IRRIGATION WATER QUALITY AND QUANTITY

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Several standards have been proposed for evaluating the quality of irrigation water; the most widely used criteria are those established by the U. S. Salinity Laboratory several years ago (1). While these standards serve as general guides, their interpretation in any particular case is dependent upon knowledge of the characteristics of the soils upon which they are to be used, the quantity of water available, presence or absence of an adequate drainage system, the crops to be grown, and other factors. Since these factors cannot be incorporated into a single set of standards, the water quality criteria presented in Table 1 represent maximum limits of salt, sodium, and boron that permit unrestricted use of an irrigation water for most soils and crops. When these limits are exceeded, restrictions on use of the water are indicated and the other factors mentioned previously must be considered. The restrictions increase as the water quality becomes poorer, until finally the water may be unsuitable for any economic use. As research on the use of saline waters continues, the upper limit for usable waters continues to be raised, until now even brackish water can be used on highly permeable, well drained soils when a salt tolerant crop is grown and when proper water management is used. The experiment conducted by the New Mexico State University Department of Agricultural Engineering on the White Sands Missile Range demonstrate this with irrigation water having an electrical conductivity of 15,000 micromhos (EC x 10^6).

The salt and sodium hazards present in irrigation waters in the major irrigated areas of New Mexico are shown in Figure 1. As far as we know, we do not have a boron problem in the state although boron in the soil may be moderately high in places along the Rio Grande where the soil is highly saline. Irrigation waters in the High Plains, except for some in the Portales Valley, are of good quality, as are those in the mountains. The San Juan River and its principal tributaries have good quality water, but soils derived from marine shales in the San Juan area may be saline.

Water quality generally deteriorates along a river as water is diverted for irrigation and more saline drainage water returns to the river. Figure 2 shows the decrease in quality of Rio Grande water from Otowi Bridge, above Albuquerque, to El Paso Dam for the year 1963 (2). From Leasburg Dam, at the northern end of the Mesilla Valley, to El Paso Dam, at the southern end, the water changed from being borderline to questionable in salinity. Fortunately, most of the crops grown in the Mesilla

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Table 1. Standards for Irrigation Water Quality

Hazard	Satisfactory Water
Salinity	less than 750 EC x 10^6 (1) less than 500 ppm (2)
Sodium	less than 10 SAR (3) less than 1 me/l RSC (4)
Boron	less than 0.3 ppm (2)

(1) EC x 10^6 = electrical conductivity (mhos) x 10^6 = micromhos.

(2) ppm = parts per million.

(3) SAR = Sodium-adsorption-ratio = $\frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$

Ion concentrations are in Me/l

(4) RSC = Residual sodium carbonate = $(CO_3+HCO_3)-(Ca+Mg)$

Ion concentrations are in Me/l

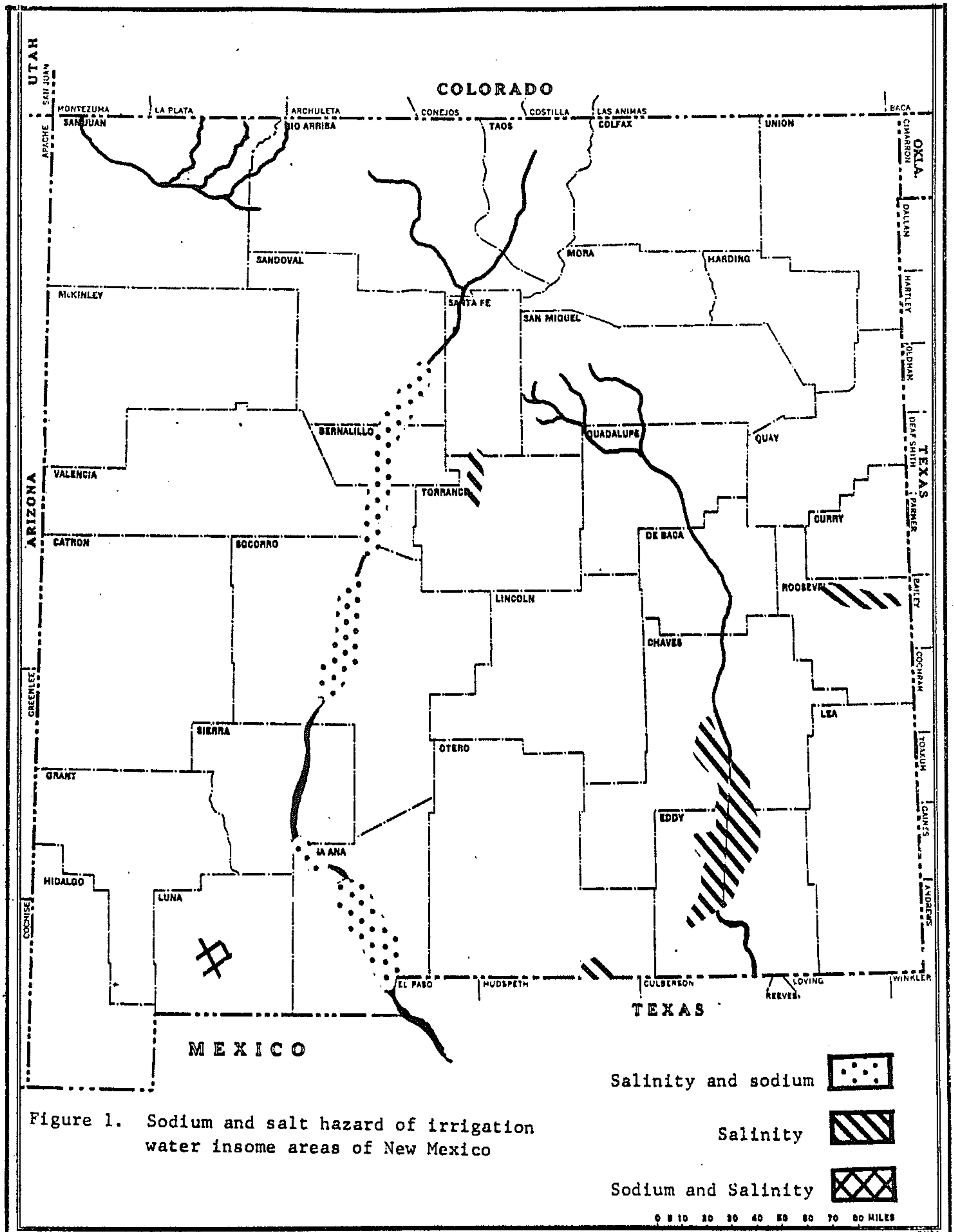

Figure 1. Sodium and salt hazard of irrigation water insome areas of New Mexico

Figure 2. Change in quality of water with location on Rio Grande, 1963

Location:	Otowi Bridge	San Marcial	Elephant Butte	Caballo Dam	Leasburg Dam	El Paso Dam
EC x 10^6:	367	705	630	692	800	1,322
SAR:	0.8	2.0	1.9	2.1	2.3	4.1

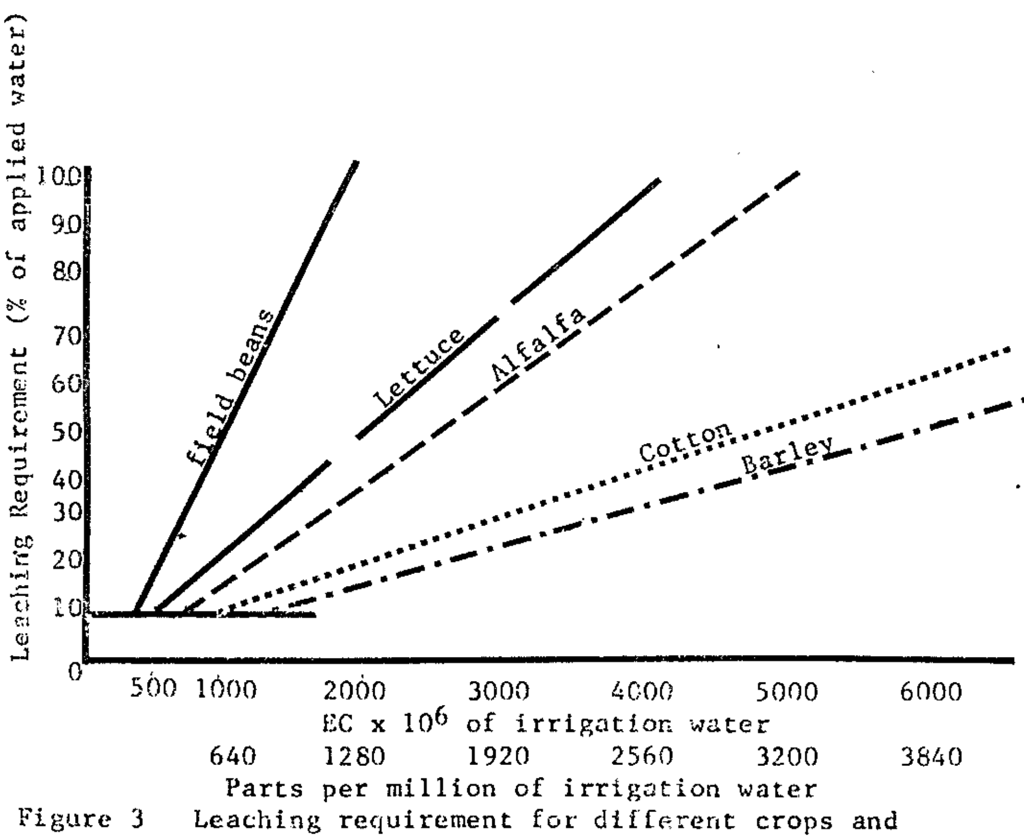

Figure 3 Leaching requirement for different crops and irrigation waters.

Valley are at least moderately salt tolerant, but salt accumulations have caused some fine textured soils to be abandoned. The sodium hazard also increases along the river, but is less of a threat than salinity. Similar deteriorations in quality occur along the Pecos and San Juan Rivers, from the standpoint of salinity.

Two factors of importance in using irrigation water that exceeds the salinity limit for unrestricted use are considered in Figure 3: leaching requirement and salt tolerance. When a water has an electrical conductivity of about 1,500 millimhos, a farmer has two major choices to make:

1. He can grow a salt tolerant crop like barley or cotton and irrigate as usual, or

2. He can grow a salt sensitive crop like beans and make frequent heavy irrigations.

The second choice means that much of the applied water will be wasted in the drainage system, making for a low water use efficiency. Leaching requirement refers to the fraction of the applied irrigation water that must be leached through the soil in order to maintain soil salinity at some given level. It is calculated from the formula:

$$\text{Leaching requirement} = \frac{ECiw}{ECdw} \times 100$$

where ECiw is the electrical conductivity of the irrigation water and ECdw is the maximum permissible electrical conductivity of the water that passes through the root zone as drainage water. ECdw depends upon the salt tolerance of the crop and is about 2,000 micromhos (2 millimhos) for beans, 6,000 micromhos for alfalfa, and 10,000 micromhos for cotton. The leaching requirement, then of an irrigation water having an electrical conductivity of 1,500 millimhos would be about 75 if beans were grown, 25 if alfalfa were the crop, and 15 if the crop were cotton. This means that, for beans, 75 percent of the applied irrigation water should be leached through the soil at each irrigation in order to keep the salt level in the soil low enough for good yields to be obtained. Similarly, 25 percent of the water must be leached through the soil for alfalfa and 15 percent for cotton. As the salinity of the irrigation increases, the leaching requirement increases for any one crop. If the water had 2,000 micromhos electrical conductivity, its leaching requirement when growing beans would be 100, meaning that all of the applied water should be leaching water. Obviously, the efficiency of water use goes down as the leaching requirement goes up. This is why the observation is made that conservation of water is not compatible with using saline water for irrigation. On the graph, the horizontal line at a leaching requirement of 10 is intended to indicate that normal irrigation leads to at least that much leaching.

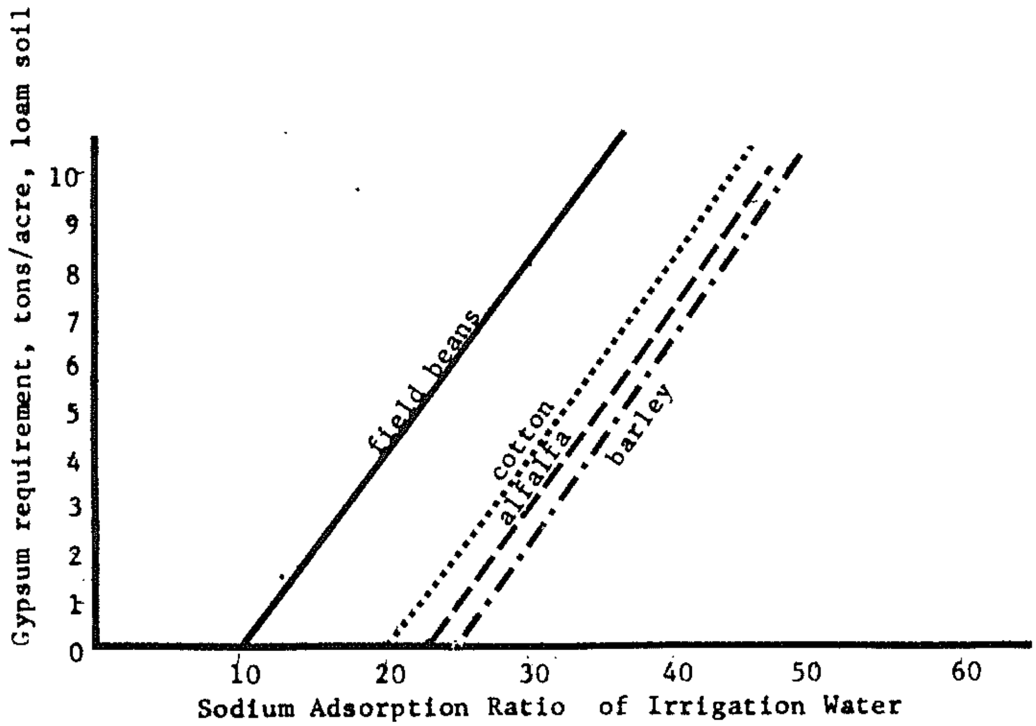

Figure 4 Gypsum requirement for different crops and irrigation waters

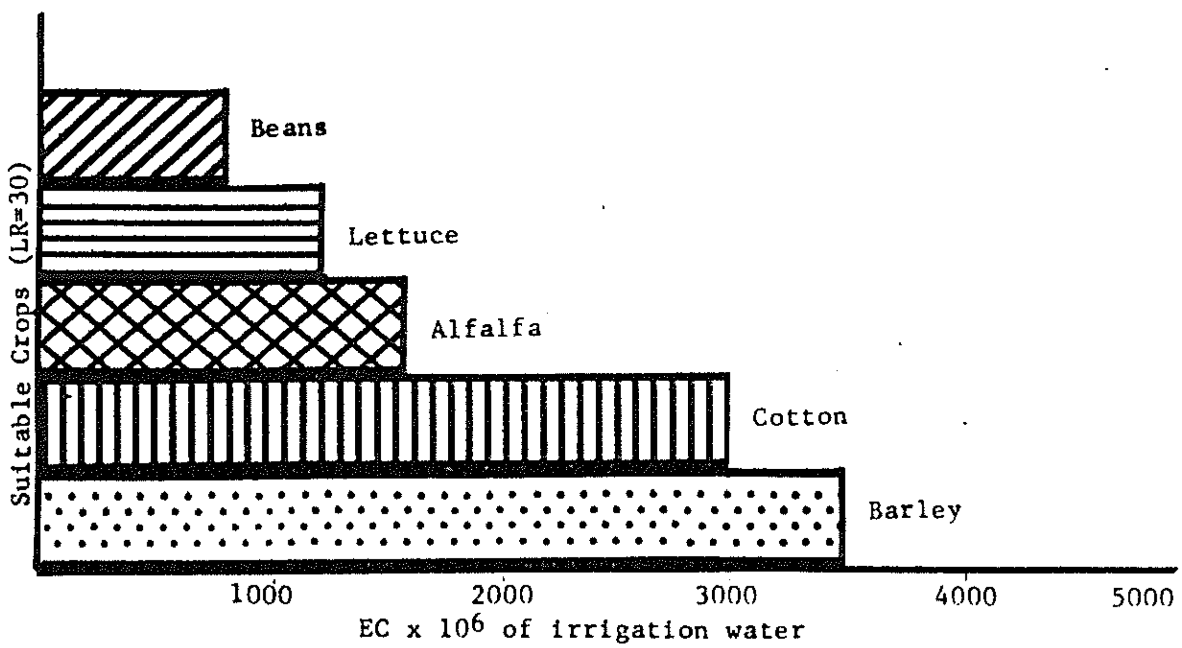

Figure 5 Choice of crops for irrigation waters of varying salinity; leaching requirement not to exceed 30.

A somewhat similar approach to using irrigation water with excess sodium is shown in Figure 4. Here the sodium hazard of the water (sodium-adsorption-ratio) is the problem and choice of crop or gypsum applications represent ways to minimize the sodium hazard. It is apparent that sodium sensitive beans would be an expensive crop to grow in a case where the water had a sodium adsorption ratio of 25 and required 6 tons of gypsum per acre every two or three years. It should be noted that the gypsum requirement is based on a medium textured soil (loam). If the soil were a clay loam or clay, the gypsum requirement would be much higher; if the soil were sandy, it would be lower.

The effect of irrigation water salinity upon the freedom of choice of crop is shown in Figure 5, which is based on the curves in Figure 3. With enough water available to permit the leaching requirement to be set at 30, any one of the five crops could be grown if the water had an electrical conductivity of less than 750 micromhos. At about 1,500 micromhos, three crops could be grown satisfactorily. At 3,500 micromhos, only barley would give average yields. If the amount of water used for leaching were doubled, any of the five crops could be grown even if the water had about 1,200 micromhos electrical conductivity.

Several other methods have been devised to minimize the adverse effect of saline water on crop growth. Farmers in the Pecos Valley in New Mexico and Texas have, for years, planted cotton on the flat or in furrows as a means of improving leaching and keeping salt concentrations low near the plant. As more is learned about water and salt movement in soils and the effect of salt on crops, new planting and watering methods have been tested. One of these successful planting methods has been the use of sloping beds that permits seeding in a position where the salt content of the soil will be at a minimum. Other research has been directed toward finding fertilizer combinations that will reduce the salt effect and determining how to make the best combined use of good and poor water.

In summary, it is impossible to say without qualifications whether any particular irrigation water can or cannot be used satisfactorily for crop production. Any water can cause problems under some circumstances. Rather than center our attention on limitations in water use, we can profitably consider how to make beneficial use of waters that are now classified as undesirable. Given a permeable soil and a deep water table, the two most important factors in using saline or high boron waters are the kind of crop to be grown and the quantity of water available. For sodium waters, these two factors plus the need for gypsum are the major considerations. Using poor quality irrigation water is costly but can be done.

REFERENCES

U. S. Salinity Laboratory Staff, "Diagnosis and Improvement of Saline and Alkali Soils," U.S.D.A. Handbook No. 60. 1954.

Wilcox, L. V., "Discharge and Salt Burden of the Rio Grande Above Fort Quitman, Texas, and Salt-Balance Conditions of the Rio Grande Project for the Year 1963." U. S. Salinity Lab. Research Rept. 106. 1964.