T E C H N I C A L N O T E S
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

AGRONOMY NOTE NO. 57 - Arizona January 1975

LEACHING NEEDS IN IRRIGATION WATER MANAGEMENT

Recent research findings show there is a significant reduction in amounts of water formerly believed necessary for the leaching needs.

The attached leaching recommendations give leaching needs for different amounts of salinity in irrigation water and shows salt tolerances of common crops grown in Arizona.

LEACHING RECOMMENDATIONS FOR JOINT USE BY SOIL CONSERVATION SERVICE AND THE UNIVERSITY OF ARIZONA

Variable amounts of salt are present in most Arizona soils. Also, most irrigation water contains an appreciable amount of salt. During irrigation, both salt and water are stored in the soil; plants remove the water but the salts may accumulate in the root zone causing a decrease in plant growth. Leaching is the process of washing salts downward so they do not accumulate in harmful amounts in the rooting zone.

The leaching requirement is the fraction of the water applied which must move out of the root zone as drainage water in order to maintain salinity in the root zone less than a specified concentration. Leaching requirement varies directly with the salinity of the applied water and inversely with crop tolerance to salt.

Recent research at the U.S. Salinity Laboratory has helped clarify the response of plants to saline soil solutions and the depth of drainage water required. Plants can tolerate higher salinity concentrations than previously thought, without a significant yield reduction. The attached graph (based on calculations in Appendix B) shows values of leaching coefficients for several field, forage, and vegetable crops. The leaching coefficient is the ratio of the drainage water required to the consumptive use, whereas the leaching requirement is the ratio of drainage water required to the total amount

(consumptive use plus drainage water). Multiply the leaching coefficient times consumptive use to obtain the depth of drainage water needed. For example, the graph shows a leaching coefficient for cotton, with 2200 ppm irrigation water, of 0.093. If the annual consumptive use of cotton is 41 inches, the depth of drainage water required is 0.093 times 41 or 3.8 inches.

The attached table lists drainage water requirements in Central Arizona for a range of irrigation water salinities and crops. The tabulated values are intended as guidelines; the assumptions on which the calculations are based become less valid as salinity increases. Also, in many cases, the amounts of water are small in comparison to the uniformity with which leaching water can be applied with many irrigation systems.

The calculated values of leaching coefficients and drainage water are useful for planning, for comparison with previously accepted values, and as general guidelines. For actual salinity management, however, monitoring soil salinity with laboratory analyses is more useful. Substantial evidence indicates that plants respond primarily to the salinity in the least saline half of the root zone. Salinity varies with depth; usually the salinity increases with greater depths but not always. At least two soil samples should be taken, each representing half the rooting zone. Avoid surface crusts and the peaks of beds where salts accumulate.

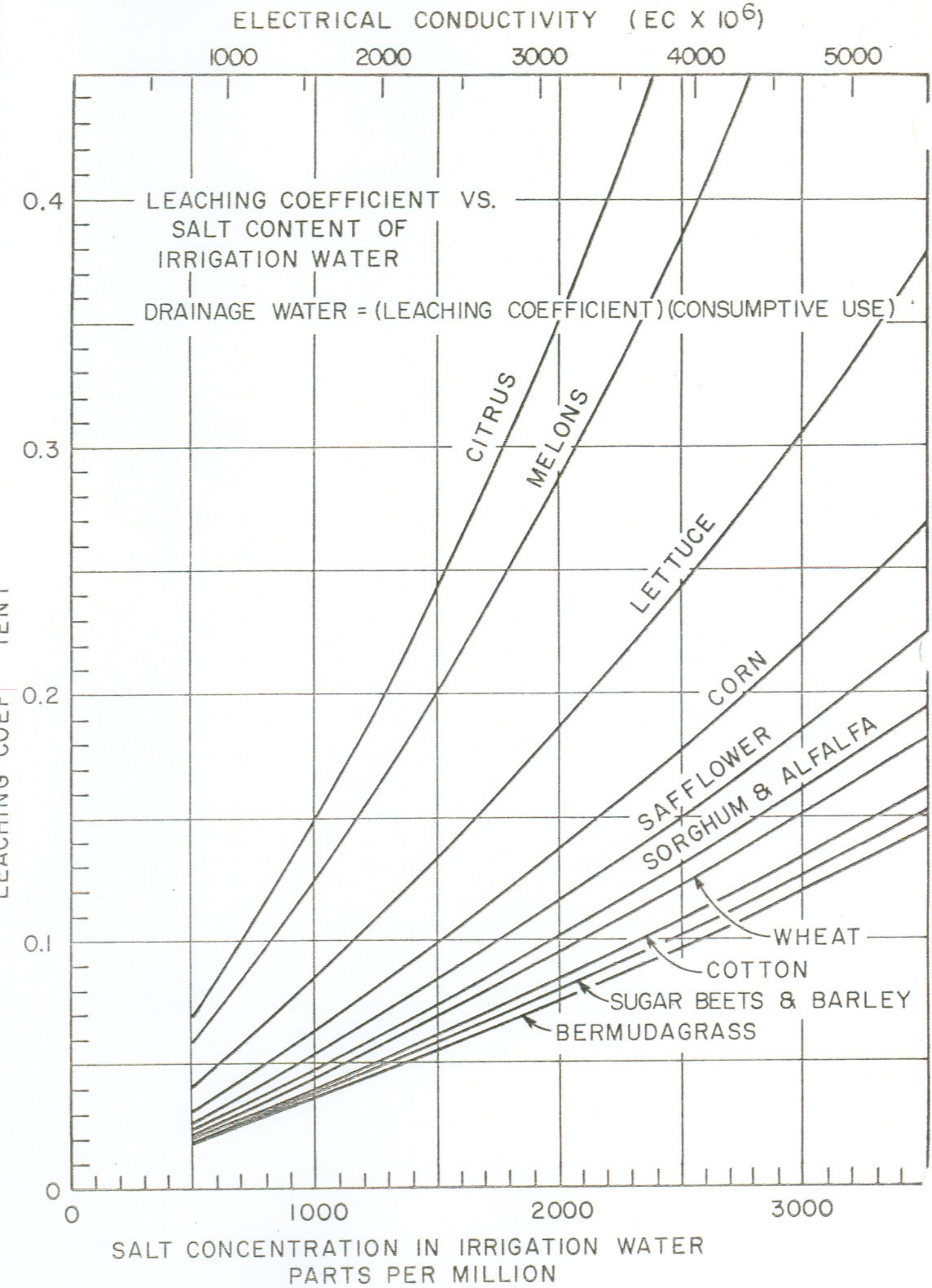
Salt tolerance of field, forage, vegetable, and fruit crops, as well as ornamentals, is shown in Appendix A. If the lowest

salinity observed exceeds the values listed, additional water for leaching should be applied. With this procedure, the leaching is accomplished when needed rather than with each irrigation. Water is wasted when excess is applied with each irrigation.

When changing from a salt tolerant to a sensitive crop in a rotation, additional leaching water may be needed. A useful guide is that 6 inches of water per foot of soil depth will reduce the salinity 50 percent; 12 inches per foot of soil depth will reduce the salinity approximately 80 percent.

Leaching can be accomplished with either sprinkler or surface irrigation. A low application rate with sprinklers provides the most leaching per unit of water. Leaching can be accomplished with border or furrow irrigation if sufficient water penetration can be achieved without excessive run-off. Salt will concentrate in beds with furrow irrigations. Alternate ponding and drying in level basins may be necessary to reduce high salt concentrations.

Soils which have become sealed due to a sodium accumulation must be treated chemically before salts can be leached satisfactorily.


ELECTRICAL CONDUCTIVITY (EC X 10^6)
1000
2000
3000
4000
5000
LEACHING COEFFICIENT VS.
SALT CONTENT OF
IRRIGATION WATER
DRAINAGE WATER = (LEACHING COEFFICIENT)(CONSUMPTIVE USE)
CITRUS
MELONS
LETTUCE
CORN
SAFFLOWER
SORGHUM & ALFALFA
WHEAT
COTTON
SUGAR BEETS & BARLEY
BERMUDAGRASS
0.4
0.3
0.2
0.1
0
0
1000
2000
3000
SALT CONCENTRATION IN IRRIGATION WATER
PARTS PER MILLION

Drainage Water Needed for Leaching in Central Arizona[a]

Crop	Annual Cons.b Use	Salinity of Irrigation Water parts per million or milligrams per liter						
		500	1000	1500	2000	2500	3000	3500
	Inches- - - - - - - - - -	-inches- - - - - - - - -						
Alfalfa	74	1.8	3.6	5.5	7.5	9.6	11.8	14.2
Barley	25	0.5	1.0	1.5	2.0	2.6	3.1	3.8
Bermuda-grass	44	0.8	1.6	2.5	3.3	4.3	5.2	6.3
Citrus	48	3.4	7.2	11.7	16.9	-	-	-
Cotton	41	0.8	1.6	2.5	3.4	4.4	5.4	6.6
Lettuce	9	0.4	0.8	1.2	1.7	2.2	2.7	3.4
Melons	19	1.1	2.4	3.8	5.5	7.4	-	-
Safflower	45	1.2	2.5	3.8	5.2	6.8	8.3	10.0
Sorghum (Grain)	25	0.6	1.2	1.9	2.6	3.3	4.0	4.8
Sugar Beets	43	0.8	1.6	2.5	3.4	4.4	5.4	6.6
Wheat	23	0.5	1.0	1.6	2.2	2.8	3.5	4.2

[a]Values will be different for other elevations and climatic regions.

[b]Based on Technical Bulletin 169, "Consumptive Use of Water by Crops in Arizona," Agricultural Experiment Station, The University of Arizona, 1968.

Appendix A

Salt Tolerance of Crops*

Crop	Electrical Conductivity of saturation extract (EC_e) at which yields decrease by about 10 percent (mmhos/cm @ 25°C)
Field Crops	
Barley	12
Sugarbeets	10
Cotton	10
Safflower	7
Wheat	7
Sorghum	6
Soybean	5
Corn	5
Sesbania	4
Beans	2
Forage Crops	
Bermuda grass	13
Tall wheatgrass	11
Barley hay	8
Tall fescue	7
Crested wheatgrass	6
Birdsfoot trefoil	6
Alfalfa	3
Orchardgrass	2
Clovers, alsike and red	2
Vegetable Crops	
Beets	8
Spinach	6
Tomato	4
Broccoli	4
Muskmellon	4
Cabbage	3
Potato	3
Corn	3
Sweet potato	3
Lettuce	2
Bell Pepper	2
Onion	2
Carrot	1
Beans	1

*Adapted from Chapter 4, Section 16, Drainage of Agricultural Lands, Soil Conservation Service National Engineering Handbook.

Appendix A Continued

Salt Tolerance of Fruit Crops*

Crop	Electrical conductivity of saturation extract (EC_e) at which yields decrease by about 10 percent. mmhos per centimeter at 25 C
Date palm	8
Pomegranate Fig Olive	4 - 6[2]
Grape	4
Orange, grapefruit, lemon[3]	3 - 2.5
Apple, pear	2.5
Plum, prune, peach, apricot almond	2.5
Boysenberry, blackberry raspberry	2.5 - 1.5
Avocado	2
Strawberry	1.5

[1] In gypsiferous soils, EC_e readings for given soil salinities are about 2 millimhos per centimeter higher than for non-gypsiferous soils. Date palm would be affected at 10 millimhos per centimeter, grapes at 6 millimhos per centimeter, etc., on gypsiferous soils.

[2] Estimate

[3] Lemon is more sensitive than orange and grapefruit; raspberry is more sensitive than boysenberry and blackberry.

* Adapted from Agriculture Information Bulletin No. 292, United States Department of Agriculture, 1965.

Appendix A Continued

Relative Salt Tolerance of Ornamental Shrubs and Ground Covers

Plant	Electrical Conductivity of saturation extract (EC_e) at which plants show effects of salinity. (mmhos/cm@ 25 C)
Bougainvillea	11
Natal Plum	10
Rosemary	9
Euonymus	9
Dracaena	7
Oleander	7
Bottle Brush	6
Juniper	6
Pyracantha	6
Silverberry	6
Arborvitae	5
Dodonea	5
Xylosma	4
Boxwood	4
Lantana	4
Texas Privet	4
Viburnum	4
Hibiscus	3
Heavenly Bamboo	3
Pittosporum	3
Algerian Ivy	3
Rose	3
Burford Holly	3
Pineapple Guava	3
Star Jasmine	3

Adapted from "Salt Tolerance of Ornamental Shrubs and Ground Covers" by L. Bernstein, L. E. Francois, and R. A. Clark, Journal of Am. Soc. Hort. Sci. 97(4), 1972.

Appendix B

Calculation of Leaching Coefficient

I. Salt balance in soil solution

Salt in = Salt out

$D_{iw} C_{iw} = D_{dw} C_{dw}$ (neglecting salt precipitation in the soil) in which: D_{iw} is depth of irrigation water applied,

D_{dw} is depth of drainage water leaving root zone,

C_{iw} is salt concentration of irrigation water, and

C_{dw} is salt concentration of drainage water.

Assume $C_{iw} = k\ EC_{iw}$ and

$C_{dw} = k\ EC_{dw}$

in which: k is a constant,

EC_{iw} is electrical conductivity of the irrigation water, and

EC_{dw} is electrical conductivity of the drainage water.

$$D_{iw}\ EC_{iw} = D_{dw}\ EC_{dw}$$

II. Depth of drainage water

$$\frac{D_{dw}}{D_{iw}} = LR = \frac{EC_{iw}}{EC_{dw}}$$