOGIA

Main novelties and innovations introduced by DC-WAT :

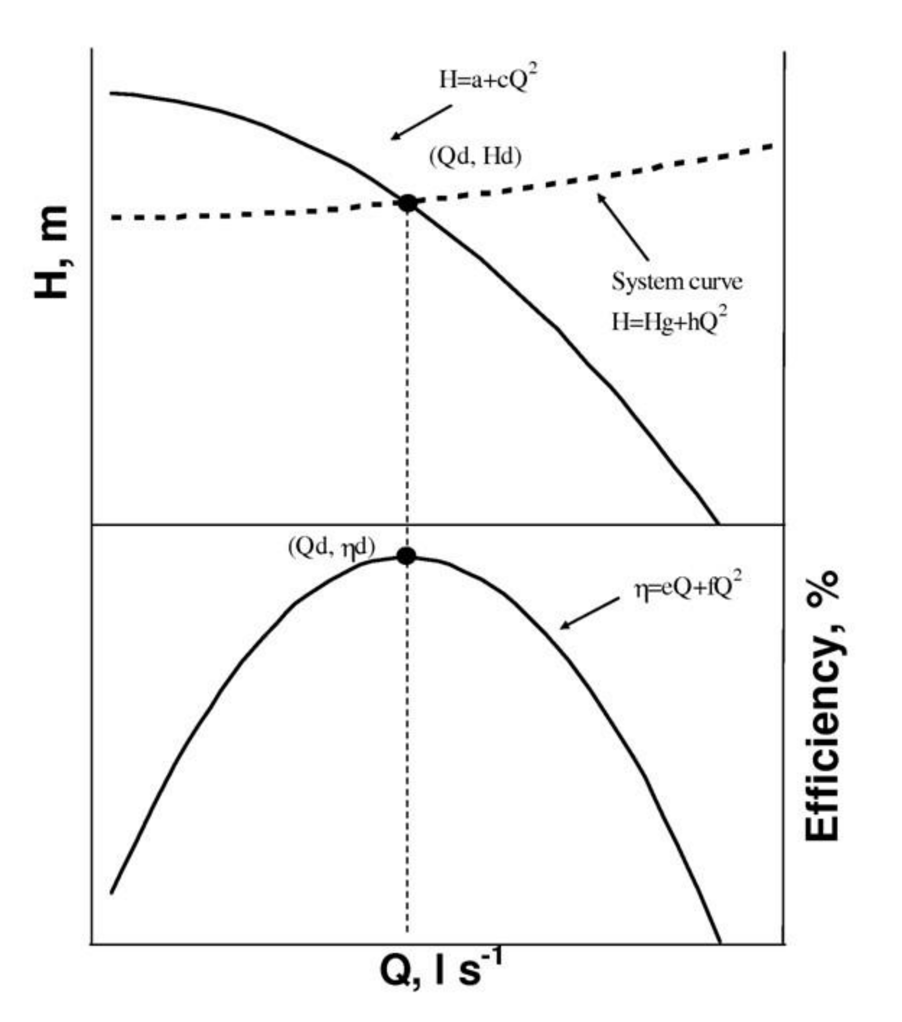
- To consider the water abstraction and its application as a whole.
- Determines the type of pump and estimate fluctuations in the SWT during the irrigation season.
- To select the design and management of irrigation subunit leading to a minimum C_T
- Have into account the type of aquifer and obtain the optimum drilling and pumping pipe diameters.
- Select the power access and the moment to work during the irrigation season to minimize the energy and investment costs.

METHODOLOGY: Optimization process in **DC-WAT**



Metodología

Curvas caracteristicas Q-H y Q- η de las bombas



$$H = a + cQ^2$$

$$\eta = eQ + fQ^2$$

METODOLOGIA

Optimization process (Downhill Simplex method)

Objective function

$$\text{MIN}\ (C_a + C_{op})$$

$$C_{inv} = C_{pump} + C_{pi} + C_{pp}$$

$$C_{op} = \sum_{i=1}^{12}\sum_{j=1}^{k}\left(N_p\right)_i Pa_{ij} + \sum_{i=1}^{12}\sum_{j=1}^{k}\left(N_p\right)_i T_{ij} P_{ij}$$

$$C_{pump} = g\, N_B^3 + h N_B^2 + k N_B$$

$$N_B = \frac{9{,}81\ Q\ H}{\eta}$$

$$C_{pi} = l\, D_{dist}^{m}$$

$$C_a = C_{inv}\, CRF$$

T= monthly operation time

P = energy price (€/kWh)

Optimization variables : *c* coefficient , D_{dist} and D_{dist}

Values of the different parameters related with the sprinkler irrigation system

Spacing of sprinklers (m x m)	h_a (kPa)	E_a (dimensionless)	AR_a (mm h^{-1})	Diameter of Nozzles (mm)	Corn gross water requirement $m^3ha^{-1}yr^{-1}$
18 x 18	300	0.77	5.90	4,8+2.4	8,249
	350	0.79	6.33	4,8+2.4	8,049
15 x 15	350	0.82	8.00	4,4+2.4	7,766

Corn net water requirement 6500 $m^3ha^{-1}yr^{-1}$

Values of the different parameters related with the drip irrigation system pepper and vineyard crops

Parámetro	Valores en las condiciones de referencia	
	pepper	vineyard
Pendiente del terreno	0%	
x	0.5	
CV_{qmf}	0.05	
D_{ramal} (nominal) PE 0.25MPa	16 mm	
Nivel dinámico (ND)	60 m	
Superficie de la parcela (S)	10 ha	
Longitud de línea eléctrica de MT	1 km	
Separación entre plantas	0.4 m	1.5 m
Necesidades netas de riego anuales (R_n)	5900(1) $m^3\ ha^{-1}\ Y^{-1}$	1500(1) $m^3\ ha^{-1}\ Y^{-1}$
Caudal del emisor (q_a)	2 $L\ h^{-1}$	4 $L\ h^{-1}$
Separación entre emisores	0.75 m	1.25 m
Separación entre laterales	1.0 m	3.0 m
Relación de transpiración (Tr)	1.05	1.0

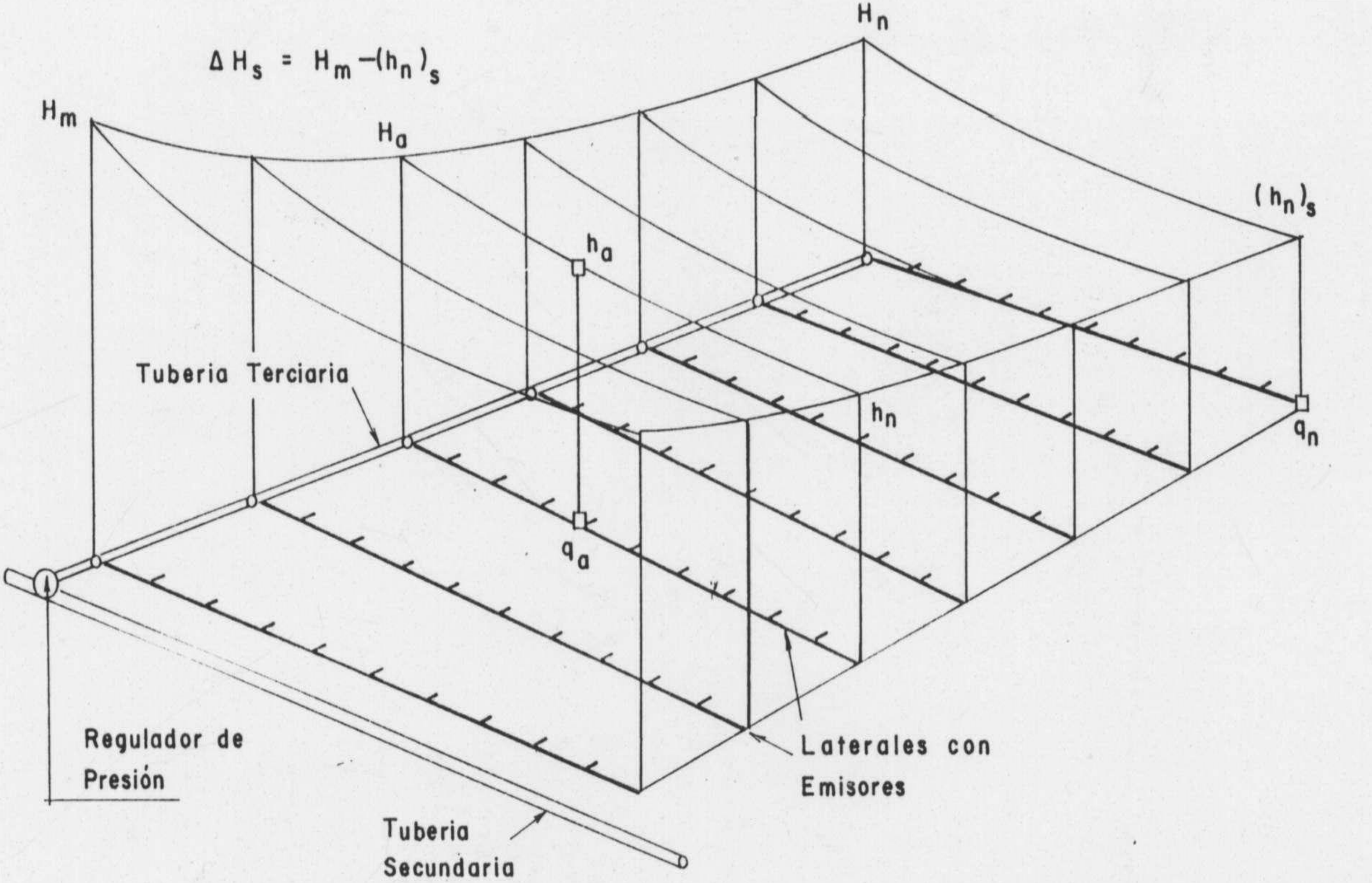
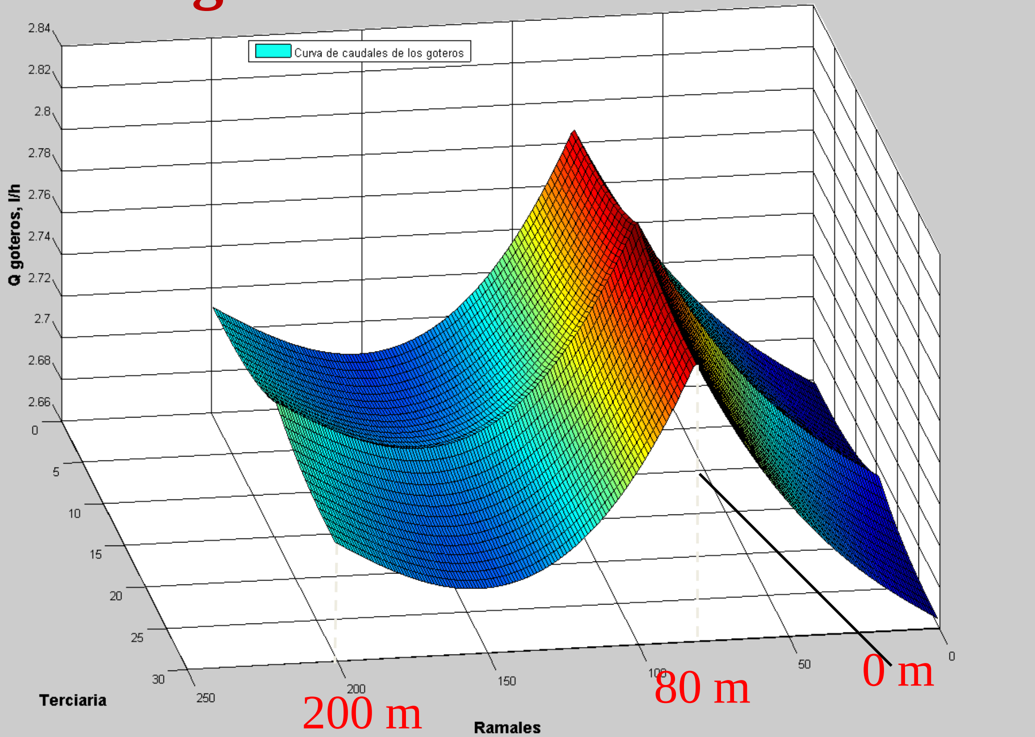


Fig. 17.2 Distribución de presiones en una subunidad de riego en terreno horizontal.

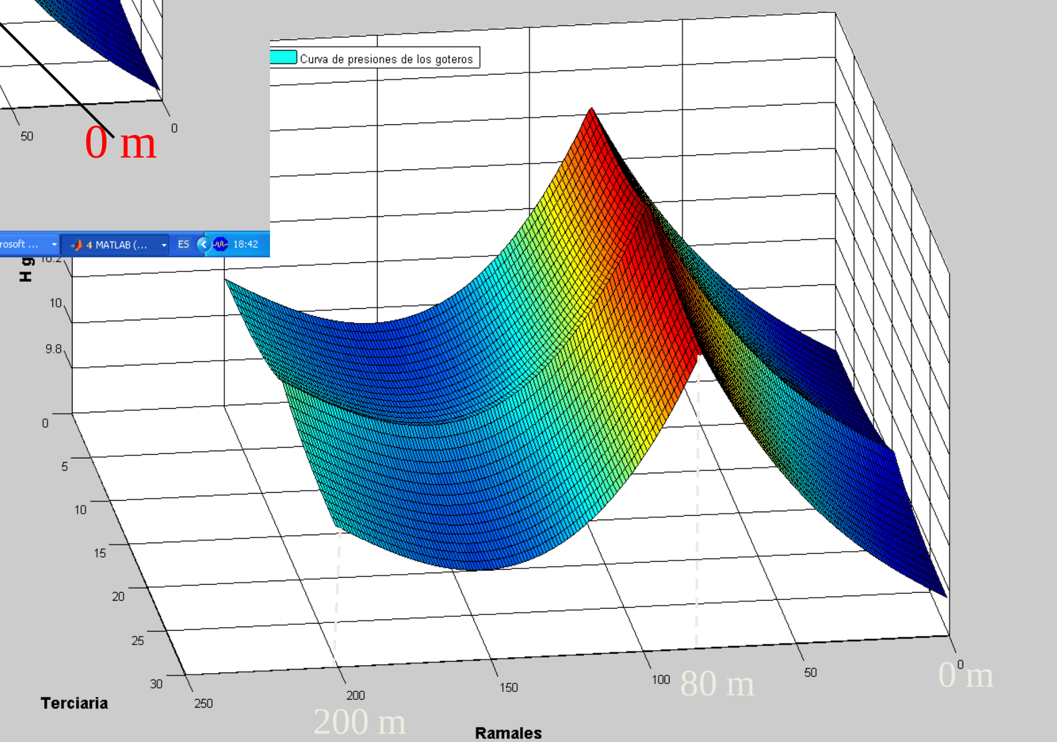
Discharge distribution in the subunit



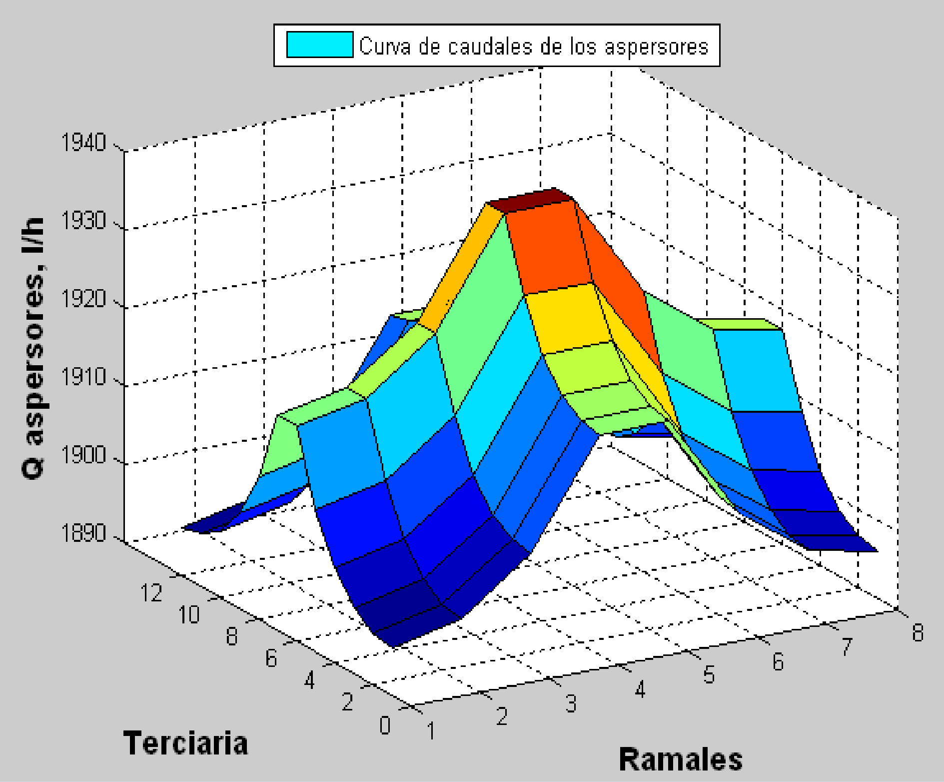
Lateral slope: 1%

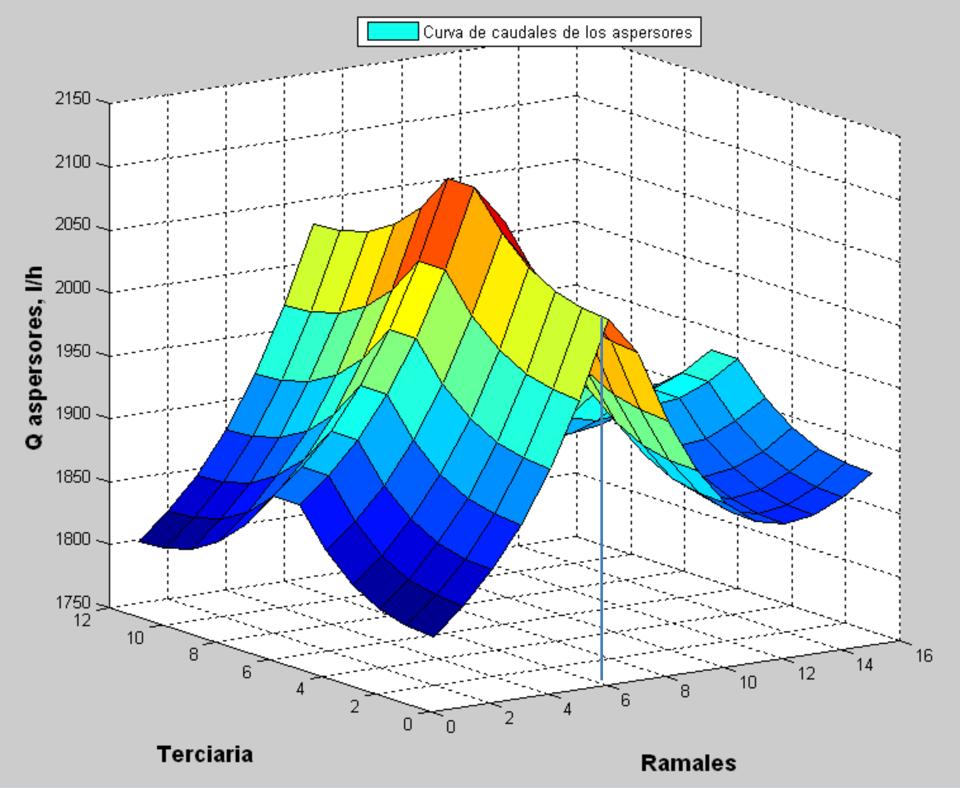
Manifold slope: 0%

Pressure head distribution



Discharge distribution of the sprinkler for 18x18 spacing and H_o= 350 kPa





EU= 97.3% and Δq=2.3%

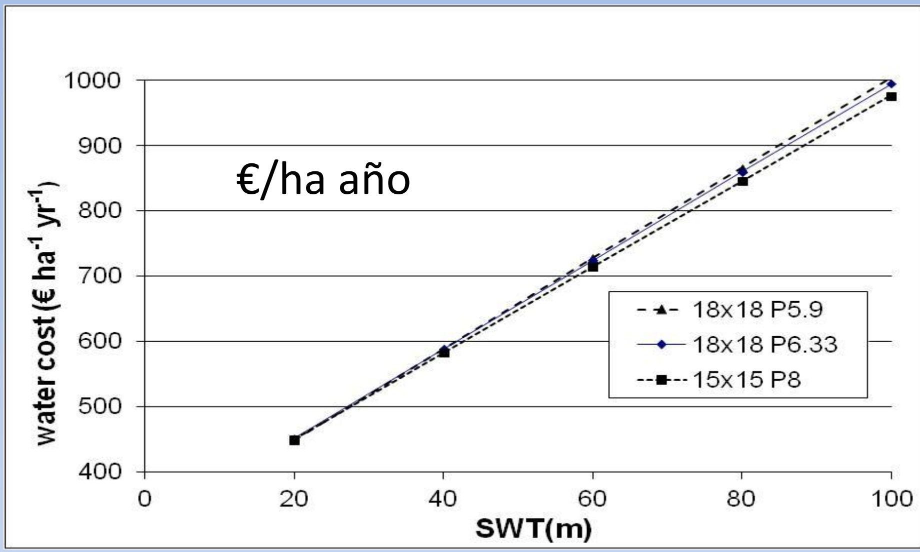
EU= 92.3% and Δq=15.7%

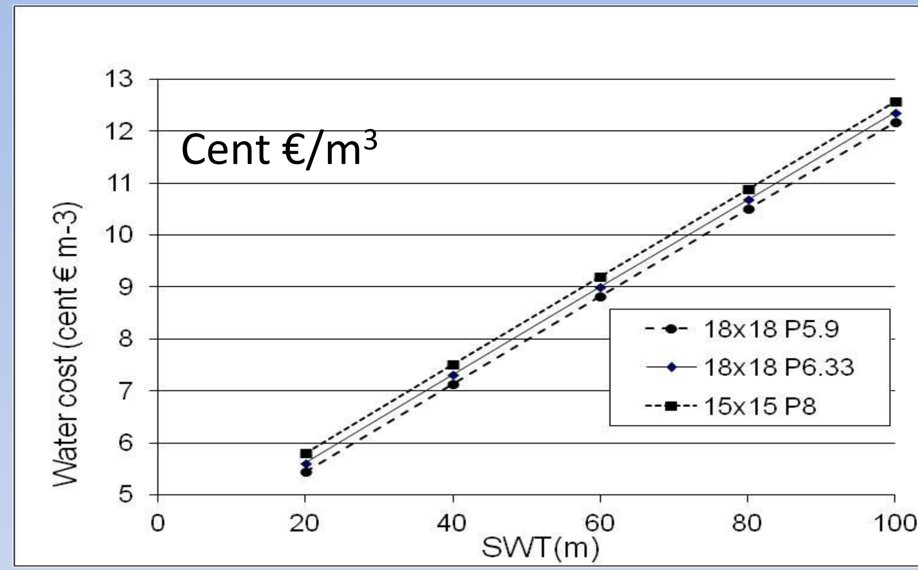
(a) 3.1 ha (12 laterals with 8 sprinkler each) and S_{ol}=0%,

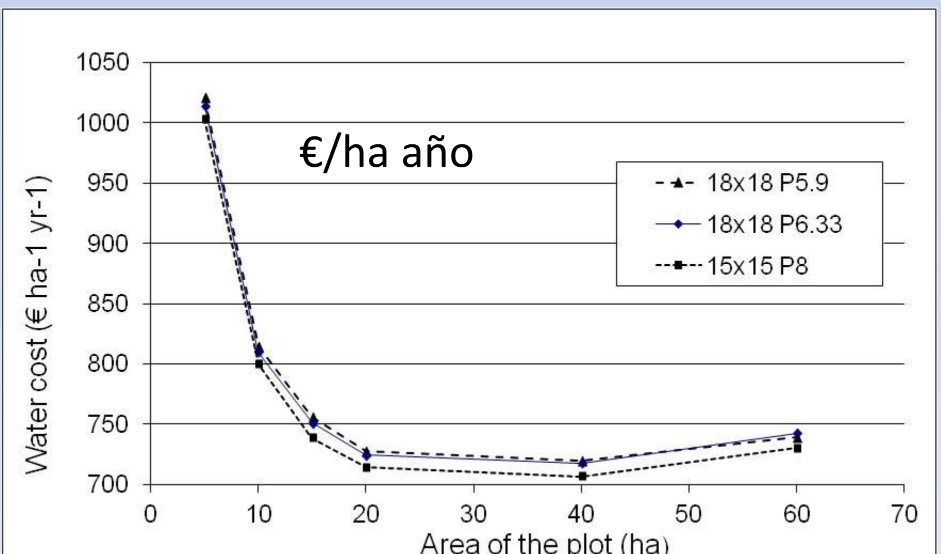
(b) 6.2 ha (12 laterals with 16 sprinklers each) and S_{ol}=3%,

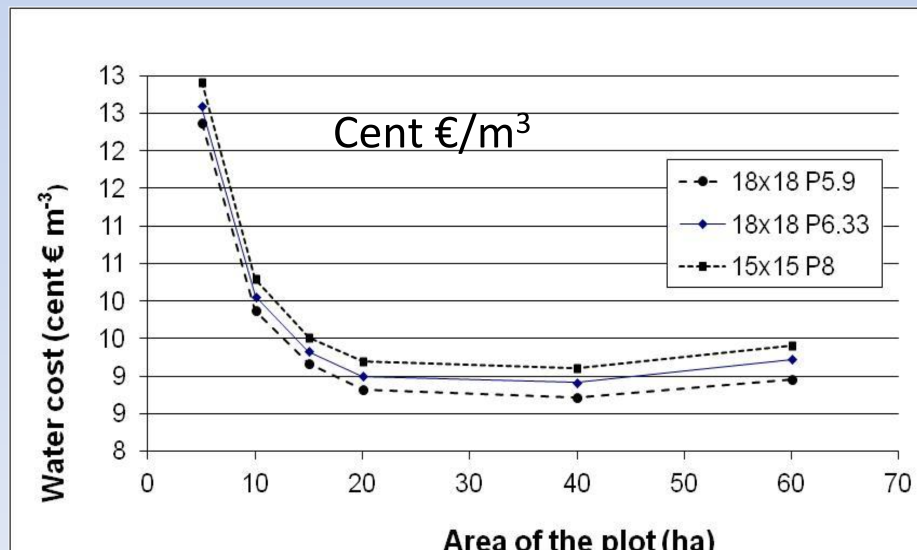
RESULTS

Cost of water transport from the source to the subunit inlet (C_w), for a corn crop in the unconfined aquifer

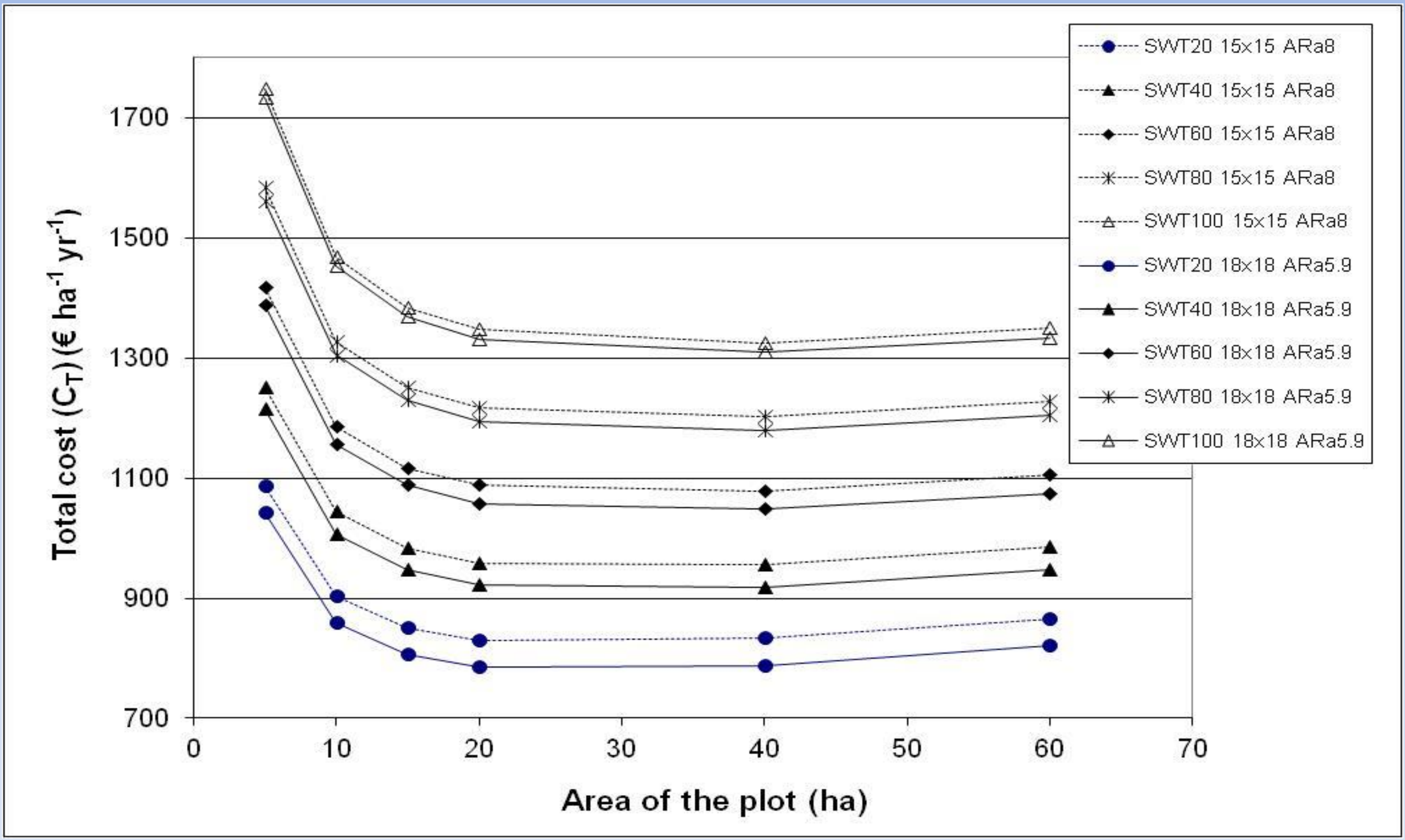






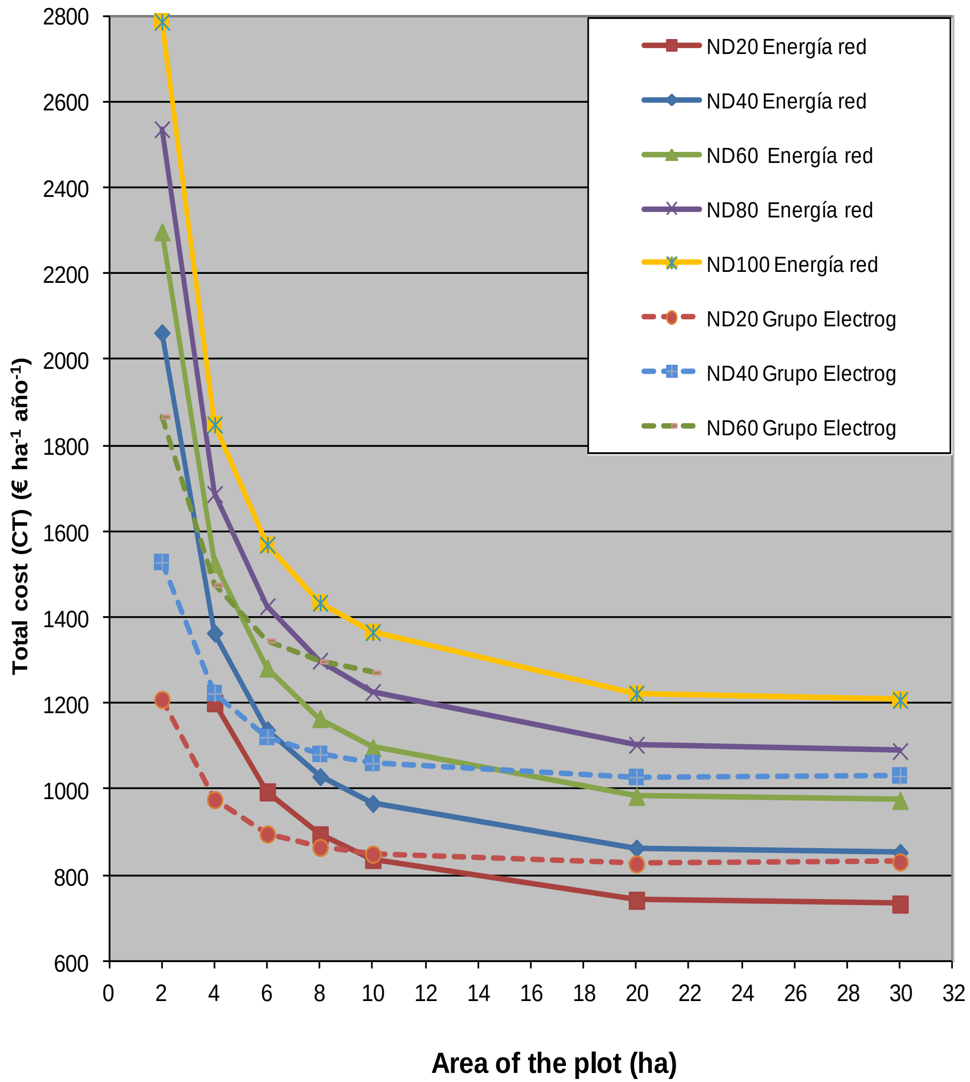


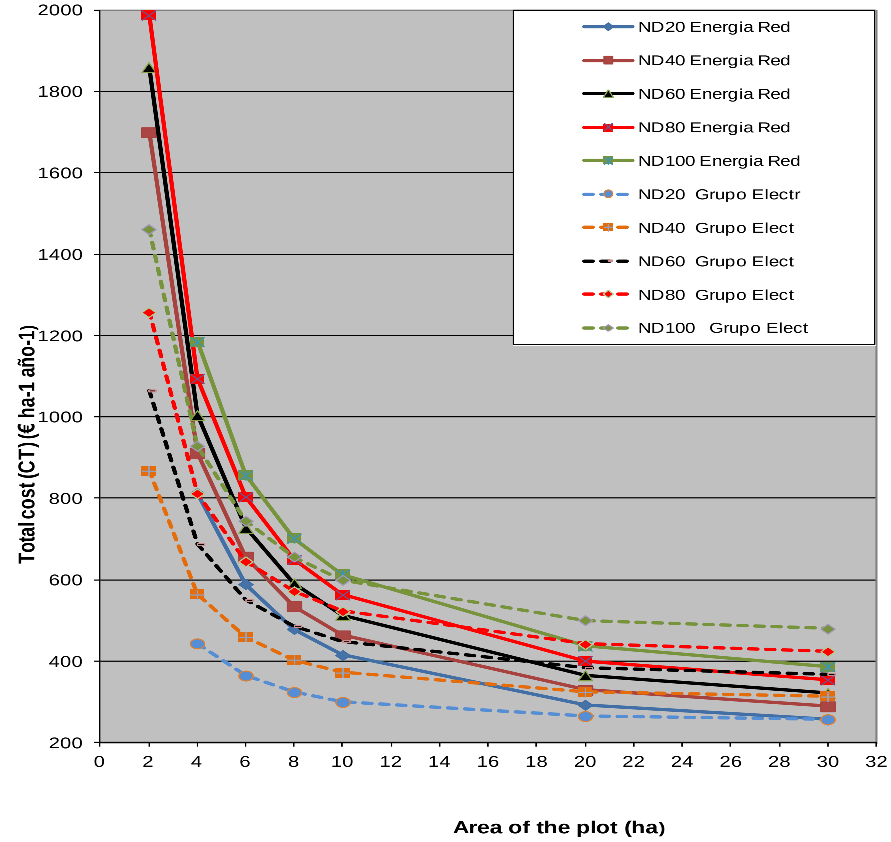
Pattern of C_T with the S for different sprinkler spacing and SWT in the unconfined aquifer



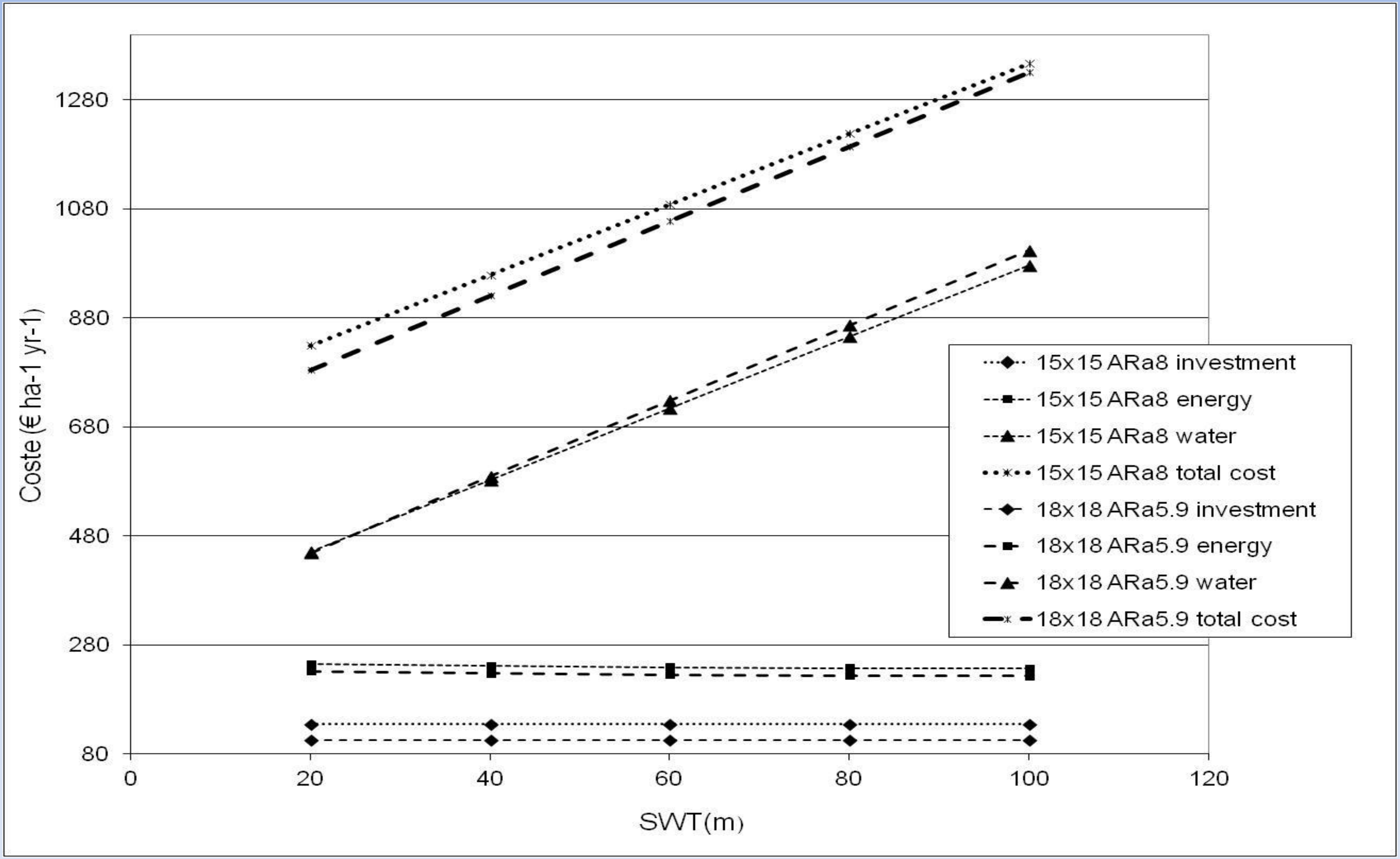
Lower C_T for 18x18 with AR_a= 5.9 mm h^{-1} and NS= 12

Pattern of C_T with the S for pipe and vineyard



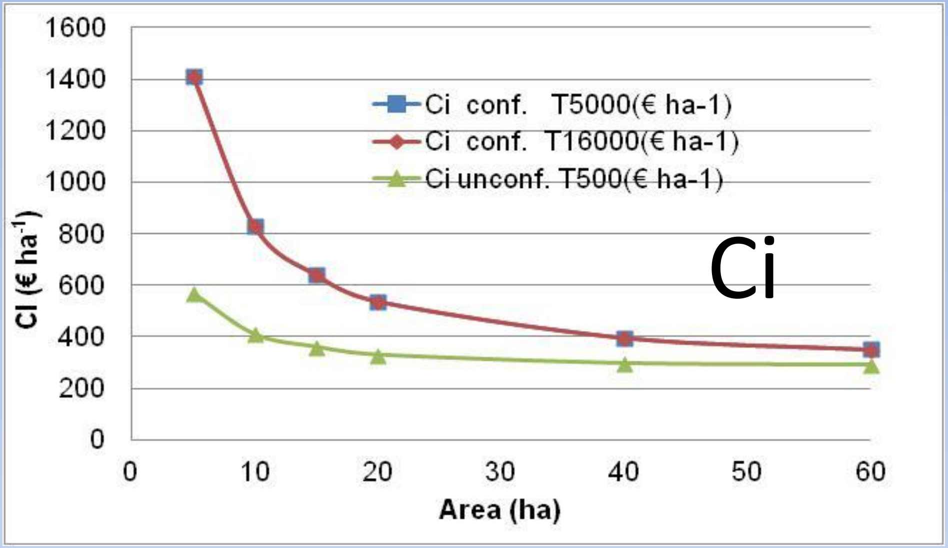


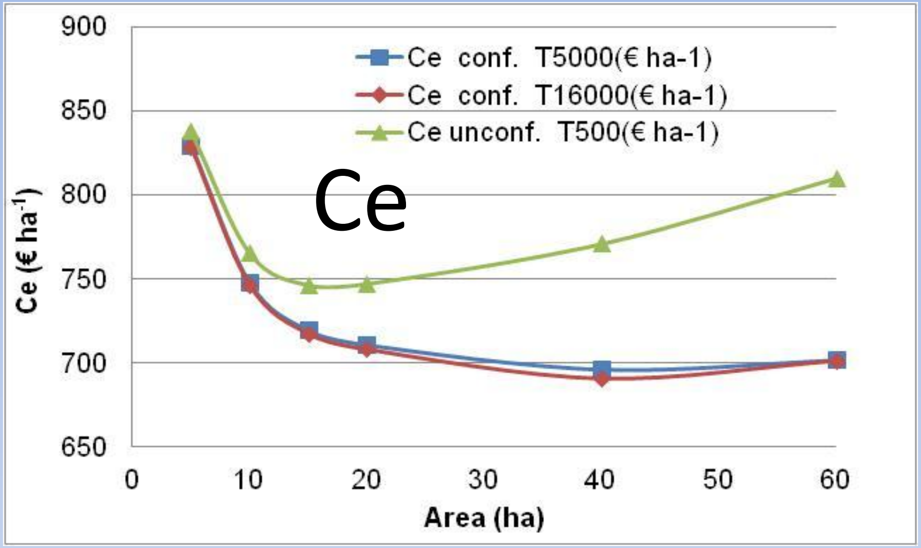
Components of C_T (C_w, C_{as}+C_{ms}, C_{es}), for different SWT for S=20 ha NS=12 for 18x18 (1.66 ha) and NS=15 for 15x15 (1.33 ha)

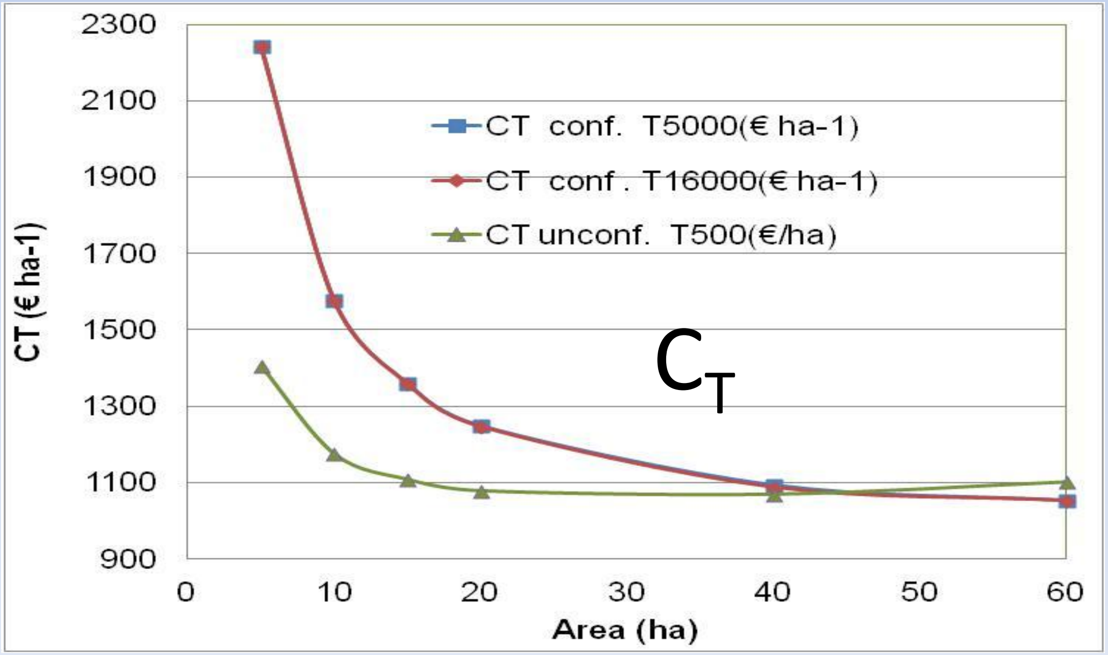


Sprinkler spacing, h_0 and ARa have low influence in C_T

Comparison between unconfined and confined aquifer for 18x18, ARa=6.33 mm h^{-1} and SWL= 60 m







CONCLUSIONES

- For the case studies energy represent up to 70% of the cost of water application in plot.
- It is very important the proper pump selection and its operation time (into the energy rate periods) throughout the irrigation season
- The water cost (C_w) is mainly conditioned by the transmissivity (T) values, the proper pump selection and the borehole and pumping pipes, (directly interrelated).
- DC-WAT tool, adaptable to the specific conditions of investment and energy cost in each country, is useful for analyze the irrigation system as a whole, from the water source to the emitter, integrating the main factors implied in the process.
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