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SUNFLOWER (*HELIANTHUS ANNUUS*) DEVELOPMENT UNDER DILUTED SEA WATER IRRIGATION

B. O. Arredondo Vega, L. Alcaraz M. and F. X. Arredondo Vega *

Centro de Investigaciones Biológicas de Baja California Sur, México

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ABSTRACT. Sunflower (*Helianthus annuus*) plants were grown under controlled conditions and divided into four groups: the control one received regular tap water for irrigating purposes and the other three received 5; 12.5 and 25 % sea water dilutions respectively. During a 30 d period, stems, leaves and roots length were measured. Statistical differences ($p < 0,001$) were observed in the leaves length when comparing the 12.5 and 25 % plants against the control group.

RESUMEN. Durante un período de 30 d y bajo condiciones controladas, se hicieron germinar y crecer plantas de girasol (*Helianthus annuus*) utilizando agua de mar diluida (5; 12,5 y 25 %) para su riego. Los parámetros siguientes fueron estudiados en cada grupo de plantas: longitudes del tallo, de las hojas y de la raíz. Cuando se comparó cada uno de ellos con un grupo control, se encontraron diferencias estadísticamente significativas ($p < 0,001$) en las plantas sometidas a riego con agua de mar al 25 %, siendo la longitud de la hoja la mayormente afectada (a partir del grupo de plantas irrigadas con agua de mar al 12,5 %).

INTRODUCTION

Saline stress in plants can be manifested at the biochemical and physiological level. Long term exposure to a high salt environment can eventually cause external manifestations such as stuntet growth. Under such conditions the seed and plant enzyme mechanisms may switch to urgent vital survival activities [1, 2].

Sunflower plants have been catalogued as moderate saline tolerant plants [3]. Its commercial importance is due to the high yield of seeds from which valuable oil is extracted. Under proper conditions a 1 500 kg hm $^{-2}$ seed yield can be obtained [4]. Sunflower plants could represent an alternative crop in geographical areas with sodic-saline soils and water.

This work reports the preliminary results of the effects of saline conditions over a 30 d period, on sunflower plants growth.

MATERIALS AND METHODS

Locally purchased "grey stripe" sunflower seeds (*Helianthus annuus*, L. cv. grey stripe [5]) were employed. Five seeds were sown in (10 × 7) cm cardboard pot. Each pot received a mixture of vermiculite and soil (1:3 ratio). The soil was collected from the experimental fields of the Centro de Investigaciones Biológicas de Baja California Sur, located at El Comitán 20 km northwest from the city of La Paz, Baja California Sur, México (Fig. 1). Soil samples were obtained from 0 to 10 cm, 10 to 20 cm and 20 to 40 cm depth and analyzed. All three samples were air dried and passed through a 2 mm sieve. In order to carry out the analyses a 1:2 soil-water ratio was used. pH was determined with a calomel electrode (pH meter E-520 Metron Switzerland). Electroconductivity and total salts were measured with the use of a wheatstone bridge [6]. Organic matter was determined by the pipette method [3].

Plants were divided into four groups, the controls received regular tap water, the remaining three were irrigated with 5; 12,5 and 25 % sea water (Table I). In all cases the diluting agent was regular tap water. Electrical conductivity [3] percentage of total salts [7] and NaCl [8] were estimated in the tap water and in each of the dilutions.

* Present Address:
The Galto Laboratory, Department of Genetics and Biometry.
University College London, Wolfson House. 4 Stephenson Way, London NW1 2HE

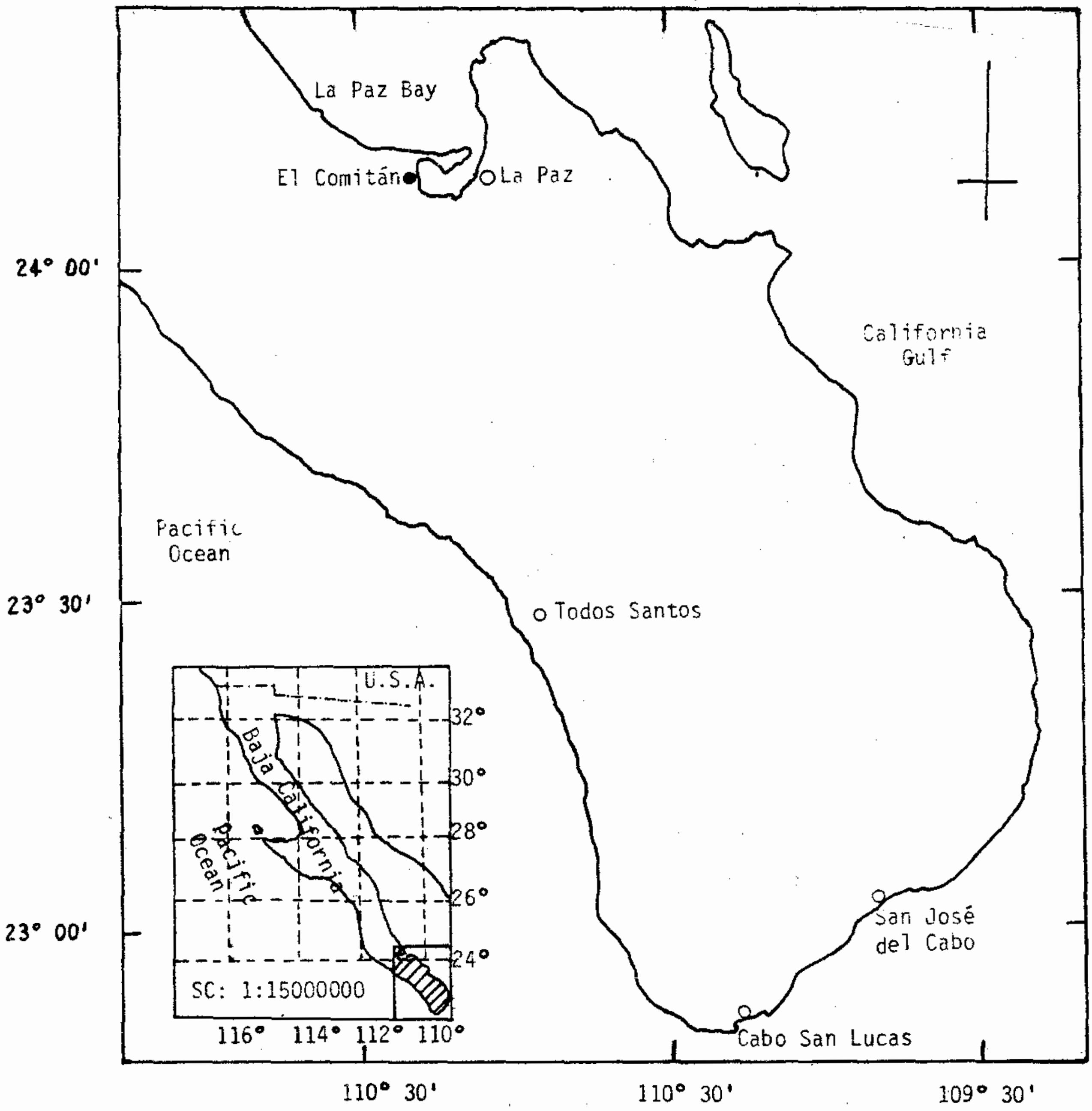

Fig. 1. Localization of the experimental field of Centro de Investigaciones Biológicas de Baja California Sur

TABLE I

Analyses of the water dilutions used in the experiments

	pH	Electric conductivity (mS/cm)	Total salts (%)	NaCl (%)
Tap Water	8,0	1,1	0,09	0,07
5 % sea water	8,0	4,0	0,26	0,20
12,5 % sea water	7,9	8,0	0,51	0,44
25 % sea water	7,9	13,8	0,88	0,80
100 % sea water *	7,9	55,2	3,53	2,90

* Only for comparative purposes

The plants were irrigated every 72 h. Seed germination and plant gowth, during a 30 d period ocurred under continous illumination (195 $\mu Em^{2} \cdot s^{-1}$), constant temperature (25 °C ± 2 °C) and constant humidity (78 to 80 %). Every 72 h one plant per group was carefully separated from the pot and stems, leaves and roots length were measured. The data were subjeted to the Student's t statiscal test [9]. Soil analyses were repeated at the end of the experiment.

RESULTS

From the data shown in Table II, the sampled soil falls in the slightly alkaline non saline category, with a high sand content that confers a low water retention capability, high permeability and low cation exchange characteristics [10].

TABLA II

Average results from the analyses of the soil from the experimental field of Centro de Investigaciones Biológicas de Baja California Sur at El Comitán

	Depth (cm) 0 to 10	10 to 20	20 to 40
pH	7,9 ± 0,16	7,9 ± 0,17	8,0 ± 0,20
Electric. conductivity (mS/cm)	0,84 ± 0,44	1,06 ± 0,64	0,60 ± 0,18
Total salts (%)	0,05 ± 0,02	0,07 ± 0,02	0,04 ± 0,01
Organic matter (%)	0,42 ± 0,09	0,45 ± 0,15	0,39 ± 0,15
Texture (%)			
sand	89,83 ± 5,1	89,39 ± 3,2	88,35 ± 2,4
silt	5,71 ± 0,8	8,58 ± 3,6	8,11 ± 0,9
clay	2,3 ± 0,9	3,1 ± 0,7	2,02 ± 0,6

Figure 2 shows the variation in length of the stems, leaves and roots over the 30 d experiment. Table III reports the analysis of the pot soil mixture at the end of the experiment. It can be seen that in all the sea water irrigated pots a pH increase from 0,4 to 0,7 to 1,0 pH units was registered when comparing the 3 different groups (5; 12,5 and 25 %) with the control group and with the original soil (o to 10 cm depth). This shifted the soil from a slightly alkaline to a moderate alkaline soil category. The 5 % sea water dilution with les than 2 $mS \cdot cm^{-1}$ of conductivity and 0,1 % of total salts can not be considered as an entirely saline soil. The accumulated salts in the 12,5 and 25 % dilutions were enough to curtail any growth.

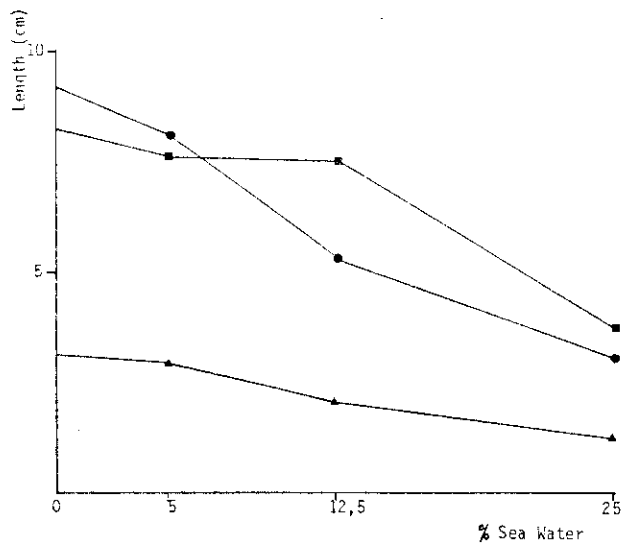

Fig. 2. Effect of diluted sea water concentrations on leaves (▲), stems (●) and roots (■) of the sunflowers after 27 d of growth

TABLE III

Average results from the analyses of the soil at the end of the experiment

	pH	Electric conductivity (mS/cm)	Total salts (%)
Control	7,9 ± 0,17	0,60 ± 0,28	0,038
5 % sea water	8,3 ± 0,30	0,76 ± 0,15	0,049
12,5 % sea water	8,6 ± 0,15	1,90 ± 0,54	0,122
25 % sea water	8,9 ± 0,10	3,80 ± 1,69	0,243

DISCUSSION

When using the Student's t test to compare the stems, leaves and roots length between the 5 % sea water and the control group no differences were observed in agreement to previous reports for sunflower plants [3]. In the 1[illegible] % sea water sunflower group significative differences ($p < 0,001$) were observed at leaves length when compared with the control group. The 25 % sea water plant group showed significative differences ($p < 0,001$) in all parameterts studied (Table IV). Roots growth was maintained more or less constant in the 5 and 12,5 % sea water groups. This can be explained by the fact that in spite of the roots being directly exposed to the saline environment they are less affected than the vegetative shoot growth, fruit, or seed production [11-13]. In the heterogeneus saline environment originated in the pots, the roots showed a tendency to proliferate in the non saline areas.

TABLE IV

Statistical analysis of the parameters studied

	Control (tap water)	5 % sea water	12,5 % sea water	25 % sea water
Roots length (cm)	8,19 ± 3,68	7,67 ± 2,64	7,51 ± 2,64	3,60 ± 1,15
	(n = 69)	(n = 53)	(n = 47)	(n = 32)
s^2	13,54	6,09	7,05	2,6
SE	0,44	0,33	0,38	0,26
DF		120	114	99
p		0,57	0,68	3,72
t		NS	NS	< 0,001
Stems length (cm)	9,23 ± 3,97	8,05 ± 3,66	5,31 ± 2,78	3,0 ± 0
	(n = 67)	(n =57)	(n =45)	(n = 27)
s^2	14,28	13,44	7,74	0
SE	0,46	0,50	0,41	0
DF		118	110	92
p		1,13	1,12	4,39
t		NS	NS	< 0,001
Leaves length (cm)	3,09 ± 0,68	2,9 ± 0,80	2,0 ± 0,53	1,22 ± 0,41
s^2	(n = 69)	(n = 53)	(n = 45)	(n = 19)
SE	13,64	0,64	0,28	0,17
DF	0,44	0,109	0,080	0,095
p		118	110	84
t		1,15	8,24	9,06
		NS	< 0,001	< 0,001

s^2 variance; SE standard error; DF degrees of freedom; p probability; t Student's t test

Recently, Rawson and Munns [14] reported that sunflower leaf expansion under saline stress is inhibited by a direct salt effect on the utilization rate of stored assimilates and not directly by the carbohydrate status in the plant environment or the plant itself. Such utilization rate, for the expansion of the leaf, is active mainly during the luminous period. The use of a short storage of assimilates, and almost no leaf expansion occurs during the dark period. In our experiment, constant luminosity and an almost closed and increasingly saline environment, prevented any further plant growth, probably at an early stage.

Open field experiments and longer growth periods are necesary to study the effects of salinity on sunflower seed and oil production.

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