Use of saline water for irrigation

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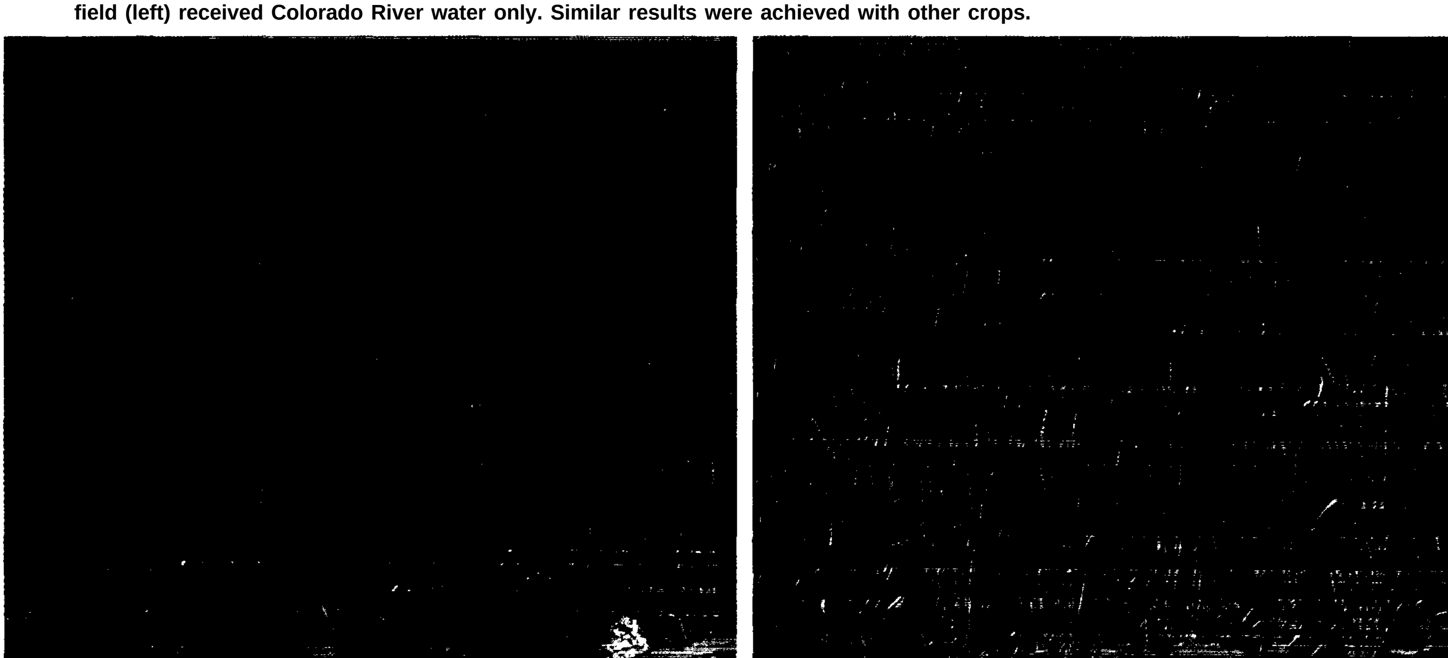
Expansion of irrigated agriculture would contribute significantly toward meeting world food and fiber needs but, at the same time, would run headlong into competition for ever more limited water supplies. By reassessing the criteria for suitability of water (and land) for irrigation, however, available supplies can be expanded significantly. Very conservative standards have been used in the past. If these standards are relaxed, water generally classified as too saline for irrigation can often be used successfully without hazardous long-term consequences to crops or soils, even under conventional farming practices. Adoption of new crop and water management strategies would further facilitate the use of saline waters for irrigation and could make possible a sizable expansion of irrigated agriculture.

Considerable saline water is available, including drainage water from irrigated projects and shallow groundwater. Saline waters can be used to aid California in its water conservation efforts and to develop new supplies for irrigation. Estimated water demands in the San Joaquin Valley, for example, are 14.6 million acre-feet per year, and normal-year supplies average only about 12.9 million acre-feet. The average annual groundwater overdraft is 1.7 million acre-feet, about three-fourths of which occurs in the southern Valley. Annual water demands in the Valley are projected to grow to 16.8 million acre-feet by the year 2000. Without new supplies, the overdraft will double to 3.6 million acre-feet.

Paradoxically, at the same time the lower Valley has a serious water deficit, disposal of excess drainage water has become a problem. Shallow water tables are developing in a number of San Joaquin Valley basin locations, and by the year 2000, a projected 1 million acre-feet of drainage water per year will require disposal. The average salt concentration of this drain water ranges from 4,000 to 5,000 mg/L. Construction of a drainage system to the San Francisco Bay, the only outlet from the San Joaquin Valley, is both expensive and controversial.

In the Imperial Valley, annual discharge of drainage water to the Salton Sea amounts to about 1.5 million acre-feet; its average salt concentration is about 3,500 mg/L. In this valley, as in the San Joaquin Valley, reuse of drainage water could reduce disposal problems and increase the amount of water available for irrigation.

Many such brackish waters, which are not now used for irrigation because they are deemed too salty, can be used effectively with properly adapted management practices. In fact, whether inadvertent or planned, such reuse is common in many places; however, farmers could carry reuse much further by successively irrigating a sequence of crops of increasing salt tolerance. This approach has little appeal to most farmers, because it restricts them to salt-tolerant



Brackish drainage water has been successfully reused for irrigation. In U.S. Salinity Lab experiments, wheat irrigated with saline Alamo River water after seedling establishment with less saline Colorado River water (right) showed no loss of yield. The control field (left) received Colorado River water only. Similar results were achieved with other crops.

crops, and it requires special management practices and equipment to obtain a good stand on saline land. Use of saline waters for irrigation would probably be more acceptable if these limitations could be circumvented.

One strategy is to substitute saline (drainage) water for normal (low-salinity) water to irrigate certain crops in the rotation when they are in a suitably tolerant growth stage; the normal water is used at other times. The timing and amount of substitution possible varies with the quality of the two waters, the cropping pattern, climate, certain soil properties, and the irrigation system. Whatever salt buildup occurs in the soil from irrigating with the brackish water can be alleviated in the subsequent cropping period when a more sensitive crop is grown with the low-salinity irrigation water.

Soil does not usually become unduly saline from use of brackish water for a part of a single irrigation season and often not when this practice is continued for several seasons. The maximum soil salinity in the root zone that results from continuous use of brackish water does not occur when such water is used for only a fraction of the time. Furthermore, yield of the sensitive crop is not likely to be reduced if proper preplant irrigations and careful management are used during germination and seedling establishment to leach salts out of the seed area and shallow soil depths. Subsequent in-season irrigations will leach the salts farther down in the profile ahead of the advancing root system and reclaim the soil before the brackish water is used again to grow a suitably tolerant crop. This cyclic use of low- and high-salinity water prevents the soil from becoming excessively saline, while permitting substitution of brackish for better quality water for a substantial fraction of the irrigation water used over the long period.

The suggested strategy for using brackish waters for irrigation is being evaluated in three U.S. Salinity Laboratory experiments. One is a 40-acre field experiment begun in January 1982 on a cooperator's farm in the Imperial Valley. The other is a field experiment that has been under way for six years near Lost Hills in the San Joaquin Valley.

Two cropping patterns are being tested at the Imperial Valley location: a successive-crop and a block rotation. The two-year successive-crop rotation consists of wheat, sugarbeets, and melons. Colorado River water (900 mg/L total dissolved salts) is being used in the preplant and early irrigations of wheat and sugarbeets and for all irrigations of melons. The remaining irrigations are from the Alamo River (drainage water of 3,500 mg/L total dissolved salts).

The block rotation consists of cotton (a salt-tolerant crop) for two years, followed by wheat (intermediate salt tolerance), and then by alfalfa (more sensitive) for a block of several years. Drainage water is being used for a large part of the cotton irrigations. Beginning with the wheat crop, only Colorado River water will be used. Wheat should withstand the salinity initially present in the soil from irrigating the cotton with brackish water and should yield well when irrigated with Colorado River water. Desalinization of the soil is expected to be sufficient from irrigations of wheat with Colorado River water so that alfalfa can be grown without loss of yield.

To date, one cycle has been completed in the successive-crop rotation (one wheat, one sugarbeet, and one melon crop), and in the first two years of the block rotation, two cotton crops have been harvested. No yield loss occurred in any of these crops where Alamo River water was substituted for Colorado River water after seedling establishment. The percentages of drainage water substitution for normal irrigation water in the test were 76 in wheat, 82 in sugarbeets, and 54 in cotton. Melons, a salt-sensitive crop irrigated with Colorado River water, were grown without yield loss on the same land that had been farmed to wheat and sugarbeets with some Alamo River irrigation water. (Melon yields were compared with those in the control, in which only Colorado River water was used for all irrigations of all crops.)

In the first four years of the Lost Hills field experiment, a very saline water (6,000 mg/L total dissolved salts) was successfully used to irrigate cotton after seedling establishment with California aqueduct water (300 mg/L total dissolved salts). Wheat was then grown with aqueduct water for desalinization purposes. Sugarbeets were subsequently grown under the cyclic strategy, to be followed by guar and cotton.

This is a demanding test, because the groundwater under the site is more saline than sea water and has been at depths of 1½ to 4 feet for the last three years; there has been little opportunity for leaching, and soil salinity has increased to abnormally high levels. In spite of these problems, yields were good: 1982 cotton lint yields were 2.3 bales per acre and 1984 sugar yields were 4.1 tons per acre when irrigated with drainage water after seedling establishment, compared wtih 2.8 bales and 4.2 tons per acre, respectively, when irrigated with aqueduct water only.

This experiment, when completed, should provide appropriate data to evaluate the long-term effects of the strategy. Until then, although the results support the credibility of the proposed strategy, it cannot be claimed that its validity has been established.

A new experiment has just been initiated to simulate the two field conditions in a controlled lysimeter facility. A computer model is being developed to predict the chemistry of the soil water with cyclic crop/water use within the root zone and over time for a variety of cropping situations. The model will be tested with the empirical data obtained. It will be used to help evaluate the long-term consequences of the strategy.

Frequently, drainage water is inadvertently recovered and used for irrigation elsewhere, because drainage often returns by diffuse flow to the water supply system. This often decreases water quality without adding to the water supply that contributes to crop production. A plant must expend energy that would otherwise be used in biomass production to extract water from a saline (low osmotic potential) soil solution. When a water of excessive salinity for crop production is mixed with a low-salinity water and used for irrigation, the plant can remove only the "good water" fraction from the mix until the salinity again becomes excessive — until the fraction of the mix made up of the excessively saline portion is left. This fraction is just as unusable at this point as it was before mixing, because it requires more energy than the plant can muster to separate the pure water from such a low-osmotic-potential solution. Thus, diluting excessively saline water with less saline water does not stretch the water supply for crops that could not use the water before dilution. This saline water component is usable only on crops that are sufficiently salt-tolerant to use the water undiluted. Mixing saline water back into a receiving water can increase the latter's salinity sufficiently to limit its usability for sensitive crops and other uses as well.

Greater flexibility and opportunity for crop production results if the two water types are used separately in a cyclic crop/water management strategy. Once the waters are mixed, this alternative is lost. It may not always be feasible or practical to prevent such natural mixing, but intentional mixing should be carefully evaluated along with the cyclic alternative.

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