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Effect of leaching on soil irrigated with sodium bicarbonate water applied by drip irrigation, with two irrigation and nitrate treatments.

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Introduction

There are high concentrations of nitrate in the ground waters in various regions in the Canary Islands. In Tenerife and Gran Canaria most of the agricultural valleys have well waters with concentrations of nitrate above 100 mg/L. In this case, the Spanish government has to apply European Community laws concerning regulation of subterranean water contamination. The farmers that cultivate in these areas are inspected to determine irrigation water nitrate and fertilizer use.

All the water used by agriculture is subterranean and of low salinity. The principal anions are chloride and bicarbonate and the cations are sodium and magnesium. Most of the waters have high SAR values and the gallery waters (water mined from horizontal shafts with recharge from upland non-irrigated areas) have high pH and high bicarbonate.

Tomato is the second most important crop in the Canary Inlands with 3000 ha in cultivation. This crop is the most important in San Nicolas valley with about 500 ha under net houses. This valley is situated in the west of Gran Canaria Islands, and the well waters of San Nicolas have the highest concentrations of nitrates of waters in the Canary Islands.

Materials and Methods

A three-year trial, during 1999, 2001 and 2002 was carried out between June and November of each year. It was set up to study the soil and crop response to soil nitrate contamination, soil leaching and irrigation water. Tomatoes were grown in 16 drainage lysimeters with 5.9 m^3 capacity (3.9 m x 2.5 m x 0.6 m) in a greenhouse. The experimental design was randomized blocks in split-plots with four repetitions and experimental units of 24 plants. The water and the fertilizers were applied by trickle irrigation in rows. The amount of water applied was determined according to the FAO methodology for a class A evaporation pan (E_0) (Doorenbos and Pruitt, 1976) placed in the middle of the greenhouse. The crop evapotranspiración value (ET) was calculated by multiplying the daily E_0 with the monthly crop coefficient (Kc) of. 0.3, 0.5, 0.6, 1.0,1.2 y 1.0, from the first to the sixth month respectively (Castilla et al, 1995).

The experiment was carried out with the tomato cultivar *Daniela* with two irrigation and two nitrogen treatments (R1N1, R1N2, R2N1 and R2N2). To obtain leaching a percentage plus was added to the evaporation pan value, in the case of R1, 24% and in R2, 38%. Fertilization was daily with fertigation and the quantity of the products used is shown in Table 1, for the two nitrate treatments. The nitrogen needs for Canary Islands for tomato is between 500 and 700 kg/ha (Rodriguez, et al 1989) The two nitrogen treatments were 348 kg/ha in N1 and 696 kg/ha in N2.

At the end of the season, the plants were removed from the field and a leaching irrigation of 60 mm was applied. The leaching method and the water quality were different in the three years.

Table I shows the chemical analysis of the irrigation and leaching water used in 1999. This water had a high pH and Na and Mg were the principal cations balanced by high alkalinity. That year the 60 mm of leaching water was applied by the drippers in the irrigation line, wetting only the irrigation zone. Thus in 1999 leaching had a vertical component in the rows with limited horizontal movement.

Table I.-Irrigation and leaching water used in the tomato lysimeters during 1999, 2001 and 2002.

Irrigation water	pH	EC	Ca	Mg	Na	K	Alk.	Cl	S-SO_4	NO_3	SAR
		dS m^{-1}	me/L							mg/L	
1999	8.89	0.90	0.74	2.75	5.54	0.42	6.39	2.26	0.80	3.32	4.20
2001 and 2002	8.62	0.20	0.56	0.63	0.98	0.10	1.36	0.83	0.08	4.60	1.27

During 2001 and 2002 the chemical composition of the water was different than in 1999. As shown in Table I, these waters had lower EC and SAR values than in 1999. These waters produced a slight and moderate hazard regarding reduction in the soil infiltration rate according to the criteria of Ayers and Westcot, (1986).

Leaching in 2001 was achieved by wetting the entire soil surface, with drippers installed in the irrigation system after the plants were removed from the soil. In 2002 leaching was by surface irrigation, applied in a pulse. Nitrate fertilizers were not applied in 2002 as the nitrate necessary for the tomato crop was available from soil reserves.

Results and Discussion

During the experiments we expected to get drainage water according with the irrigation treatments and calculated ET, but this did not occur. The lysimeters had drainage only at the end of the crop, after day 150. The soil was sampled at the end of the crop, before leaching and after leaching, in the 16 lysimeters at two depths (15 and 40 cm), for the three years.

In 1999 the irrigation water pH and alkalinity was higher than in other years. The soil pH between rows was lower than in the crop rows, before leaching it oscillated at 15 cm between 5.67 in R1N2 and 5.93 in R2N1. Higher pH values of 7.06 were observed after leaching in R1N1 at 15 cm depth. In the year 2001 with less irrigation water and lower pH and alkalinity, the soil pH response was similar to 1999. The soil pH in 2002 at 40 cm was almost uniform between 6.12 and 6.54.

Figure 1 presents the ESP in % (with respect to the CEC) in the soil for the two depths, four treatments, before and after leaching. In the rows, after leaching, where the fertigation was applied the soil ESP was lower than 5% at 15 cm depth in all the treatments during 2001 and 2002, except in 1999 in R1N1 was observed ESP data of 6.69. Although the leaching system was different in three years, in all treatments the ESP increase between rows after leaching.

The changes in the soil EC values is presented in Figure 2. As for ESP the higher values were observed between rows. The irrigation water and the fertigation in this irrigation system produce a salt accumulation in the boundaries of the wetting soil volumes (Kruse, 1990). A horizontal salt movement was induced in the soil when leaching was applied, also in the year 2002 where the entire soil surface was wetted.

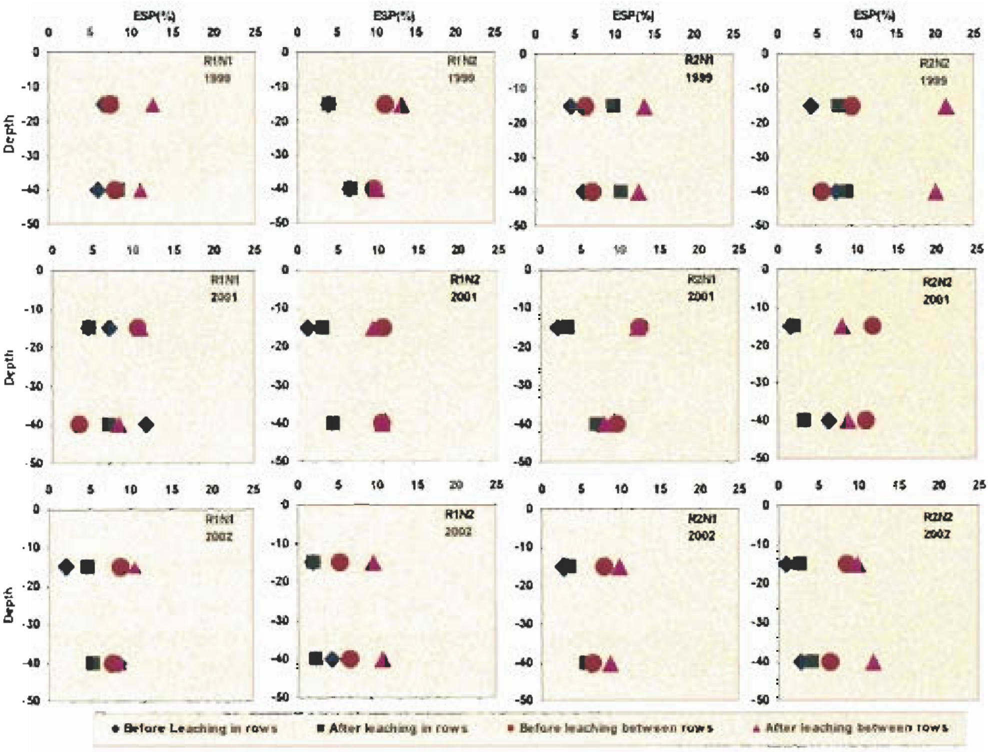

Figure 1.- ESP (%) in the soils, in two depths (15 and 40 cm) before and after leaching in the tomato lysimeters, for the four treatments after the plants were removed.

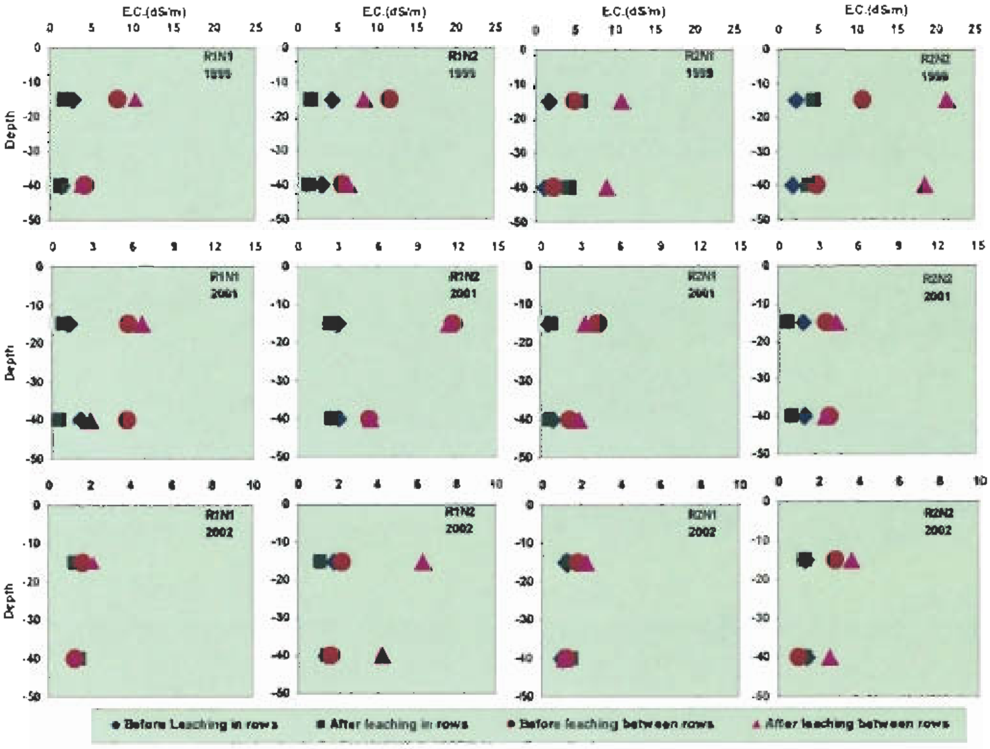

Figure 2.- E.C. (dS/m) in the soils,(at 15 and 40 cm), before and after leaching in the tomato lysimeters,

The high EC values observed in the soil did not correspond with the EC of the irrigation water (in1999, 0.9 dS m^{-1}), and the fertilizers accumulated as salts between rows. In the higher nitrate and the lower irrigation treatment, the nitrate concentration after leaching was 3.54 g L^{-1} at the 15 cm depth. The highest value in soil nitrate was at 15 cm in the treatment R1N2 in 2001 with 5.32 g L^{-1}. In 2002 when nitrate fertilizers were not applied, the nitrate moved from the soil in the rows and between rows, after leaching in this year the highest nitrate value was 2.30 g L^{-1} at 15 cm.

The relationship between ESP and EC is shown in Figure 3, we found a linear correlation between rows before and after leaching, the r^2 value was 0.94 in the sampled soils after leaching. The ESP values increased at the same time that the EC increased only in 1999 when the EC and the SAR in irrigation water was highest.

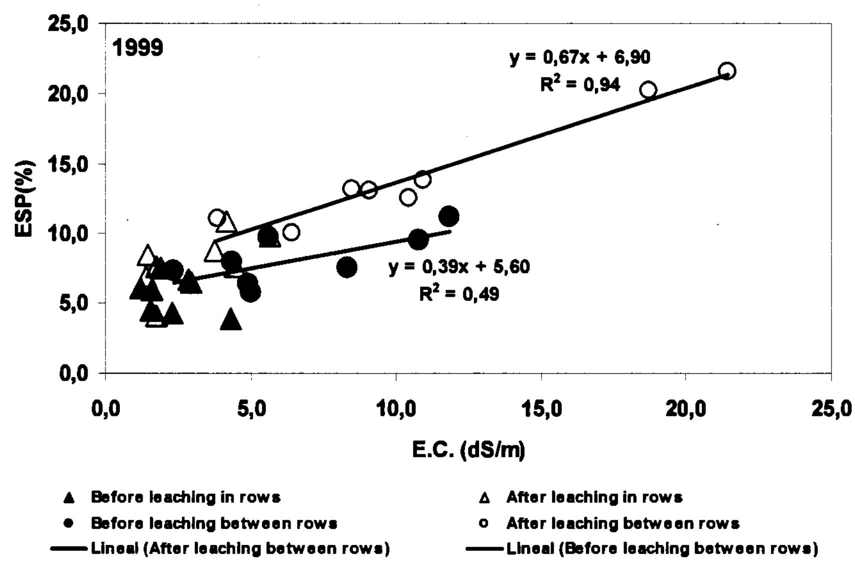

Figure 3.-ESP versus Electric Conductivity in the soils for the four treatments, before and after leaching, in the rows and in between rows, for the year 1999.

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