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Drip irrigation and drainage between water saving and salinity control: Field evidence from the Lower Cheliff (Algeria)

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L'irrigation goutte à goutte et le drainage entre l'économie d'eau et le contrôle de la salinité: observations sur le terrain du Bas-Chéliff (Algérie)

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Presentation outlines

1. Introduction
2. Material and Methods
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Introduction

Agriculture in the lower Cheliff plain consists of permanent crops including citrus, olive and various fruit trees (apple, apricot, and pomegranate). Horticulture is also important, and it focuses especially on artichoke. The globe artichoke is a plant native to the Mediterranean, which has a significant commercial interest in the area of the plain of lower Cheliff. This plant is well adapted to the soils of the area, because it is moderately tolerant to soil salinity with 4.9 dS m^{-1} of threshold electrical conductivity in the saturation extract (ECe) (Shannon and Grieve, 1999), The question of how much irrigation is necessary to allow salt leaching without wasting water can be answered with the help of salt balance models. There are several salinity models that enable water resources saving and avoid soil salinisation. The one-dimensional monthly transient-state SALTIRSOIL_M model allows applications in this way (Visconti et al., 2013).

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Material and Methods

1.The SALTIRSOIL_ M model

The one-dimensional monthly transient-state SALTIRSOIL_ M model (Visconti, 2013) is based on a tipping bucket algorithm for simulating the soil water downward movement where the soil is split in a number n of layers or nodes. The calculations implemented in the model to assess the irrigation management, crop development, actual evapotranspiration, chemical equilibria and electrical conductivity, were presented in a previous work (Visconti et al., 2011).

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2.Study area

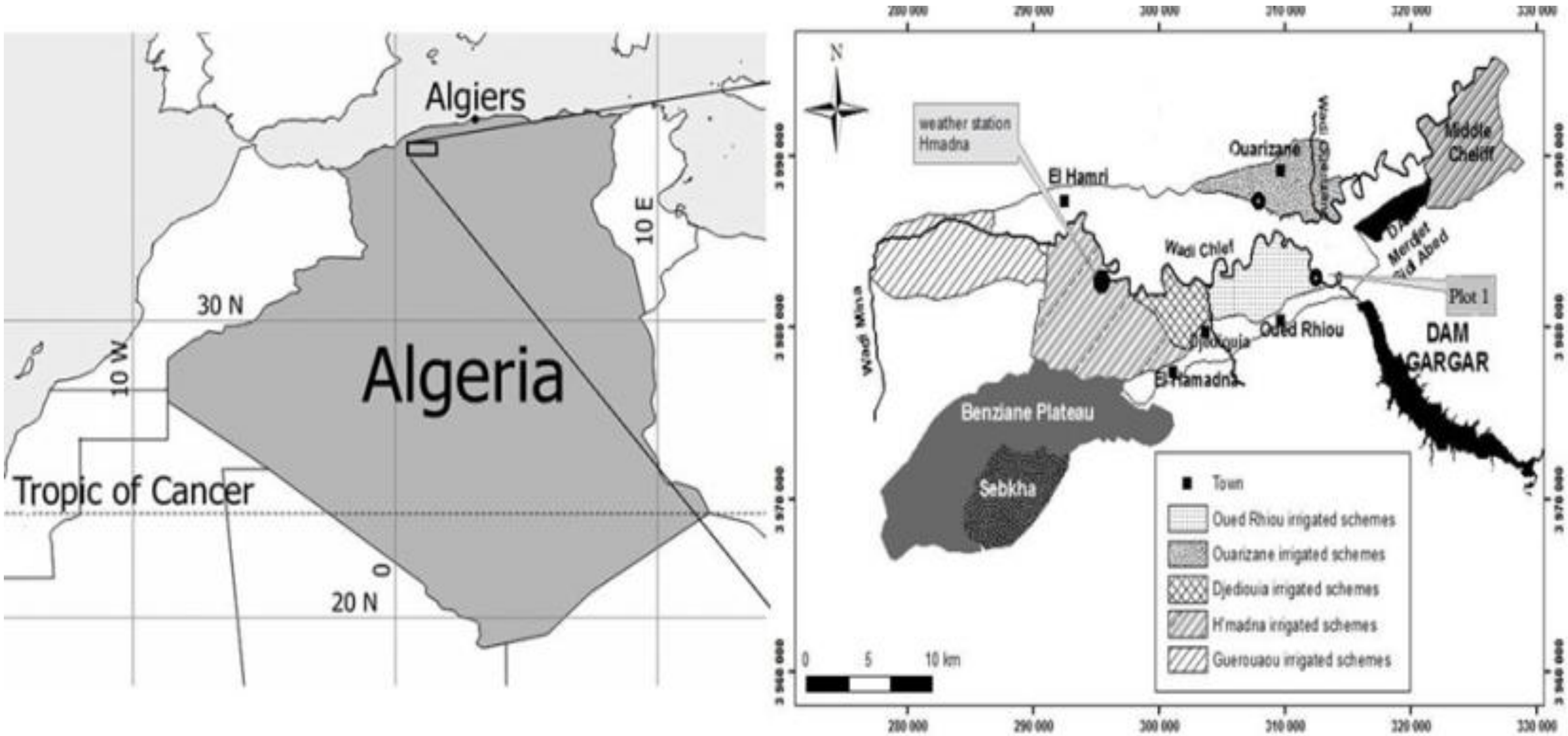

Figure 1. Geographical location of the study area in Algeria

3.Weather, crop and irrigation data

The only costs for the application of SALTIRSOIL_M at plot scale are those derived from its data requirements, which are listed in Table 1.

Table 1. Weather, irrigation management and crop development data used in the simulations*

Plot 1 / Artichoke													
Month	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**TOTALS**
Year	2010	2010	2010	2010	2011	2011	2011	2011	2011	2011	2011	2011	2010-2011
Weather													
R (mm)	4.4	63.9	66.7	17	68.6	17.5	62.4	58.6	7.4	1	0	0.2	367.7
Rf (day)	2	4.3	6	6.5	12.5	6.1	11.7	11.2	4.8	4	0	3.9	73
ET_0 (mm)	148.7	124.6	84.6	61.4	34.8	53.2	81.8	103.2	178.6	207.1	234.8	198.5	1511.3
Irrigation management													
I (mm)	56	57.9	65.5	54	29	26.2	29	28.1	15.3	3	0	0	364
If (day)	2	2	2	2	2	2	2	2	1	0	0	0	17
Crop development													
Fc,m	0.13	0.13	0.41	0.77	0.75	0.75	0.75	0.75	0.46	0.02	0.00	0.00	–
Kcb,m	0.15	0.15	0.50	0.92	0.90	0.90	0.90	0.90	0.55	0.12	0.00	0.00	–

*R, milimeters of rainfall; Rf, number of rainy days; I, milimeters of irrigation; If, number of irrigation days; Fc,m, canopy ground cover; Kcb,m, basal crop coefficient

Results and discussion

1.Water quality

The water properties of the first agricultural farm are shown in table 1. They are slightly saline, non-sodic (SAR = 2.1), non-alkaline (RSC = 10 meq/L) (Table 1).

Table 1. Water quality in both experimental plots*

Ion / Plot	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	NO_3^-	SO_4^{2-}	Alk.	pH	EC_{25}
1	5.8	0.1	5.4	2.2	6.9	nd	3.6	5.1	7.10	1.80

*All ions in mmol L^{-1}, alkalinity (Alk.) in $mmol_C$ L^{-1} and electrical conductivity at 25 ºC (EC_{25}) in dS m^{-1}; nd, no data

2. Soil properties

Five soils classes have been described: Little evolved soils, Vertisols, calcimagnesic soils, isohumic soils, Hydromorphic soils, salsodics soils (Mc Donald et BNEDER, 1990). The soil in both plots is non-stony, clay-textured, strongly compacted, low-to-very-low in organic matter, moderately calcareous, and slightly gypsiferous according to the classification developed by Boyadgiev (1975) for Algeria (Table 2).

Table 3. Soil properties in both experimental plots*

Prop. / Plot	Top limit / cm	Bottm limit /cm	Sn (%)	St (%)	Cy (%)	SP / g g^{-1}	FC / cm^3 cm^{-3}	WP / cm^3 cm^{-3}	BD / g cm^3	CF (%)	CCE (%)	OM (%)	Gy (%)	EC_e / dS m^1	SAR
1	0	80	12.0	36.0	52.0	0.5840	0.4573	0.3144	1.75	0.0	12.6	1.8	12.2	2.48	2.0

*Sn, sand content; St, silt content; Cy, clay content; SP, saturation percentage; FC, volumetric water content at field capacity; WP, volumetric water content at wilting point; BD, bulk density; CF, coarse fragments content; CCE, calcium carbonate equivalent; OM, organic matter content; Gy, gypsum content; EC_e, electrical conductivity at 25ºC in the saturation extract; SAR, sodium adsorption ratio in the saturation extract.

3.Simulated and observed salinity in the plots

In Fig. 2 the simulated and observed main ion contents and ECe in addition to the pH of the saturated pastes are shown. In the case of the artichoke plot (P1) the regression line between observations and predictions presents a coefficient of determination (R^2) of 0.95, a root mean square error (RMSE) of 23%, and an index of agreement (IA) of 0.98.

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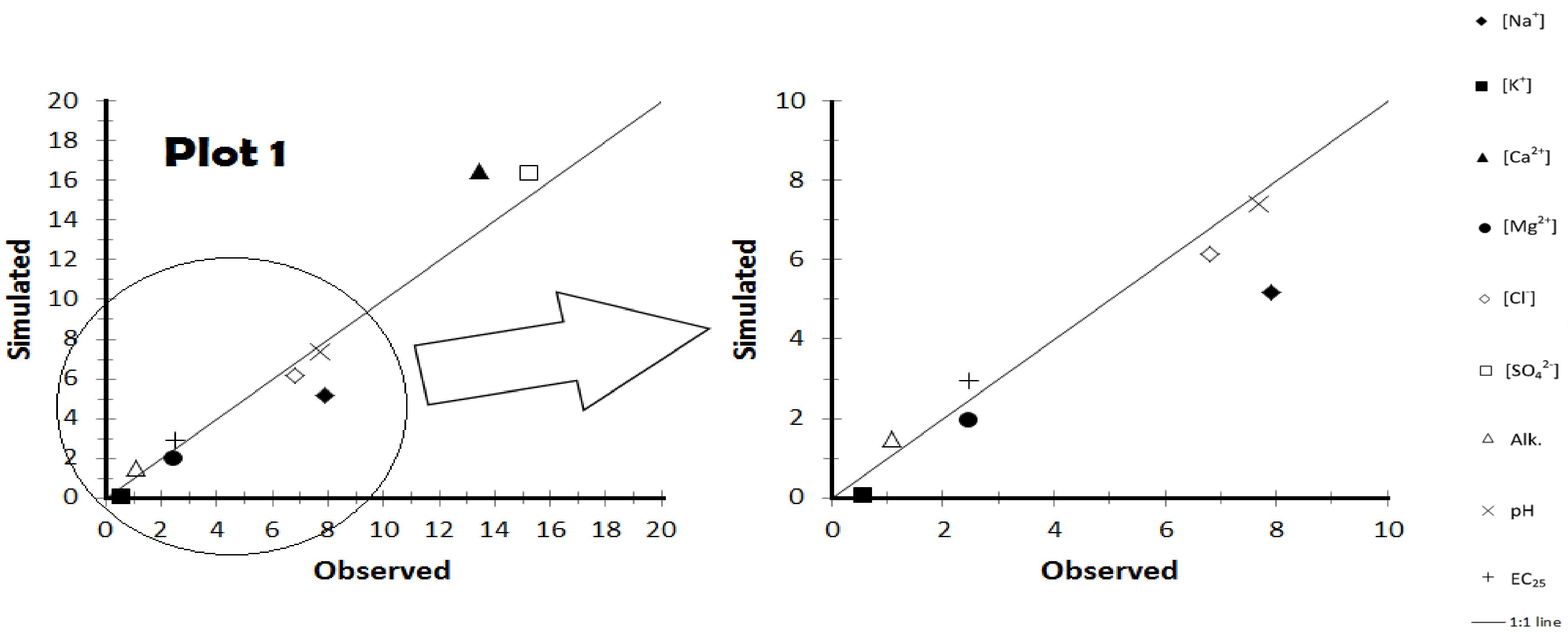

Figure 2. Scatter plots of simulations versus observations of main ion concentrations, pH and ECe in the artichoke (top) and melon (bottom) plots in June 2011. All parameters are for the saturation extract except pH, which is for the saturated paste, all ions in mmol L^{-1}, alkalinity (Alk) in $mmol_C$ L^{-1} and EC_{25} in dS/m

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In the artichoke plot (P1) the most abundant ions are calcium and sulphate, which reflect the presence of remarkable gypsum in the soil , and the balance between calcium and sulphate in the irrigation water. Calcium and sulphate are followed by sodium and chloride as the respectively, most abundant cation and anion.

The different ion abundances in the saturation extract were satisfactorily simulated by the model, which means that i) the main source of salts to the soil is the irrigation water in addition to the soil gypsum, and ii) that the soil water regime is downward.

4.Estimation of optimal irrigation amounts

In plot 1 artichoke was not subjected to any water or salinity stress according to the water balance and soil salinity.

Therefore in plot 1 the average ECe values between 0 and 80 cm depth that would have resulted from irrigating with less water, i.e. 90, 80, 70, and 60% of the actual irrigation rate (Table 4) were simulated.

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Table 4. Simulation of different irrigation schedules and their effects on the soil salinity

Plot 1 / Artichoke													
Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	TOTALS
Year	2010	2010	2010	2010	2011	2011	2011	2011	2011	2011	2011	2011	2010-2011
100% (mm)	56.0	57.9	65.5	54.0	29.0	26.2	29.0	28.1	15.3	3.0	0.0	0.0	364
90% (mm)	50.4	52.1	59.0	48.6	26.1	23.6	26.1	25.3	13.8	2.7	0.0	0.0	328
80% (mm)	44.8	46.3	52.4	43.2	23.2	21.0	23.2	22.5	12.2	2.4	0.0	0.0	291
70% (mm)	39.2	36.5	41.3	34.0	18.3	16.5	18.3	17.7	9.6	1.9	0.0	0.0	233
60% (mm)	33.6	27.8	31.5	25.9	13.9	12.6	13.9	13.5	7.3	1.4	0.0	0.0	181

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In plot 1 if 70% of the farmer's irrigation rate, i.e. 233 mm yr^{-1}, had been applied to the crop, it would have suffered water shortage during the cropping season, specifically in December and April with, respectively, 6 and 10 mm of water deficit, i.e. over the threshold of 5 mm for just one month we chose as water stress criterion. On the contrary if 80% of the farmer's irrigation rate, i.e. 291 mm yr^{-1}, had been applied, deficits over 5 mm would have not been observed any month. Besides, using 80% of the farmer's irrigation rate the maximum monthly ECe would have resulted to be 3.24 dS m^{-1}, i.e. well below the threshold ECe for artichoke (4.9 dS m^{-1}).

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Then the irrigation schedule optimization in this plot can be carried out on basis just the water requirements, and 290 mm yr^{-1} would have been an adequate irrigation rate for this plot in the 2010-2011 season. This means a leaching fraction of just 8% compared to the leaching fraction of 15% actually produced, i.e. the drainage water production would have drop from 109 to just 50 mm yr^{-1}.

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Usual irrigation doses for artichoke in lower Cheliff are between 300 and 700 mm yr^{-1} using drip irrigation. In fact in this case of study, crop evapotranspiration (ETc) amounted to 687 mm during the artichoke cropping season of 2010-2011. However, as the rainfall during the same time span amounted to 387 mm, it adequately contributed to roughly half of the crop water requirements with the subsequent irrigation water savings.

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The annual rainfall in the lower Cheliff was between 0.0 and 107.9 mm during the reference period 1985-2010 , and therefore a general irrigation rate between 328 and 364 mm yr^{-1}, distributed in 30% in September and October, 35% in November and December, 15% in January and February, 15% in March and April and, finally, 5% in May and June can be recommended. Look for this data and provide an estimate of the irrigation water requirement of artichoke in the Lower Cheliff plain.

Conclusion

The simulation of the soil salinity in June of one artichoke in the Lower Cheliff plain (NW Algeria) was carried out with the SALTIRSOIL_M model.

Simulations and observations of major inorganic ions and hence electrical conductivity at 25 ºC in the saturation extracts (ECe) were similar with IA over 0.95. Such agreement gave us confidence to next use the model for irrigation recommendation. In the artichoke plot neither water nor salinity stress was revealed by both observations and simulations. Therefore the optimum irrigation schedule in plot 1 was sought simulating the ECe that would result from irrigating with less water. Use of 280 mm yr^{-1} could have saved irrigation water, and reduced water losses through drainage, while having soil salinity well below harmful levels.

Adequately tested, soil salinity models can be of remarkable use to improve irrigation for water saving and salinity control in semi-arid Mediterranean horticulture like in the Lower Cheliff plain.