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IRRIGATION FREQUENCY AFFECTS SOIL SALINITY OF DRIP IRRIGATED AVOCADO

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Abstract
In the future the quality of the irrigation water in Israel will decrease and its salinity and SAR (Sodium Absorption Ratio) will increase. The effect of these changes on the soil and crops depends on the irrigation system design and on irrigation and leaching management. The steady state approach, where soil storage capacity is not considered, frequent irrigation and increased leaching is recommended. Increased water application increases the salt load and contamination of the ground water. Under the Mediterranean climate conditions typical of avocado growing areas in Israel, winter leaching causes large seasonal fluctuations in salinity. This depends largely on soil storage. Optimal irrigation will satisfy the crop water requirements and avoid damaging levels of chloride (Cl) and salinity with minimum deep percolation of salts that pollute the ground water. A study using avocado tested the effects of the size of the irrigation pulse volume and the irrigation frequency on soil salinity. The mean soil salinity at 60-cm depth was higher under daily than under "every other day" irrigation as a result of the more rapid increase in salinity with depth. The salinity, and thus also the leaching fraction (LF), at 60 cm were similar in the two frequencies. We recommend the *in situ* monitoring of soil salinity as a tool for managing the irrigation and leaching of avocado (Table 2).

Introduction
Continual replacement of the diverted fresh water from agriculture to priority consumers, with marginal water results in a gradual increase in the salinity of the aquifers. This will result in higher salinity and SAR for future irrigation water. Avocado orchards are planted over the main groundwater aquifers in Israel. The winter rainfall in the area (> 500 mm/year) leaches the entire root zone of soluble salts. The annual fluctuations in salinity depend on the salt input and the amount of leaching with irrigation water. The relative sensitivity to salinity and shallow roots allow for small storage capacity for water and salt in the root zone (Maas 1990). These capacities are affected strongly by the interactions between the patterns of the water distribution, the irrigation and leaching management and root growth. The salinity profiles depend on the volume ratios of the irrigation pulses to the root zone storage, and the fraction of deep seepage of water and salts. Reduced irrigation pulses, with the increase in irrigation frequency, accelerate the buildup of salinity and cause faster increase of salinity with depth (Bernstein and Francois 1973, Meiri 1994).

Materials and Methods
This paper presents soil solution results for the first two seasons of a study underway on avocado at Kibbutz Hama'pil located in the coastal plain of Israel using 'Ettinger' grafted on the salt tolerant rootstock VC51. The study compares irrigation every 24 or 48 hours through subsurface (20 cm deep) or surface drip systems in a design of 3 randomized blocks. The soil is sandy Hamra. Trees are spaced 6 x 6 m and each row is irrigated through 2 laterals lines located 0.5 m from both sides of the trunks. The emitters (2.3 l/h)

are spaced 1 m apart along each lateral. The annual applied water was 660 mm. The applied water ranged from 1.5 to 4 mm/day based on atmospheric demand. The water is slightly saline, with an EC of 1.4 dS/m, 6 meq/l Cl (210 ppm) and SAR of 3.9.

Soil solution salinity was determined using suction cup extracts at the 30- and 60-cm depth. Samples were taken 20 cm from an emitter under the south side of the canopy. Tensiometers and Neutron Probe Access Tubes (up to 150-cm depth) were used to determine the soil water content at a similar distance from the emitter.

It was assumed that during most of the summer the water and chloride in the suction cups positions were in steady state and the ratio of the Cl concentrations in the water and in the soil solution served to estimate the leaching fraction (LF – USSL 1956).

Results

Table 1 presents the effects of the factors; time in season, irrigation frequency and system position on the salinity of the soil solutions. The subsurface system was at the 20-cm depth, which was 10 cm above the upper suction cup. The soil salinity was higher on Julian Date 268 as compared to Julian Date 197. The small effect of the system position was the result of installing 3.5 l/h emitters on the north side of the trees and therefore applying 21% less water and nutrients on the side that had suction cups (south). This difference was corrected for the future. All the measured solutes show higher levels under daily than under "every other day" irrigation.

Table 1. Influence of time, system position and irrigation frequency on root zone salinity in avocado (means of 24 samples = 4 treatments x 3 replications x 2 depths).

		EC $dS\ m^{-1}$	Cl meq/l	Na meq/l
Julian Date	197	2.23	12.5	10.5
	268	2.98	15.8	14.2
System Position	Subsurface	2.45	13.4	11.5
	Surface	2.78	14.9	12.8
Irrigation Frequency	Every other day	2.23	12.5	10.5
	Daily	3.18	16.8	15.5

The Cl concentrations and the calculated LF at the two depths and the two frequencies (means for the two systems) showed a higher salinity at 60 cm as compared to the 30-cm depth (Table 2). There were large differences between frequencies at the 30-cm depth and small differences at the 60-cm depth. Such differences are expected for similar LF at the 60-cm depth with smaller irrigation pulses in the more frequent treatments. This can be seen from the chloride concentrations and the LFs, calculated as Cl_{ss}/Cl_i, towards the end of the season (Table 2). The large differences between frequencies only at 30 cm indicates similar water uptake to 60 cm in the two frequencies with very little or significant uptake from 30 to 60 cm under the daily and "every other day" irrigation treatments, respectively. The size of the water pulses is responsible for the level of leaching of the upper layers. The similar chloride concentration at both 30 and 60 cm depths under the daily irrigation treatment and 60-cm depth under the "every other day" treatment may indicate similar water demand under the two frequencies or that such salinity almost stopped water uptake by the tree. Individual samples with 1500 mg/l Cl at 60-cm depth show that avocado can concentrate the soil solution much above the 450 mg/l level. The increase in EC was slightly larger than the increase only from Cl (EC = 0.962 + 0.118 * me/l Cl, r^2 = 0.864).

Table 2. Irrigation frequency effects on chloride concentrations and Leaching Fractions at the 30 and 60 cm depth towards the end of the 1st irrigation season.

Depth	Leaching Fraction		Cl meq/l	
	Daily	Every other day	Daily	Every other day
30 cm	0.54	0.76	422	300
60 cm	0.51	0.48	447	475

Soil water contents were high throughout the season in all treatments with somewhat lower water content in the top layer in the subsurface irrigation as a result of limited upward movement. Below this layer all the treatments showed similar water content.

Conclusions

There was deep seepage below the wet volumes near the emitters. The calculated LF from the salinity data supports the conclusion that there was significant deep seepage in this study and there was no water deficit stress in this study. The mean salinity was higher with the more frequent irrigation treatments (daily) due to higher salinity of the upper layer under smaller irrigation pulses. Cl concentrations up to 1500 mg/l, about 15% LF, show that avocado can absorb water under such saline conditions.

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