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

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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ABSTRACT

Salinity and water deficit are major issues for agriculture development in Algeria. The Lower Cheliff plain, north western Algeria, is characterized by a semi-arid climate (P < 290 mm and Etp> 1400 mm) and high clay content (> 50%). Farmers have introduced artichoke cultivation as a salt tolerant plant to avoid possible salinity damage. Soils properties like pH, EC, alkalinity and major mineral components were measured at 80 cm with a set of repetitions considering the soil's solution of the saturated paste extract. Simultaneously, the SALTIRSOIL_M model was tested and applied to assess drip irrigation scheduling and predict soil salinity and mineral properties. The calculated irrigation amount (367 mm) is lower that the observed one (616 mm)and its occurrence show that real irrigation should be more efficient. Drainage functioning under drip irrigation is analyzed through the values of the soils electrical conductivity. Conclusions suggest that farmer's irrigation practices should be regarded with more attention in the context of Lower Cheliff.

RÉSUMÉ

Salinité et déficit en eau sont des enjeux majeurs pour le développement de l'agriculture en Algérie. La plaine du Bas-Chéliff, au nord-ouest de l'Algérie, est caractérisée par un climat semi-aride (P <290 mm et Etp> 1400 mm) et la teneur en argile élevée (> 50%). Les agriculteurs ont introduit la culture de l'artichaut comme une plante tolérante au sel pour éviter tout dommage à la salinité. Les propriétés du sol comme le pH, CE, l'alcalinité et les principaux composants minéraux ont été mesurées à 80 cm avec une série de répétitions qui envisagent la solution de l'extrait de pâte saturée du sol. En même temps, le modèle de SALTIRSOIL_M a été testé et appliqué à prédire la salinité du sol et les propriétés principales. La quantité totale calculée d'irrigation (367 mm) est plus faible que celui observé (616 mm) et son occurrence indique qu'une meilleure planification de l'irrigation semble possible. Drainage fonctionnement sous irrigation goutte à goutte est analysée à travers les valeurs de la conductivité électrique. Ces conclusions suggèrent que les pratiques d'irrigation des agriculteurs doivent être considérées avec plus d'attention dans le contexte de la Bas-Chéliff.

Keywords:drip, salinity, artichoke, model, drainage, Lower Cheliff

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1. Introduction

The salt-affected area in Algeria has been estimated to be 47.3 Mhawhich is 20% of the total in this country (Douaoui et al 2006). The LowerCheliff plain is located to thenorthwestof Algeria whichboosts soil salinization, very intensein various places within the plain, and affecting 80%of the total area(Douaoui et al 2006).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), and because it thrives well in the very fine textures of the soils in the region. The land extension dedicated to artichoke in the Lower Cheliff plain is 3,200 ha (DSA, 2014).The question of how much irrigation is necessary to allow salt leaching without wasting water can be answered with the use of soil salinity models capable of simulating both water and salt balance in the soil-water-plant system. There are several salinity models useful to appropriately schedule irrigation so as to avoid soil salinization while preserving water resources. The one-dimensional monthly transient-state SALTIRSOIL_M model is an example of these (Visconti et al., 2013).

2.Materials and Methods

2.1The 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).

2.2 Study area

The Lower Cheliff plain is located to the northwest of Algeria 250 km from Algiers, between 0° 40' and 1° 6' 8'' east longitude, and between 34° 3' 12'' and 36 ° 5' 57'' north latitude. The plain of Lower Cheliff is one of three plains of the Valley of Cheliff River (high, medium and lower Cheliff). It is part of the watershed Cheliff and occupies the western part. Oued Rhiou, Djédiouia, Hmadna, Ouarizanze are the main cities in the perimeter from east to west (Fig. 1).

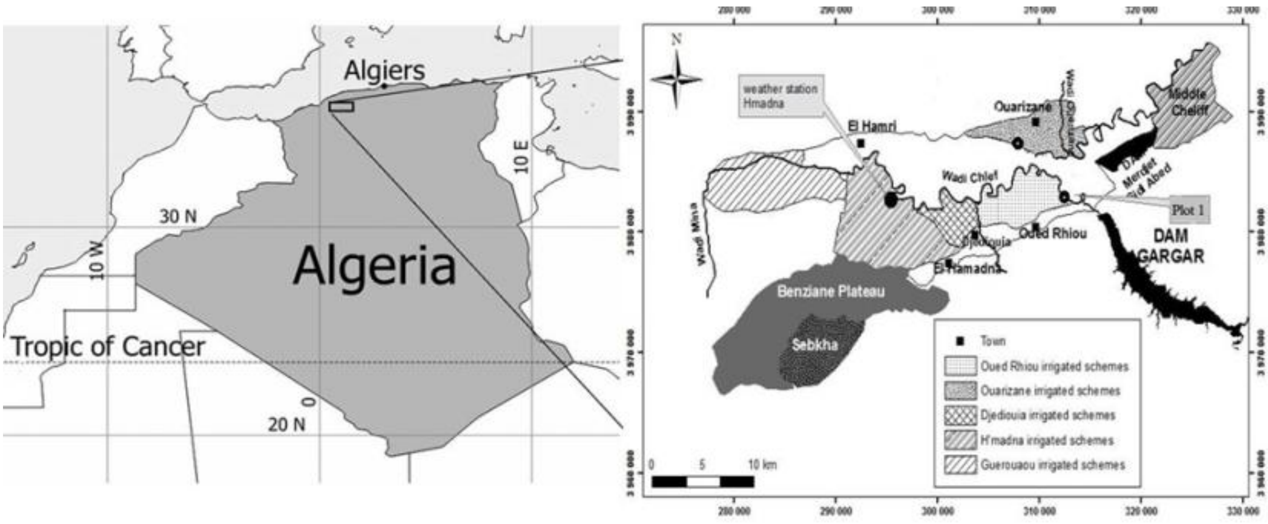

Figure1; Geographical location of the study area in Algeria

3. Results and discussion

3.1 Water quality

The well water from Fodile used in plot 1 to irrigate the artichoke is slightly saline, non-sodic (SAR = 2.1), non-alkaline (RSC = 10 meq/L) (Table 1).

Table 1. Water quality in both experimental plots

Ion	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	NO_3^-	SO_4^{2-}	Alkalinity	pH	EC_{25}
Plot 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 in $mmol_C$ L^{-1} and electrical conductivity at 25 ºC (EC_{25}) in dS m^{-1}.nd; no data

3.2. Soil properties

The soil in both plot 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 2**. Soil properties in both experimental plots

Soil	Top limit / cm	Bottom 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 (%)	log pCO_2
Plot1	0	80	12.0	36.0	52.0	0.584	0.457	0.314	1.75	0.0	12.6	1.8	12.2	-2.5

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; log pCO_2, apparent CO_2 partial pressure at equilibrium with the saturated paste

3.3Simulated and observed salinity in the plot 1

In the artichoke plot (P1) observed and predicted EC25 differ in the second significant figure, i.e. 2.48 and 2.94 dS m-1, respectively. Therefore in both plot the soil salinity was a little overestimated by SALTIRSOIL_M. In the artichoke plot (P1) the most abundant ions are calcium and sulphate, which reflect the presence of gypsum in the soil (Table 2), and the balance between calcium and sulphate in the irrigation water (Table 1). Calcium and sulphate are followed by sodium and chloride as the second most abundant cation and anion respectively.

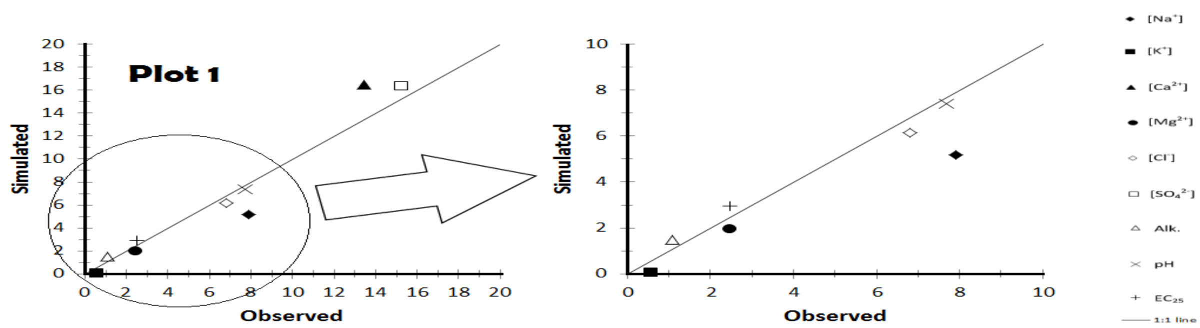

Figure2; Scatter plots of predictions versus observations of several parameters in June 2011 in both plots. All parameters are for the saturation extract except pH, which is for the saturated paste, all ions in mmol L-1, alkalinity (Alk) in mmolC L-1 and EC25 in dS/m.

3.4Estimation of optimal irrigation amounts

For plot 1 ECe at 0 and 80 cm depths that would have resulted from irrigating with (100%, 80% and 60%) of the actual irrigation rate (Tab. 3). An irrigation rate as low as 364 mm yr−1 would not have led to ECe over 2,95 dS m−1 regard less of the month of the year. Since this value is lower than the threshold ECe for globe artichoke (4.9 dS m−1), simulation of the fertilization management would not be necessary to schedule irrigation based on soil salinity. An optimum irrigation schedule must apply the minimum irrigation that avoids both water and salinity stresses. A rate of 364 mm yr^{-1} would have fulfilled these requirements, producing water savings of 59%. Besides, this irrigation rate would have decreased drainage down to 108 mm yr^{-1}, i.e., 33% of the actual value (Tab 3). Usual irrigation doses for artichoke in lower Cheliff are 600–700 mm yr−1 using drip irrigation. However, in the case of study, crop evapotranspiration (ETc) amounted just to 687 mm from 1^{st} September to 08^{th} Jun. However, a general irrigation rate between 364 and 455 mm yr^{-1}, distributed in 15% in August and September,34% in October and November, 23% in December and January, 15% in February and March and, finally, 13% in April and Jun can be recommended. Specific irrigation dates and amounts should be selected based ECe estimations carried out .This way, modeling complement each other to optimize drip irrigation.The joint drainage of both months amounted to 28.4 mm, which was 26% of the whole drainage. In January a total 62 mm of drainage occurred, which was a consequence of the excess of irrigation over crop evapotranspiration in both months.

Table 3. Simulation of different irrigation schedules and their effects on the soil salinity

Plot 1													
Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	%
Irrigation	70	72,33	81,92	67,47	36,27	32,76	36,27	35,1	19,13	3,75	0	0	100
Irrigation	56	57,87	65,53	53,98	29,02	26,21	29,02	28,08	15,31	3,00	0	0	80
Irrigation	42	43,4	49,15	40,49	21,76	19,66	21,76	21,06	11,48	2,25	0	0	60

4. Conclusions

The simulation of the soil salinity in June of two crops in the Lower Cheliff plain (Algeria) was carried out with the SALTIRSOIL_M model. The soil saturation extract main ion composition and electrical conductivity wassimulated. Simulations and observations of major inorganic ions and hence total soluble salts in the saturation extract were similar. The optimum irrigation schedule in the experimental plot was sought simulating the EC that would result from irrigating with less water. Use of 300 – 400 mm yr^{-1} , and shorter and Drainage functioning under drip irrigation is analyzed through the values of the electrical conductivity. In fact, the comparison between the measured and calculated data indicates higher magnitude of the measured data. This result suggests that farmer'sirrigation volumes should contribute to salts leaching.more frequent irrigations could have reduced water losses through drainage while keeping soil water content at optimum values, and soil salinity well below harmful levels for plot 1. These conclusions suggest that farmer's irrigation practices should be regarded with more attention in the context of Lower Cheliff.

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