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Leaf Scorch and Mineral Nutrition of Avocado Trees Irrigated With Saline Water

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Introduction

The 'Fuerte' avocado *(Persea americana* Mill.) is grown commercially in the Atlixco region, 150 km south-east of Mexico City. Irrigation water is generally classified as medium to high-salinity water (13).

The avocado is a crop very susceptible to salt stress, and plantations frequently show typical symptomatology of salt injury. In the last years, visual symptoms resembling chloride and sodium toxicity have been accentuated.

The degree of leaf damage attributable to salinity stress is dependent on weather conditions such as air temperature and wind velocity; age, stage of canopy development, and water and nutrient status of avocado trees (2,10). The presence of necrotic areas in scion leaves due to chloride and sodium excess is dependent on rootstock (4). Leaves of avocado varieties on Mexican rootstock tend to accumulate more chloride and show more tip burn than leaves of the same varieties on West Indian rootstock (3,4). In the Atlixco region, the Mexican rootstock predominates in all plantations.

The present field study focuses, under commercial conditions, on leaf scorch and mineral nutrition in avocado trees.

Material and Methods

The avocado orchard is located 10 km south of Atlixco City at 1800 m above sea level. Annual average maximum/minimum temperatures are 28°/4°C in May and January, respectively. Annual rainfall is 850 mm and concentrated from May to September. Soil is a sandy loam Fluvisol coated with eolic sand (15). Irrigation is applied by flooding at fourteen-day intervals.

Twelve year old avocado 'Fuerte'/Mexican race seedlings of unknown origin, planted at 8x8 m in the square system, were selected, forming two groups of six trees. The first group included trees showing clear visual symptoms of salt injury in the leaves (tip burn and firing of the margins). The other group was formed with trees that in general had a normal appearance; that is, they presented very few scorched leaves.

Leaf samples were taken during one year at two month intervals beginning in October 1983 (initiation of irrigation season), from the twelve trees. Scorched and non-scorched whole mature leaves of several branches were collected on each date, obtaining two samples consisting of 40 leaves from each tree. Dried (70 °C), finely ground leaf samples were analyzed by the Soil Fertility Laboratory, Colegio de Postgraduados, México. Leaf analysis was practiced in compound samples representing the six trees of each group on every sampling date. Sodium (Na^{+}), potassium (K^{+}), calcium (Ca^{+2}), and magnesium (Mg^{+2}) were determined, using emission spectroscopy. The turbidimetric, dry ashing followed by titration with silver nitrate and the vanadate molybdate - yellow procedures, were used for total sulfates ($SO_4^{=}$), chloride (Cl^{-}), and phosphorus (P), respectively.

Water samples were taken and analyzed on each irrigation date (twelve in total) to assess water quality. Electrical conductivity (EC), pH, anions (CO_3^{-2}, HCO_3^{-2} Cl^{-}, and SO_4^{-2}) and cations (Na+, K+, Ca^{+2}, and Mg^{+2}) were determined using standard procedures (12).

At the end of the irrigation season, soil samples were collected at the drip line of each tree and combined into a sample for the following depths: 0 to 30, 30 to 60, 60 to 90, and 90 to 120 cm. Saturation extracts of these samples were analyzed similarly to water.

Results and Discussion

In the twelve irrigation dates, chemical composition of irrigation water did not show a definite trend. The average composition in meq liter^{-1} was as follows: CO_3^{-2} = 0.6; HCO_3^{-2} = 8.9; Cl^{-} = 1.4; SO_4^{-2} = 1.1; Na^{+} = 2.2; K^{+} = 0.2; Ca^{+2}= 5.5; Mg^{+2}= 3.6. The pH was in the range of 6.0 to 8.3 and the average EC was 1.0 dS.m^{-1}. Water chloride ranged from 0.8 to 1.8 meq.L^{-1}, which means that irrigation water is of poor quality for avocado crop (11).

Soil electrical conductivity increased at the end of irrigation season in all depths (Table 1). The greatest EC values corresponded to depths 0 to 30 and 30 to 60 cm in soil of trees with clear visual symptoms of salt injury in the leaves. An EC value greater than 2.0 dS.m^{-1} is hazardous for avocado trees. Chloride level also was greater in soil of trees with scorched leaves. The maximum value of 1.97 meq.L^{-1} in the 0 to 30 cm depth is plentiful to cause toxic effects (2). Sulfate levels greater than 30.0 meq.L^{-1} (Table 1) could affect the performance of avocado trees. The presence of high levels of sulfates could be a consequence of continuous application of ammonium and potassium sulfates to the orchard soil.

As occurred in the chemical composition of irrigation water, leaf analysis for P, Ca, Mg, Na, and $SO_4^{=}$ did not show a definite trend throughout the seven sampling dates. Based on the average concentration of these elements for all sampling dates (Table 2), it appears that leaf P is lower in trees with symptoms of salt stress and even lower in scorched leaves of these trees. Leaf Ca and Mg showed the opposite trend. Magnesium leaf concentration close to or higher than 1.0% level could be considered excessive and likely to be due to the great K/Mg imbalance in the soil (Table 1). Total SO 7, frequently being higher than 1.0% (Table 2), was above the adequate level (6). It appears that sulfate accumulation in the soil (Table 1), is the origin of high levels of $SO_4^{=}$ in the leaves. Sodium concentration was similar in all leaves and below the limit considered as toxic for avocado (6).

Table 1. Soil pH, EC, cations, and anions beneath the drip line of normal (N) and with symptoms of salt stress (SSS) avocado trees at the end of irrigation period.

Analysis	Soil depth (cm)							
	0 - 30		30 - 60		60 - 90		90 - 120	
	N	SSS	N	SSS	N	SSS	N	SSS
pH (saturated soil paste)	7.7	7.6	7.9	7.4	7.8	7.7	7.9	7.7
Saturation extract								
EC Initial (dS/m) at 25°C[z]	0.44	0.53	0.47	0.52	0.41	1.21	0.41	1.51
EC (dS/m) at 25°C	0.86	2.04	0.64	1.83	0.86	1.61	0.81	1.61
Cations ($meq.l^{-1}$)								
Na^+	3.00	4.91	2.74	4.91	3.13	5.78	3.00	5.91
K^+	0.44	0.73	0.35	0.82	0.44	1.03	0.44	0.68
Ca^{+2}	7.12	17.50	4.12	17.50	6.50	11.25	4.87	10.00
Mg^{+2}	3.60	9.77	1.95	8.74	2.47	7.20	2.07	7.20
Anions ($meq.l^{-1}$)								
CO_3^{-2}	2.42	2.07	1.73	2.07	0.35	2.07	2.07	0.69
HCO_3^-	3.28	6.91	Traces	2.21	Traces	0.17	Traces	
SO_4^{-2}	40.84	32.27	38.44	34.56	37.99	30.56	31.13	33.99
Cl^-	0.89	1.55	0.78	1.97	0.87	1.58	1.04	1.59

[z] Soil EC prior first irrigation.

Table 2. Effect of leaf scorching on P, Ca, Mg, Na, and S concentrations in leaves of 'Fuerte' avocado trees.

Tree group	Leaf characteristic	Concn (% dry wt)[z]				
		P	Ca	Mg	Na	S
N	Non-scorched	0.18	0.99	0.93	0.008	1.02
	Scorched	0.13	1.29	1.30	0.007	1.00
SSS	Non-scorched	0.13	1.18	1.05	0.008	0.94
	Scorched	0.09	1.44	1.61	0.011	0.96

[z] Each value is the average for all sampling dates of compound samples consisting of 6 trees in each group. Then no statistics available.

Leaf chloride throughout the sampling period (Fig. 1) was very high for a crop like the avocado (1,6,7). In normal trees, the trend in chloride leaf concentration was similar for scorched and non-scorched leaves. However, in trees with symptoms of salt injury, it appears that leaf chloride was higher in scorched leaves than in those non-scorched in three sampling dates realized in the dry season. Differences disappeared in samples collected in the rainy season. High increased chloride concentrations might be the origin of leaf scorching.

Potassium leaf levels were highest in non-scorched leaves and above the limit reported as deficient (Fig. 2). In scorched leaves, leaf K was lower and close to the deficiency level. In avocado, low concentrations of leaf K can result in symptoms similar to chloride toxicity (5), although this effect still is not very clear under field conditions (9).

Leaf analysis shows that leaf scorching in avocado trees could be the result of nutrient interactions. High increased chloride concentrations are related to low levels of leaf K. Opposite to the lower K levels, magnesium leaf concentrations were highest in scorched leaves. This negative relationship between K and Mg under saline conditions has been found in citrus (14) and other species. Increased $SO_4^{=}$ in the soil (Table 1) might have restricted phosphate and nitrate uptake (14), enhancing leaf scorching due to excessive chloride levels in leaves (8).

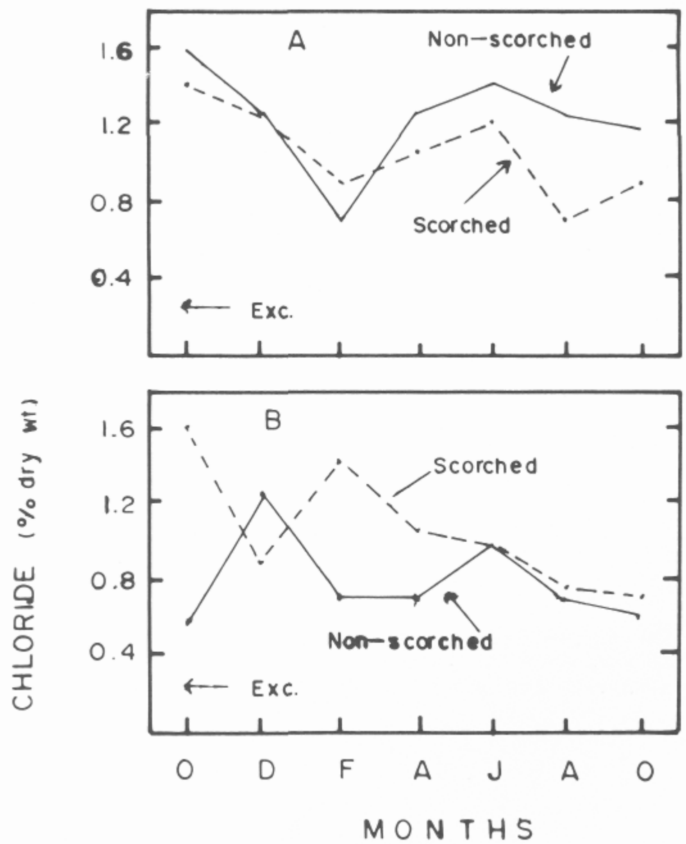

Fig. 1. *Chloride leaf concentration in mature leaves in seven sampling dates: (A) normal trees, and (B) with clear symptoms of salt stress. "Exc." is the level reported as excessive for avocado.*

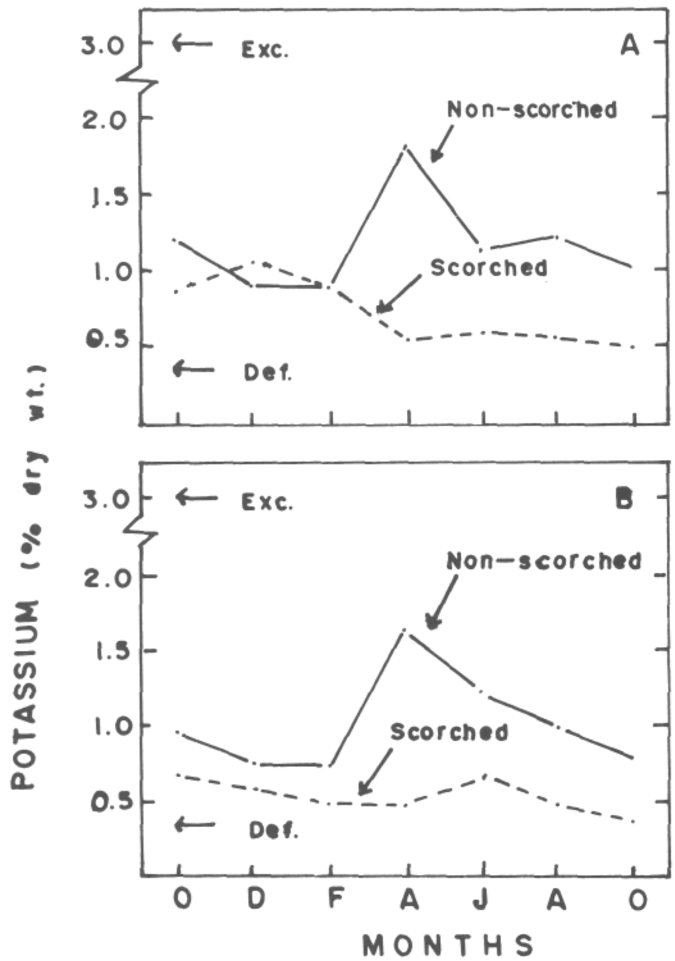

Fig. 2. *Potassium leaf concentration in mature leaves in seven sampling dates: (A) normal trees, and (B) with clear symptoms of salt stress. "Def." is the level reported as deficient for avocado.*

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