EVALUATION OF SOIL SALINITY LEACHING REQUIREMENT GUIDELINES

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Workgroup that did the evaluation

ABSTRACT

Water for irrigation is a major limitation to agricultural production in many parts of the world. Use of waters with elevated levels of salinity is one likely option to meet the supply of increased demands. The sources of these waters include drainage water generated by irrigated agriculture, municipal wastewater, and poor quality groundwater. Soil salinity leaching requirements that were established several decades ago were based on steady-state conditions. Recently transient-state models have been developed that potentially can more correctly predict the dynamics of the chemical-physical-biological interactions in an agricultural system. The University of California Center for Water Resources appointed a workgroup to review the development of steady-state analyses and transient-state models and to determine whether the current recommended guidelines for leaching requirement based on steady-state analyses need to be revised. The workgroup concludes that the present guidelines overestimate the leaching requirement and the negative consequences of irrigating with saline waters. This error is particularly large at low leaching fractions.

LEACHING REQUIREMENT (LR) – The minimum leaching fraction (LF) that is required over a growing season for a particular water salinity (ECw) to achieve maximum yield of a given crop.

SALT TOLERANCE of a crop is related to Maas and Hoffman coefficient values (threshold ECe* and slope)

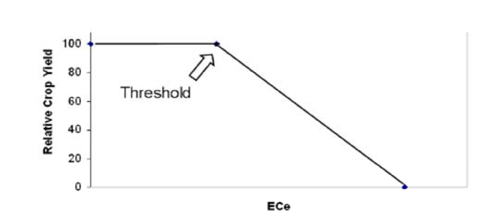
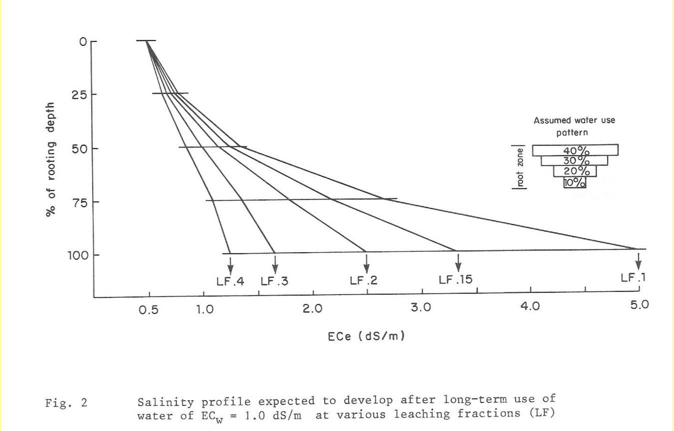
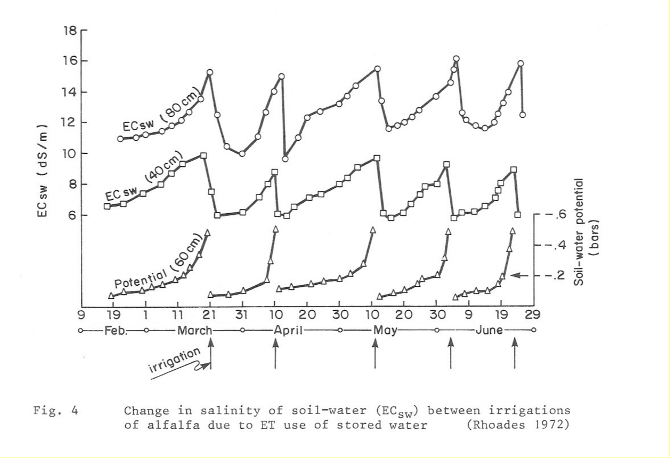


Figure 1. General relationship between relative crop yield and soil salinity.



(Ayers and Westcot, 1985)



Steady-state Calculated Distribution

Actual Field Distributions

Table 1
The average ECe/ECw as a function of the leaching fraction for four steady-state models for use in determining the leaching requirement. A&W refers to Ayers and Westcot (1985) and UC1 and UC2 refer to guidelines in Hanson et al.(2006)

LF	A & W	UC 1	UC 2	Eq. 1*
0.05	3.2	2.9	1.9	4.2
0.10	2.1	2.0	1.4	2.2
0.15	1.6			1.6
0.20	1.3	1.5	1.1	1.2
0.25	1.2			1.0
0.30	1.0	1.0	1.0	0.85
0.40	0.9	0.85	0.9	0.70
0.50	0.8	0.75	0.75	0.60

Table 2
Maximum ECw that would allow maximum yield of a crop with tolerance ECe* equal to 1.5 dS/m

LF	A & W	UC 1	UC 2	Eq. 1*
0.05	0.47	0.52	0.79	0.36
0.10	0.71	1.15	1.07	0.68
0.15	0.94	--	--	0.94
0.20	1.15	1.00	1.36	1.25
0.25	1.25	--	--	1.50
0.30	1.50	1.50	1.50	1.76
0.40	1.67	1.76	1.67	2.14
0.50	1.88	2.00	2.00	2.50

UC 2 guideline prescribes higher acceptable water salinity than the others. UC2 is based on high-frequency irrigation and a water-uptake weighted average root zone ECe, whereas the others are based on a linear average.

* Eq. 1 LR = ECw/(5ECe* - ECw)

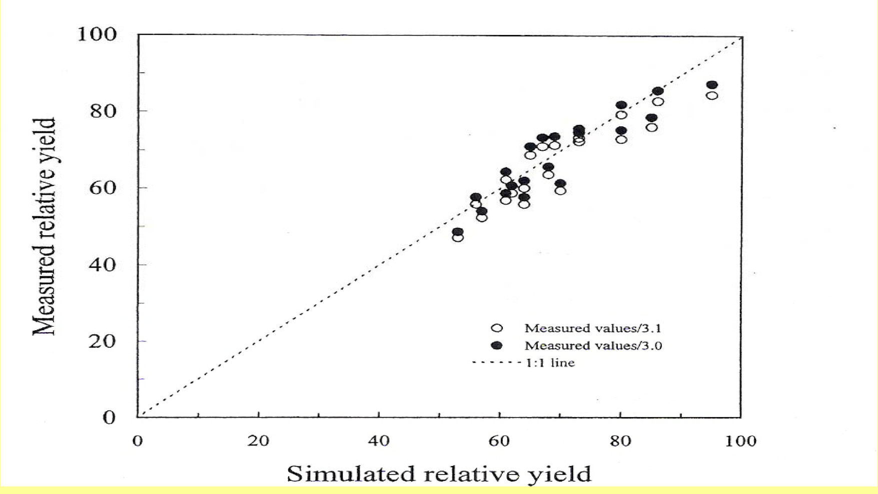
SHORTCOMINGS OF LEACHING REQUIREMENT CONCEPT

1. Maximum yield may not be the economically optimal yield.
2. Initial soil salinity levels are not considered.
3. Rainfall or other precipitation is not generally considered.
4. Irrigation scheduling is usually based on the desired ratio of applied water to potential ET and not LF.

TRANSIENT-STATE MODELS

Several transient-state models have been developed including ENVIRO-GRO, HYDRUS, SWAP, SALTMED, and UNSATCHEM.

ENVIRO-GRO (Pang and Letey, 1998) simulated results have been compared to an experiment in Israel on corn (Shalhevet et al., 1986) that included five irrigation water salinities ranging from 1.7 to 10.2 dS/m and four irrigation intervals ranging from 3.5 to 21 days (Feng et. al, 2003). The results are depicted in Figure 4.



The AW/PET value calculated with ENVIRO-GRO (E-G) and several steady-state models to achieve maximum corn yield when irrigating with water of 1 and 2 dS/m. A&W refers to Ayers and Westcot (1985), UC1 and UC2 refer to guidelines in Hanson et al. (2006), and E-G refers to ENVIRO-GRO (Pang and Letey, 1998).

ECw	A&W	UC1	UC2	Eq 1	E-G
1	1.19	1.19	1.11	1.15	<1.05
2	1.82	1.67	1.75	1.44	1.17

REASONS TRANSIENT-STATE SIMULATIONS RESULT IN LOWERIRRIGATION

1. Except for UC2 the steady-state approach assumes that the crop responds to the linear average root zone salinity that increase greatly as LF decreases, with the highest concentrations at the bottom of the root zone where roots are the sparsest.
2. Salt concentration at a given depth does not remain constant with time. Concentration increases as water is extracted, but water "flushes" the salts downward with each irrigation. The concentration immediately after irrigation near the soil surface would be close to the irrigation water salinity.
3. For most soils, the volumetric soil-water content would be reduced by less than half between irrigations; thus concentrating the soil-water salinity by less than two between irrigations.

CONCLUSION

The workgroup concludes that the present guidelines based on steady-sate analyses overestimate the leaching requirement and the negative consequences of irrigating with saline waters. However, soil salination is still a potentially very negative consequence of irrigation and cannot be ignored.

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