drought tips

Number 92-16

Leaching

Leaching is applying irrigation water in excess of the soil moisture depletion level to remove salts in the root zone. The excess water flows down through the root zone, carrying salts with it.

This excess water, expressed as a percent of the applied irrigation water, is the leaching fraction. Effective salinity control means ensuring that the leaching fraction is large enough to prevent excessive salt accumulation in the root zone.

The actual leaching fraction is the percent of the applied irrigation water (minus any surface runoff) that drains below the root zone. It is defined as:

$$\frac{LF = (100)\ D_d}{D_a}$$

where LF = leaching fraction (%),
D_d = amount of water draining below the root zone, and
D_a = amount of applied irrigation minus surface runoff.

Because measuring the actual amount of drainage water is impractical, techniques have been developed to relate the leaching fraction to the average root zone soil salinity and to the salinity of the irrigation water.

The following procedure can be used to estimate the leaching fraction:

1. Obtain soil samples from within the root zone. Each sample should represent equal depth intervals.

2. Measure the electrical conductivity (ECe) of the saturated extract of the soil samples (part of the laboratory analysis).

3. Measure the electrical conductivity (ECi) of the irrigation water.

4. Calculate the average root zone salinity by summing the values of each depth increment and dividing by the number of increments.

5. Use figure 1 to estimate the leaching fraction. Draw a horizontal line through the value of ECe and draw a vertical line through the value of ECi. The intercept of these lines is the leaching fraction. Estimate the leaching fraction from the values assigned to the diagonal lines nearest the intercept point.

Example: What is the leaching fraction for the following root zone salinity when the EC of the irrigation water is 1 dS/m?

Depth interval (feet)	ECe (dS/m)
0-1	1.0
1-2	3.6
2-3	6.2
3-4	9.4

The average root zone salinity is (1.0 + 3.6 + 6.2 + 9.4) / 4 = 5.0. From figure 1, for an ECe = 5.0 dS/m and an ECi = 1.0 dS/m, the leaching fraction is about 4%.

In this example, soil salinity increased as the depth of the root zone increased. If, however, soil salinity is highest near the surface and is relatively constant or decreases with depth, the above procedure will not apply. In that case, the leaching fraction would be zero, regardless of soil salinity levels.

Estimating the Leaching Fraction Needed to Prevent Yield Loss

The leaching requirement is the leaching fraction (the amount of excess water) needed to keep the root zone salinity levels within that tolerated by the crop. This requirement depends on the crop's tolerance to salinity and on the salinity of the irrigation water.

The procedure for estimating the leaching requirement is as follows:

1. Determine the threshold value salinity (ECt) for the crop. The threshold value salinity is the maximum soil salinity tolerated by the crop without any yield reduction. These tolerance levels are given in the ***drought tips*** 92-17 (Water Quality Guidelines for Vegetable and Row Crops), ***drought tips*** 92-18 (Water Quality Guidelines for Field and Forage

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Crops), and ***drought tips*** 92-19 (Water Quality Guidelines for Trees and Vines).

2. Determine the electrical conductivity (ECi) of the irrigation water.

3. Use figure 1 to estimate the leaching requirement. First, select the appropriate ECT value (the maximum salinity the crop can tolerate) from the tables in ***drought tips*** 92-17 (Water Quality Guidelines for Vegetable and Row Crops), ***drought tips*** 92-18 (Water Quality Guidelines for Field and Forage Crops), or ***drought tips*** 92-19 (Water Quality Guidelines for Trees and Vines).

Using figure 1, draw a horizontal line from the selected ECt value (shown along the left side of the figure as mean root zone salinity), and a vertical line through the appropriate ECi value (shown along the bottom of the figure as salinity of applied water). The point at which the two lines intersect is the estimated leaching requirement.

Example: What is the leaching requirement for cotton irrigated with water having an ECi of 2 dS/m?

Cotton will tolerate a maximum root zone salinity of 7.7 with no yield reduction (from the leaflet "Crop Salt Tolerance"). For an ECt = 7.7 dS/m and an ECi = 2 dS/m, the leaching requirement is about 5 percent (from figure 2). If the leaching fraction is larger than the leaching requirement, salinity control should be adequate. But if the leaching fraction is less than the leaching requirement, the soil salinity may increase to levels greater than what the crop can tolerate without a reduction in yield.

Leaching Requirements of the San Joaquin Valley

Leaching requirements for areas of the San Joaquin Valley where saline shallow water tables are not present have been estimated using the procedure outlined above. In these areas, the EC of the irrigation water may be between 0.3 dS/m and 0.5 dS/m. Because of the low-salinity irrigation water, leaching requirements are very low. Table 1 lists leaching requirements for some San Joaquin Valley crops.

Crop	Leaching Requirement (%)
Almonds	6
Barley	1
Beans	10
Canteloupe	5
Corn	5
Cotton	2
Lettuce	8

Table 1. Leaching requirements for some San Joaquin Valley Crops (ECi= 0.5 dS/m)

Attainable Leaching Practices

The actual leaching fraction at any location in a field partially depends on the uniformity of applied water. Uniformity is defined as the evenness of the applied water. If the same depth of water is applied everywhere in the field, the uniformity is 100 percent. However, since no irrigation system is capable of a 100-percent uniformity, different parts of the field will always receive different amounts of water. The more nonuniform the water application, the greater the differences in the amount of water received and the higher the average leaching fraction.

Table 2 lists average leaching fractions for various distribution uniformities (the distribution uniformity is an index used to quantify the uniformity of applied water) needed to maintain a 5-percent leaching fraction in the least-watered areas of the field.

Distribution Uniformity (DU)%	Average Leaching Praction (LF) %
75	37
83	26
95	14

Table 2. Average leaching fractions needed to maintain at least a 5-percent leaching fraction throughout the field.

percent to 75 percent under low wind conditions. For these systems, nearly 37 percent more water in excess of the soil moisture depletion is needed to maintain at least a 5-percent leaching fraction. The average leaching fraction maybe reduced to 26 percent for linear-move sprinkler machines or for low-energy precise application (LEPA) machines, which have measured DU's of between 80 percent and 85 percent.

Theoretically, trickle irrigation systems can have a DU of nearly 95 percent, although most measured DU's have been 80 percent to 90 percent. Even if the DU is 95 percent, 14 percent of the applied water will be subsurface drainage.

This analysis shows that applying irrigation water to obtain a very small leaching fraction throughout a field is not possible if adequate leaching is to occur, even with very high uniformities. Very low leaching fractions are attainable only by deficit-irrigating part of the field. If the average leaching fraction of the low quarter is 5 percent, for a DU = 75 percent, the field-averaged leaching fraction would be about 30 percent. Areas deficit-irrigated, however, receive no leaching fraction, and therefore salinity problems may occur over the long term. This would be particularly serious under surface irrigation and trickle irrigation, where patterns of variability of applied water are consistent from irrigation to irrigation. It may be less serious under sprinklers, where a more random pattern can occur.

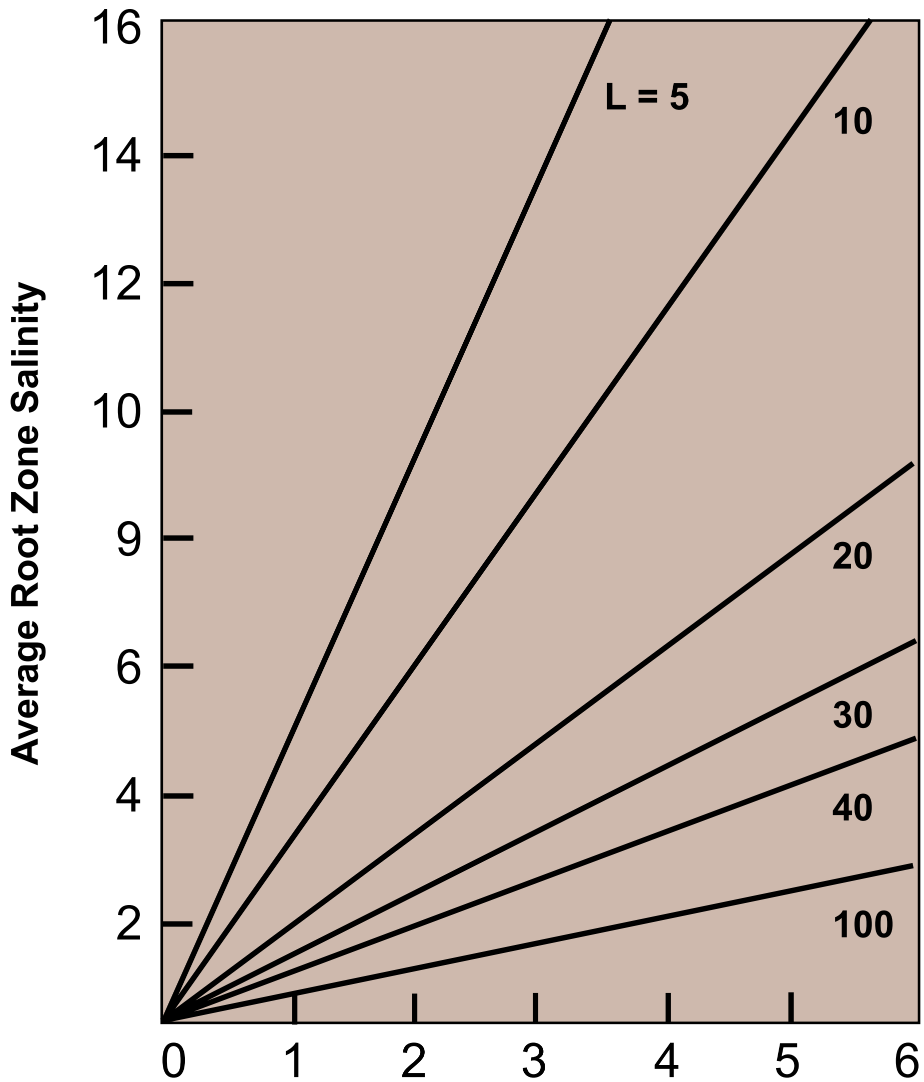

Figure 1. Salinity of Applied Water, dS/m

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