SALINITY EFFECT OF IRRIGATION WITH TREATED WASTEWATER IN BASAL SOIL RESPIRATION IN SE OF SPAIN

A. Morugán, F. García-Orenes, J. Mataix-Solera

GEA (Grupo de Edafología Ambiental). Departamento de Agroquímica y Medio Ambiente, Universidad Miguel Hernández, Avenida de la Universidad s/n, 03202-Elche, Alicante, Spain. amorugan@umh.es

INTRODUCTION

The use of treated wastewater for the irrigation of agricultural soils is an alternative to utilizing better-quality water, especially in semiarid regions where water shortage is a very serious problem. Wastewater use in agriculture is not a new practice, all over the world this reuse has been common practice for a long time, but the concept is of greater importance currently because of the global water crisis. Replacement of freshwater by treated wastewater is seen as an important conservation strategy contributing to agricultural production, substantial benefits can derive from using this nutrient-rich waste water but there can also be a negative impact. For this reason it is necessary to know precisely the composition of water before applying it to the soil in order to guarantee minimal impact in terms of contamination and salinization.

MATERIALS AND METHODS

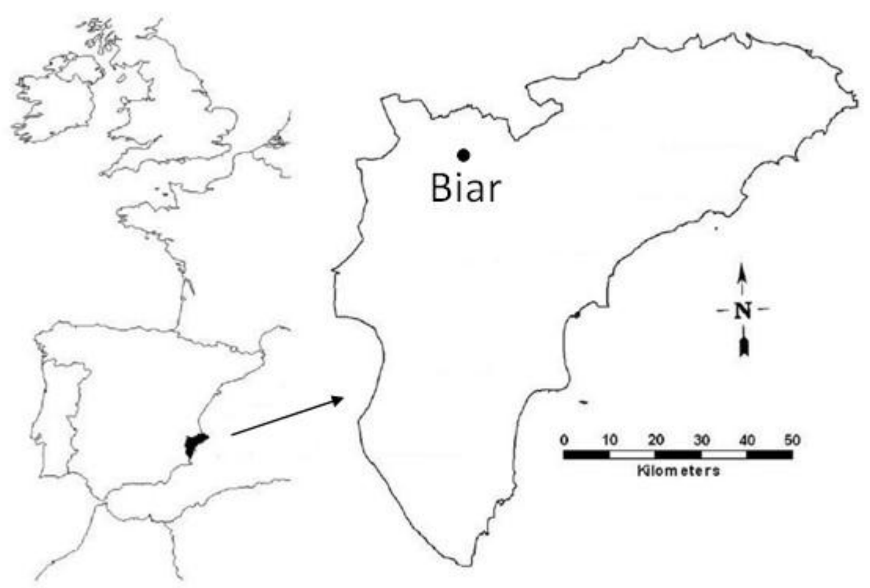

Figure 1. Localization of the agricultural area of study in Biar (Alicante, Spain)

In this work we have been studying, for more than three years, different parameters in calcareous soils irrigated with treated wastewater in an agricultural Mediterranean area located at Biar (Alicante, SE Spain), with a crop of grape (*Vitis labrusca*) (Figure 1).

Three types of waters were used for the irrigation of the soil: fresh water (control) (TC), treated wastewater from secondary (T2) and tertiary treatment (T3). Two different doses of irrigation have been applied to fit the efficiency of the irrigation to the crop and soil type during the study period (Table 1). A soil sampling was carried out every four months.

Table 1. Summary of the different doses of irrigation water

Dose (L m^{-2})	Frequency (each X days)	Start	End
10	7	06/09/2006	06/03/2008
50	15	06/03/2008	27/05/2009

The soil of this study is classified as a Typic Xerofluvent, and the main characteristics are shown in Table 2.

Study design

9 plots of 8 m^2 (3 plots per treatment: TC, T2 and T3) randomly distributed

Soil moisture: Monitorized at three depths (2.5, 12.5 and 22.5 cm) by means of soil moisture sensors connecting to data-loggers

Meteorological conditions: Controlled by the installation of meteorological station near to the study plot

Soil sampling

Eight soil samplings were carried out, in September 2006 (S1), February 2007 (S2), June 2007 (S3), November 2007 (S4), April 2008 (S5), June 2008 (S6), November 2008 (S7) and March 2009 (S8). The first soil sampling was conducted before irrigation treatments. The samples were taken using 100 cc cylinders. Nine samples per plot were taken at each sampling from the 0-5 cm depth (n=81).

Soil analysis

Soil electrical conductivity (EC) was analysed in aqueous extract in a 1:5, w/v.
The basal soil respiration (BSR) was monitored with a multiple sensor respirometer (Micro-Oxymax, Columbus, OH, USA) (Figure 2).

Figure 2. Respirometer Micro-Oxymax, Columbus.

Table 2. Summary of the main soil properties (0-5 cm depth)

Texture (% sand, silt, clay)	Loam (32, 42, 25)
pH	8.4
EC (µS/cm)	186
Nk (g/Kg)	1.3
OC (g/Kg)	13.6
C/N	10.5
P (mgP/100g)	1.19
CO_3^{2-} (%)	42.5

EC: Electrical conductivity; Nk: Kjeldahl Nitrogen; OC: Organic Carbon; P: Available Phosphorus.

RESULTS AND DISCUSSION

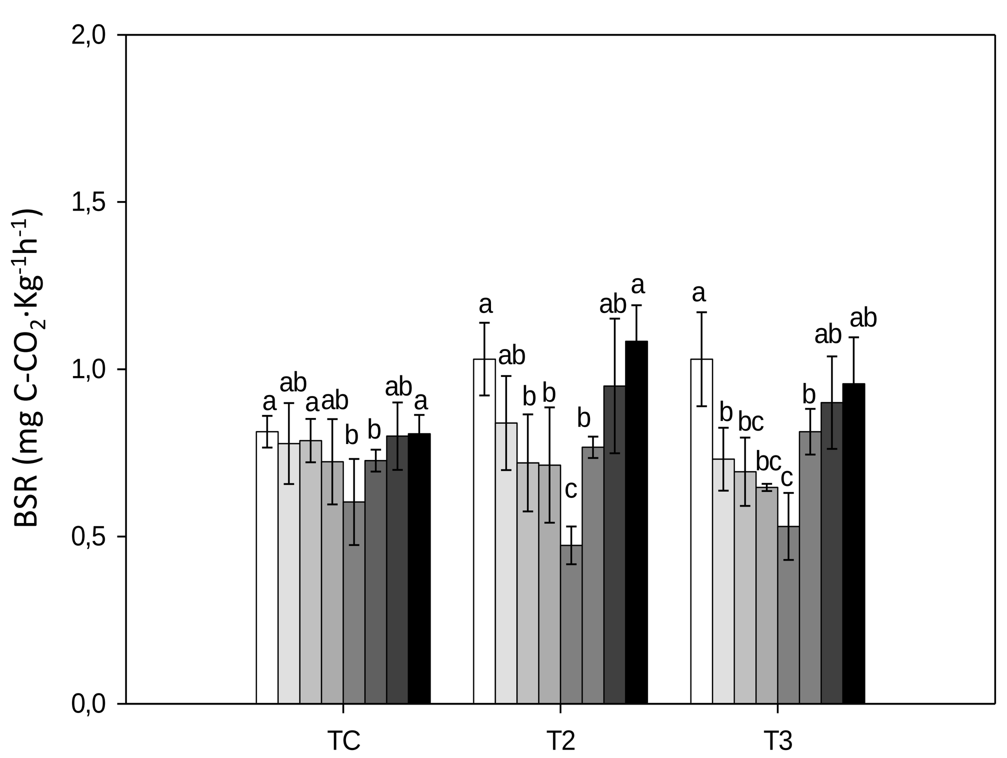

Figure 3. Mean values (± standard deviation) of basal soil respiration. Different letters indicate significant differences (P<0.05) between samplings – from white (first sampling) to black (last sampling) – for each treatment after one-way ANOVA

We show the results of the evolution of basal soil respiration (BSR) in Figure 3. We observed a similar pattern of behaviour for BSR between treatments, a decrease at the first eighteen months of irrigation (from sampling 1 to sampling 5) and an increase at the end of study (from sampling 5 to sampling 8) in all the treatments; this trend is more marked for the secondary and tertiary treatments.

In our study case, the variations of BSR obtained for all the treatments seem to be closely related to the dose and frequency of irrigation (Table 1) and the related soil wetting and drying cycles. Therefore, this decrease occurred during first dose and frequency (10 L m^{-2} per week).

The microorganisms present in soils are very vulnerable to the changes in soil moisture (Sparling et al., 1987) and for this reason BSR is highly sensitive and responds very quickly to disturbances in the soil, such as changes in irrigation. A rapid increase in BSR just after rewetting of dried soil has been observed frequently (Bottner, 1985; Van Gestel et al., 1993). Drying is known to cause the death of microorganisms not adapted to high water tension and to increase the availability of nutrients to survivors (Zornoza et al., 2007).

The results also showed a negative correlation (R= -0.51) between BSR and saline content in soils irrigated with wastewater (T2 and T3) (Figure 4). The decrease in BSR for these treatments may be also due to the salinity of waste water (Figure 5). The lower values of BSR were detected at T2 and T3 treatments at sampling 5, corresponding with an increase of electrical conductivity (EC) in soil especially in that irrigated with the secondary treatment. An increasing trend in BSR can be observed after this time, probably due to the leaching of salts and the decrease of water EC. Several studies show negative correlations between BSR and saline content in irrigated soils (Sardinha et al., 2003; Tripathi et al., 2006).

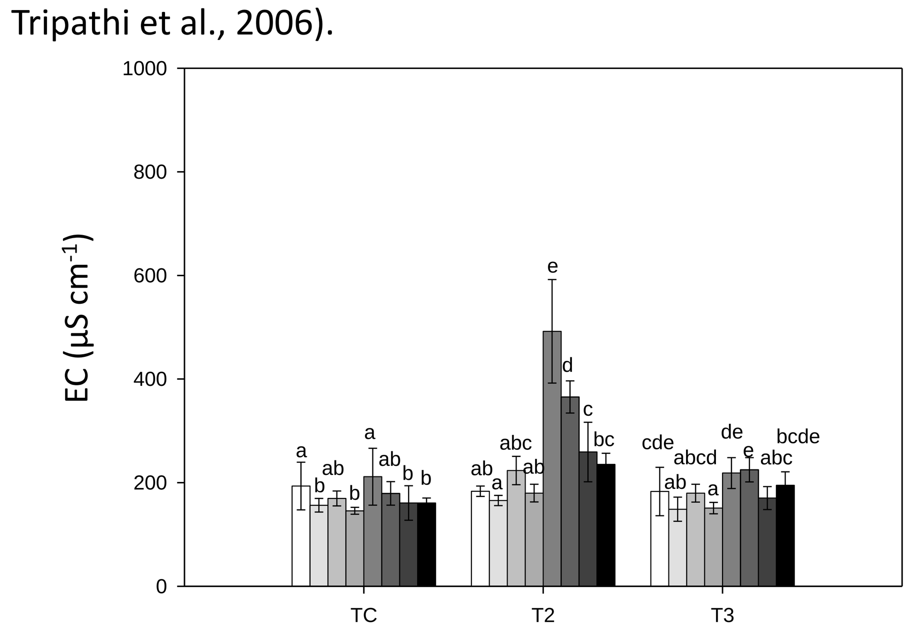

Figure 4. Mean values (± standard deviation) of electrical conductivity (EC) in soil. Different letters indicate significant differences (P<0.05) between samplings – from white (first sampling) to black (last sampling) – for each treatment after one-way ANOVA

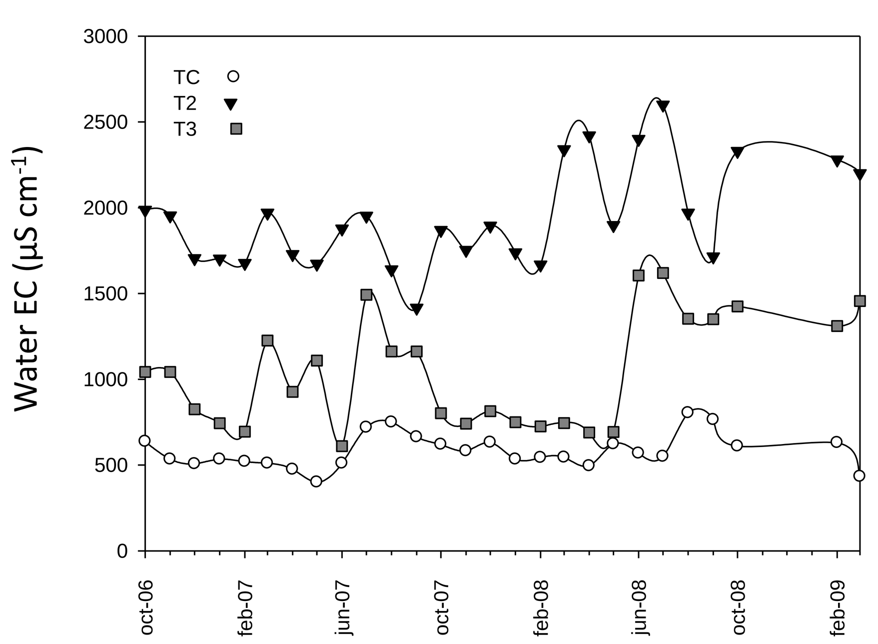

Figure 5. Electrical conductivity of the different waters used for irrigation during the study period. TC: Control treatment, T2: Secondary treatment and T3: Tertiary treatment

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CONCLUSIONS

We saw a modification in the basal soil respiration in all treatments when the dose and frequency of irrigation changed, which can be attributed to the strong wettings and drying cycles in the soil.

The increase of EC was not in any case enough high to produce big problems with crop productivity or soil salinization. An increasing trend was observed in BSR after a period of leaching of salts and a decrease of EC.

An exhaustive control of EC of treated wastewater is necessary to avoid undesirable effects on crop yield and to assess the feasibility of using these waters in this type of soil.

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