

SUPPLEMENTAL DATA, ETC. (From FAO-29)

1. Soil Salinity Affects Yield of Crop.

To calculate expected yield, Y, where soil salinity (ECe) is the most important factor affecting productivity:-

The Equation ($Y = 100 - b (ECe - a)$) relates the effect of soil salinity (ECe) which is expected upon yield of crop (Y), reduced by some amount that depends upon salt tolerance of crop expressed by a and b.

$$Y = 100 - b (ECe - a) \quad (1)$$

Y = percent relative yield of crop.

a = salinity threshold value for the crop, meaning maximum ECe at which 100% yield can be obtained (take from Tolerance Tables, column headed 0% expected yield reduction).

b = Percent reduction in yield per unit increase in soil salinity (ECe) above the threshold value (a).
Calculate from $b = \frac{100}{\frac{1}{2} \text{ Max ECdw} - a}$. Max ECdw is taken from right-hand column of UC-Crop Tolerance Tables opposite the crop in question (or Max ECe from FAO-29).

ECe = average salinity of root zone (determined from soil analysis).

Example: Crop = corn
a = 1.7 mmhos/cm
b = 12.05 percent (from $\frac{100}{\frac{1}{2} \text{ Max ECdw} - a} = \frac{100}{10 - 1.7} = 12.05\%$)

Question 1: What yield of corn should be expected if root zone is 4 feet and soil analysis indicates soil salinity to be

0-1 ft.,	ECe = 3.0 mmhos/cm
1-2 "	ECe = 4.5 "
2-3 "	ECe = 6.0 "
3-4 "	ECe = 8.0 "

Answer 1: Use equation (1),
a = 1.7 mmhos/cm; b = 12.05%; ECe = 5.4 mmhos/cm. (average)
 $Y = 100 - b (ECe - a)$
 $Y = 100 - 12.05 (5.4 - 1.7)$
Y = 55.42% yield

Question 2: What soil salinity would be expected to allow 90% yield of corn?

Answer 2: Equation (1) $Y = 100 - b(E_{ce} - a)$ can be solved for E_{ce} , $E_{ce} = \frac{100 + ab - Y}{b}$ (2)

From the question, crop = corn; yield = 90%

From Tolerance Tables, $a = 1.7$ mmhos/cm, $b = 12.05\%$

$$E_{ce} = \frac{100 + (1.7)(12.05) - 90}{12.05}$$

$E_{ce} = 2.53$ mmhos/cm

This says that with an average soil salinity in the root zone not exceeding $E_{ce} = 2.53$ mmhos/cm it should be possible to produce a corn yield near 90% of full potential.

2. Water Salinity Affects Yield of Crop.

To calculate expected yield, Y, where irrigation water of salinity, EC_w, is the most important factor affecting productivity.

Use equation (1): $Y = 100 - b(EC_e - a)$

Solve for equation 2, $EC_e = \frac{100 + ab - Y}{b}$

Substitute EC_w x 3/2 for EC_e, $\frac{3}{2} EC_w = \frac{100 + ab - Y}{b}$

(EC_e = $\frac{EC_w \times 3}{2}$ from assumptions of UC-Guidelines.) (3)

Solve for EC_w = $\left(\frac{100 + ab - Y}{b} \right) \times \frac{2}{3}$ (4)

Y = % yield expected

a = threshold value for EC_e which should allow 100% yield (tolerance tables, 0% expected yield reduction column)

b = yield reduction per unit increase in EC_e above the threshold value, a, calculated using $b = \frac{100}{\frac{\text{Max EC}_{dw}}{2} - a}$

or $b = \frac{100}{\text{Max EC}_e - a}$

EC_w = measured salinity of applied irrigation water (or weighted average of irrigation water, EC_w, and effective rainfall, where rainfall is EC_w = 0.1).

Example: Crop = corn

a = 1.7 mmhos/cm

b = 12.05% per unit EC_e from $b = \frac{100}{\text{Max EC}_e - a}$

Question: What water quality (EC_w) is needed for a 90% yield of corn using normal surface irrigation (furrow) methods.

Answer: Use equation (4), $EC_w = \left(\frac{100 + ab - Y}{b} \right) \times \frac{2}{3}$

$$EC_w = \left(\frac{100 + (1.7 \times 12.05) - 90}{12.05} \right) \times \frac{2}{3}$$

EC_w = 1.7 mmhos/cm is water quality needed for 90% yield.

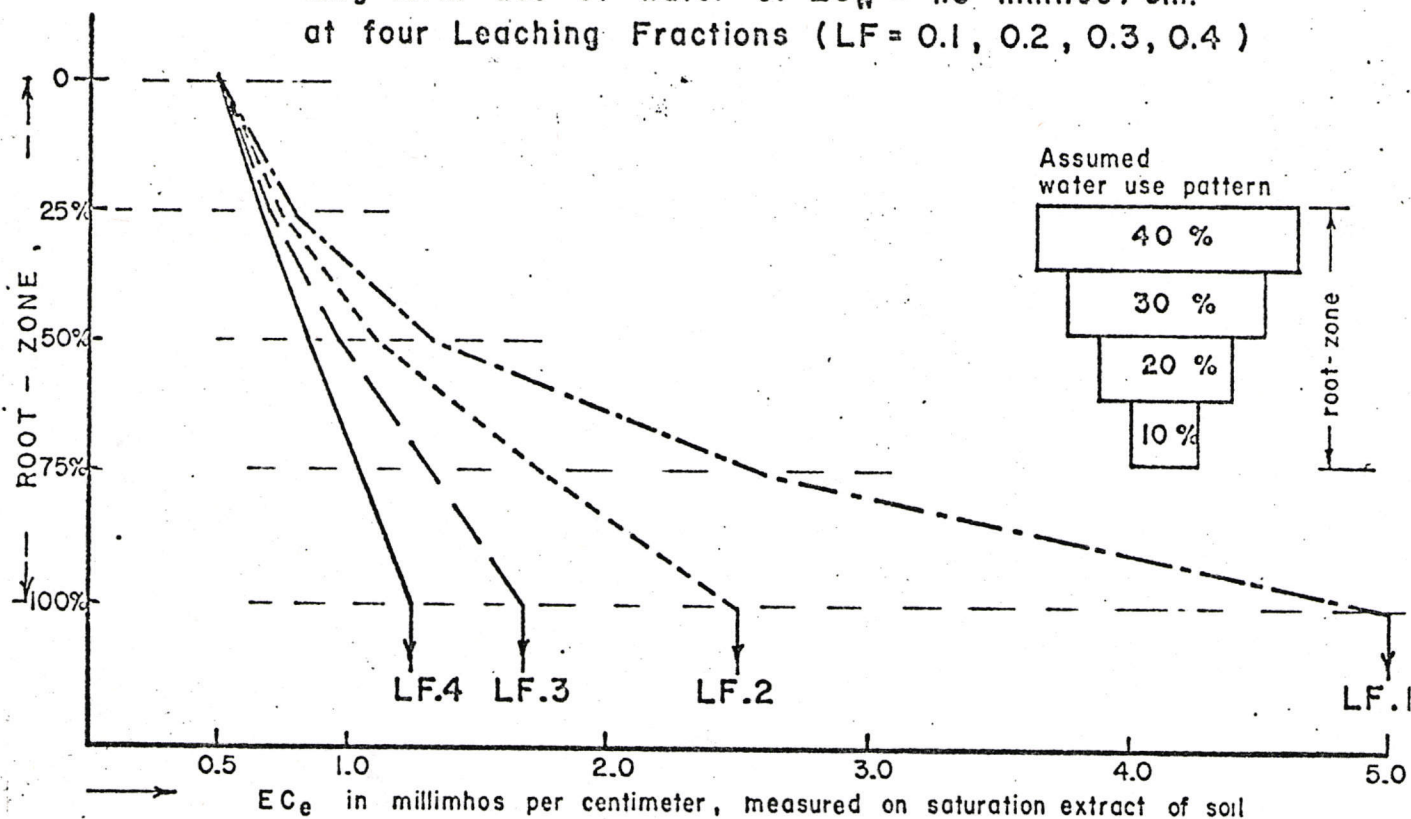
3. Estimating Actual Leaching Fraction (LF) from Field Soil Sample Data.

Salinity of soil profile determined by soil analysis often indicates effectiveness of past water management to control salinity and may give a rough but approximate effective leaching fraction that has been accomplished due to past management practices. The shape of the curve as in LF.1 as compared to LF.4 is the basis for this LF estimation procedure. (Fig. 7 below).

Upper root zone soil water availability (upper 50%) often controls crop performance. It is much easier to maintain low salinity of the upper root zone than of the lower root zone. Frequent irrigation can maintain low salinity and good soil water availability in the upper root area. An occasional leaching irrigation may be required to control salinity of lower root zone.

Fig. 7

SALINITY PROFILE. expected to develop after
long term use of water of $EC_w = 1.0$ mmhos/cm.
at four Leaching Fractions (LF = 0.1, 0.2, 0.3, 0.4)



LF means Leaching Fraction

Root Zone means Depth of Rooting

4. Leaching Requirement.

The Leaching Requirement refers to the percent of the applied irrigation water that must drain through and below the root zone to remove and control salts. Since the amount of this percolating water needed to control salt build-up depends upon both the salinity of the applied water and the salt tolerances of the crop to be grown, the Leaching Requirement (LR) equation can be written $LR = \frac{Ddw}{Dw}$ or simply $LR = \frac{ECw}{ECdw}$ where Ddw and ECdw refer respectively to depth or salinity of drainage water, and Dw and ECw refer to depth or salinity of the irrigation water.

Good water management includes both adequate irrigation to supply crop needs and adequate irrigation to include leaching needs for salt control. The management needed to assure fulfillment of the requirement for leaching (LR) will depend on the soil conditions and other characteristics of site, climate, and crop.

The Leaching Requirement (LR) is the fraction of the irrigation water that must be leached through the root zone to control soil salinity at any specified level.

LR is discussed and estimated in various ways but the same basic equation is used.

$$LR = \frac{ECw}{ECdw} \quad (5)$$

ECw = salinity of applied water.

ECdw = salinity of drainage water that can be tolerated by crop.

a) Old Procedure (USDA Handbook 60)

This is still a good LR to control salts. It may waste water.

$$LR = \frac{ECw}{ECdw}$$

ECw = EC of applied water

ECdw = ECe of saturation extract corresponding to ECe for 50% yield of crop.

b) Newer, "Minimum" Leaching Requirement (U.S. Salinity Laboratory)

$$LR = \frac{ECw}{ECdw}$$

ECw = EC of applied water

ECdw = maximum salinity of drainage water (Max ECdw of UC-Crop Tolerance Tables or 2 Max ECe of FAO-29 crop tolerance tables) that can be tolerated by crop.

Leaching Requirement (LR) obtained by this "minimum" LR procedure represents a near absolute minimum which may or may not be achievable. It gives a good indication of the essential minimum leaching necessary to control salts within crop requirements for an 85 to 100% yield potential. In UC-Crop Tolerance Tables, the column LR for each crop represents this "minimum" LR for the quality of water (ECw), and the listed crop with tolerance indicated in the column headed Max ECdw. In FAO-29 crop tolerance tables LR is not given but can be calculated using values for ECw and 2 Max ECe from the column headed Max ECe.

$$LR = \frac{ECw}{2 \text{ Max ECe}}$$

c) FAO-29 procedure (J.R. Rhoades, U.S. Salinity Laboratory Staff).

$$LR = \frac{ECw}{5ECe - ECw} \quad (6)$$

ECw = EC of applied water.

ECe = salt tolerance of crop from crop tolerance tables for whatever yield loss that may be acceptable (0-10-25-50%).

This equation allows a direct calculation of the leaching requirement (LR) for a given crop with tolerance ECe and irrigation water of quality, ECw. (ECe for appropriate yield.)

Using this equation and substituting ECw and ECe values for various crops from the crop tolerance tables in the equation 6, it is readily apparent that the relationship of soil salinity (ECe) resulting from use of irrigation water of quality ECw, will be valid only for water management resulting in a leaching fraction (LF or LR) equal to 15% (LF = 15%). This is considered the average or normal water management as far as these crop tolerance tables and the UC-Guidelines are concerned.

It follows that if "normal" management is appreciably different and accomplishes more or less leaching than 15%, the ECe to ECw relationship, too, must change and a new set of ECe to ECw estimates must be considered. For general field estimates and planning the 15% LF seems appropriate and the relationship $ECw \times 3 = ECsw$ or $ECw \times 3/2 = ECe$ is satisfactory. (ECsw means EC of soil water.)

If a 30% LF, or any other, were achieved by management, the relationship ECw to ECe would be different and could be determined from the same equation, but rearranged to solve for ECw

$$ECw = \frac{LF(5ECe)}{1 + LF} \quad (7)$$

For example, if LF= .30, and ECe for 100% yield of corn is ECe= 1.7 mmhos/cm, the ECw that should result in this soil salinity can be calculated as follows:

$$ECw = \frac{.30 (5 \times 1.7)}{1 + .30} = 1.96 \text{ mmho/cm}$$

Crop tolerance table values for soil salinity, ECe, and drainage water, Max ECdw, would remain the same and not change since ECe is the "hard" value. The ECw, however, associated with the specific soil salinity ECe would change due to the changed leaching fraction (LF). Calculated "minimum" LR values would change due to the change in ECw.

5. Drip Irrigation.

These crop tolerance tables and water quality guidelines are applicable to surface irrigation. They are not directly applicable to DRIP IRRIGATION. Nor are they directly applicable to sub-irrigation.

Research is in progress on evaluating drip irrigation and salinity effects and it indicates that a specific crop can usually tolerate higher salinity of irrigation water if irrigated by drip (trickle) systems than by other systems assuming crop ET is adequately supplied in each case.

Research has not yet progressed to the point to say how much higher salinity can be tolerated or to allow preparation of tolerance tables or methods of salinity evaluation under drip that will allow preparation of reliable tolerance tables to predict crop responses.

On sub-irrigation, the crop tolerance table, ECe values are applicable. The ECw values associated with the ECe will not directly apply. Appreciably lower ECw than indicated would probably be required to be consistent with resulting indicated ECe.