Assessment of soil salinisation risks under irrigation with brackish water in the semi-arid Tunisia

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INTRODUCTION

In the semiarid Tunisia, about 50 % of the irrigated land has been considered as highly sensitive to the salinization (DG/ACTA, 2007). To reduce and avoid the risk of soil degradation, it is important to control the soil salinity and keep it below plant salinity tolerance thresholds.

MATERIALS AND METHODS

Experimental area

Experiments were conducted in the semiarid irrigated area of Kalaat Landalous (rain 450 mm/year, ET≈1420 mm/year). The altitude varies from 2 to 6 m and the natural slope from 0.05 to 2%. The main crops are fodder, cereal, and vegetables. In 1987, drainage and irrigation system was constructed. The electrical conductivity of irrigation water was about 3 dS m^{-1}. An area covering 1400 ha surrounded by the two drainage open ditches (E1, E2) was selected within the 2900 ha irrigated area for experimental studies.

Methods

The soil and groundwater properties were analyzed at different spatio-temporal. In 1989, before land irrigation, 144 sampling plots were investigated (Fig. **1**). In each plot, soil samples were collected at 5 depths (0.1 to 2.0 m) for soil analysis. (particle size, electrical conductivity of saturated soil paste (*ECe*), exchangeable sodium percentage (*ESP*), etc.). Beside soil samples, the depth to the groundwater table from the soil surface (*Dgw*) and its salinity (*ECgw*) were measured. The overlay of the 5 soil particle size maps allows the identification of functional homogeneous areas (FHA). The soil and groundwater properties were used to identify the soil salinisation causes and evaluate areas with high salinisation risks.

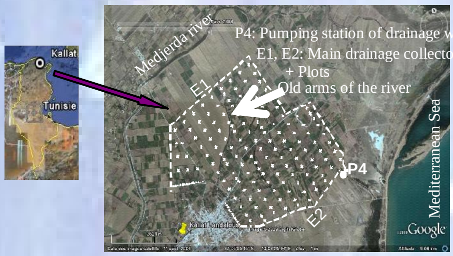
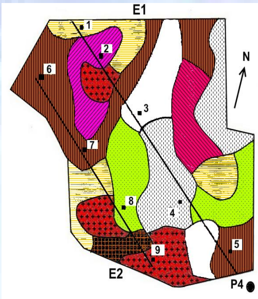


Fig. 1. Experimental area and sampling locations in Kalaat Landalous (Tunisia)

RESULTS

Functional homogeneous areas (FHA)

Statistical and geostatistical analysis of soil properties, reveals its heterogeneity and the anisotropic (Bouksila, 1992). The average fraction of *clay* varied from 28 to 34 % and *sand* from 50 to 55 %. On the basis of the fine soil fraction (Clay + fine silt), nine homogeneous functional units have been identified (Fig. **2**).



Legend

FHA	Soil depth (cm) 10	50	100	150	200
I	+	+	+	+	+
II	-	-	-	-	-
III	+	+	-	+	-
IV	+	+	+	-	-
V	+	+	-	-	+
VI	-	+	+	-	-
VII	-	-	+	-	-
VIII	+	+	+	-	-
IX	+	+	-	-	-

+: Clay+fine silt > 60%
-: Clay+fine silt < 60%
▪: Soil profile

Fig. 2 Homogeneous textural units

Impact of soil texture and groundwater on soil salinity variation

Soil particle size (**Fig**. **2**), groundwater properties and soil salinity (**Fig. 3**) showed a certain similarity regarding heir spatial variability. The lowest soil salinity corresponds to a relatively coarser soil texture, *ECgw* < 10 dS m^{-1} and *Dgw* > 2.2 m. However, the increase of *ECgw* generated all over schema an increase of *ECe* in the soil profile

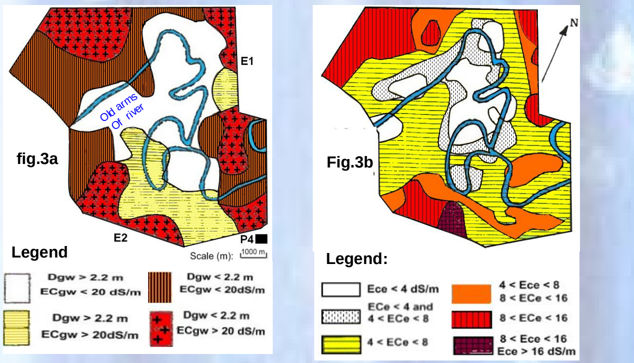


Fig.3. **a)** Spatial variability of the groundwater table properties (depth, *Dgw;* salinity, *ECgw*) and **b)** soil salinity (*ECe*) in 0-0.75 m and 0.75-1.25 m soil layer (in Bach Hamba, 1992)

Among 20 soils and groundwater variables, the best input to predict *ECe* variation using artificial neural networks (ANN) model were groundwater properties. For the root soil depth, R^2 varied from 0.73 to 0.84 and the error (RMSE) on *ECe* prediction varied from 1.24 to 2.22 dS m^{-1} (Bouksila et al., 2010).

Soil salinisation risk units

Based on the results of soil and groundwater properties , three area with different levels of risk salinisation have been identified (**Fig**. **4**):

1- Low risk of salinisation (about 400 ha): coarser texture; *Dgw* > 1.4 m in winter and *Dgw* >2.2 m in summer, *ECgw* < 15 dS m^{-1} and *ECe* < 4 dS m^{-1},
2- average risk (500 ha): fine texture, low field soil permeability (Ks <1 cm h^{-1}), 1.0<*Dgw* (m)<2.0, 10<*ECgw* (dS m^{-1})<20 , ESP >15, and 4< *ECe* (dS m^{-1}) < 8,
3- high risk (500 ha): clay soil with presence of textural stratification, Ks < 0.5 cm h^{-1}, 15 <ECgw (dSm^{-1}) <30, 1 < *Dgw* (m) < 2,
15 < *ECgw* (dS m^{-1}) < 60, ESP>15 and *ECe* > 8 dS m^{-1}

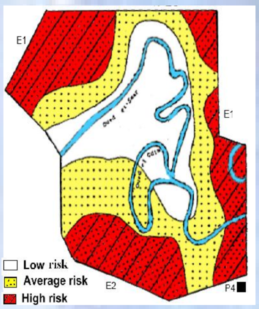


Fig. 4 Soil salinisation risk map

This map needs to be updated for sustainable land planning and water management. 15 years of irrigation and drainage in Kalaat Landalous led to the reduction of soil salinity from 7 dS m^{-1} to 3.5 dS m^{-1} and to the dilution of the groundwater from 16 to 7 dS m^{-1} (Mekki and Bouksila, 2009). The total dissolved salt exported by the drainage system (P4, fig.1) was 945 10^6 Kg and the salt balance (input – output) was negative, about - 685 10^6 tons (Bouksila et al., 2010).

CONCLUSION

In the semiarid Tunisia, based on the findings related to the soil and groundwater properties, soil salinisation factors were identified and soil salinisation risk map were elaborated. This map is appreciated by both land planners and farmers to make appropriate decisions related to crop production, and soil and water management.