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It has been concluded that little expansion in irrigated agriculture can occur in the near future because the readily available suitable lands and waters are fully developed (UN World Food Conference, 1974). This author believes that this conclusion is not entirely valid and that the concept of suitability has been misapplied because of the conservative standards used to assess the fitness of water (and land) for irrigation. Furthermore, only conventional criteria and procedures of producing crops under irrigation have been considered in the evaluation of our future production capacity. Water commonly classified as unsuitable for irrigation by conventional methods can often be used successfully to grow crops without hazardous long-term consequences to crops or soils, even with the use of ordinary farming practices. The adoption of new crop/water management strategies will further enhance the agricultural use of saline waters. Irrigated agriculture could be expanded considerably through the implementation of certain strategies which allow greater use of more saline waters for irrigation. Considerable saline water, including drainage waters from irrigation projects and frequently associated shallow ground waters, is available in many parts of the world, including the US, Egypt, Israël, Pakistan, India, Australia, and the USSR.

In this paper, I present an appropriate method for assessing the suitability of saline waters for irrigation, a brief review of relevant literature documenting the successful use of saline waters for irrigation, and the concept and summary results of a test of a new crop/water management strategy to facilitate the use of saline water for irrigation.

I - Assessing the suitability of saline water for irrigation

The suitability of a saline irrigation water must be evaluated on the basis of the specific conditions of use, including the crops grown, soil properties, irrigation management, cultural practices, and climatic factors. The "ultimate" method for assessing the suitability of such waters for irrigation consists of:

1. predicting the composition and matric potential of the soil water, both in time and space resulting from irrigation and cropping;

2. interpreting such information in terms of how soil conditions are affected and how any crop would respond to such conditions under any set of climatic variables (Rhoades, 1972).

A computer model for assessing water suitability for irrigation which uses these criteria has been developed (Rhoades and Merrill, 1976). A simplified version of it, called "watsuit", has also been developed and used to assess drainage waters for irrigation – a description of "watsuit" and example outputs are given in Rhoades (1987). A simplified, non-computerized version of "watsuit" has also been developed (Rhoades, 1984). This latter version is accomplished using **Table 1** and **Figure 1**, as discussed later.

Prognoses of suitability are made after the soil water compositions are predicted. A soil salinity problem is deemed likely if the predicted rootzone salinity exceeds the tolerance level of the crop to be grown. Use of the water will result in a yield reduction unless there is a change in crop and/or leaching fraction (L). If yield reduction can be tolerated, then the appropriately higher salinity tolerance level can be used in place of the no-yield-loss threshold values. The salt tolerances of crops have been conveniently summarized by Maas and Hoffman (1977) and Maas (1986). Example data for common grain crops are given in **Figure 2**.

The effect of salinity under conditions of frequent irrigation management (i.e. when little matric stress exists) is evaluated using the "water-uptake-weighted salinity" F_c values of **Table 1**. For infrequent irrigation (i.e. conventional management where significant matric stress occurs over the irrigation interval), the "average-salinity whole-rootzone" F_c values of **Table 1** are used (see Rhoades and Merrill, 1976 for justification for this approach of changing the index of salinity for different conditions of irrigation management). To assess toxicity hazards, specific solute concentrations are used in place of salinity (electrical conductivity is used as the expression of salinity herein). To evaluate potential sodicity (permeability crusting) problems, the sodium adsorption ratio of the topsoil together with the electrical conductivity of the infliltrating water and appropriate SAR - EC threshold relations established for the soils of concern are used (see Rhoades, 1982 for more details). The SAR of the soil water in the near-surface soil is taken to be that of the irrigation water itself for such saline waters. The SAR of the soil water at depth in the soil is predicted, if desired, using either the method of Oster and Rhoades (1977) or Suarez (1981).

Figure 1 can be used in lieu of **Table 1** to predict expected salinity for conditions of conventional irrigation; it also gives the threshold tolerance levels, of representative crops to facilitate prognosis. An analogous figure can be prepared from the data of **Table 1** for conditions of high frequency irrigation. Use of **Table 1** or **Figure 1** is illustrated with the following example. Given an irrigation water with EC = 2 dSm^{-1} and a leaching fraction of 0.10 with conventional irrigation frequency, average rootzone salinity at steady-state is predicted to be EC^e = (1.88) (2) = 3.8 dSm^{-1}, where 1.88 is the appropriate concentration factor (F_c) selected from **Table 1**. If the crop to be grown is wheat with a threshold EC_e tolerance level of 6 dSm^{-1} (**Figure 2**), the water salinity level is judged acceptable for surface methods of irrigation since the predicted salinity is but 3.8 dSm^{-1}. The same approach is used to predict (and assess) specific solute concentrations (such as chloride) in the soil water when they are of concern.

Because the effects of exchangeable sodium on swelling and dispersion are counteracted by high electrolyte concentration, the soil sodicity (permeability/crusting) hazard cannot be assessed independently of electrolyte concentration. The soil surface usually limits water infiltration and, therefore, one should evaluate the likelihood of an excessive infiltration reduction using both EC_{iw} and SAR. The values in **Figure 3** are estimates of threshold levels for the more sensitive arid-land soils. The permeability hazard is determined by observing whether the SAR – EC_{iw} combination lies to the left (problem likely) or right (no problem likely) of the threshold line in **Figure 3**. The slope of this threshold curve is steeper below SAR values of 10 and intersects the EC_{iw} axis at a value of 0.3 because of the dominating effect of electrolyte concentration on soil aggregate stability dispersion, and crusting at such low salinities. Thus, even at low levels of exchangeable sodium, permeability/crusting problems can occur, when rainfall leaches the surface soil nearly free of salt or very pure waters are subsequently used for irrigation. Such near-surface effects, however, can often be overcome by tillage, amendments, and other cultivation techniques.

Toxicity and nutritional imbalance are seldom major problems for saline waters. Where they are they should be assessed as described elsewhere (Rhoades, 1987).

II - Evidence of the potential of using saline waters for irrigation

Considerable volumes of drainage water are typically discharged from irrigation projects and, using the water suitability assessment procedures described in the previous section. I have concluded (Rhoades, 1977) that the bulk of drainage waters in the US (presumably in the world, as well) have potential value for irrigation. Use of such water would not only permit the expansion of irrigated agricultural but could also reduce drainage disposal and pollution problems as well.

Though the number of documented reports on the successful use of brackish water for irrigation is relatively limited, sufficient numbers exist to support the premise that water more saline than conventional schemes of water classification will allow, can be used for irrigation. In the US, extensive areas of alfalfa, grain sorghum and wheat are irrigated in the Arkansas Valley of Colorado with water containing not less than 1,500 mg/L of total dissolved solids (TDS) and up to 5,000 mg/L (Miles, 1977). In the Pecos Valley, water averaging 2,500 mg/L but ranging far higher has been used for decades (Moore and Hefner, 1976). Jury *et al.* (1978) grew wheat in lysimeters with water up to 7.1 dSm^{-1} without deleterious effects on yield. Paliwal (1972) gives a number of examples of continuing irrigation in India with waters of relatively high salinity. Shalhevet and Kamburov (1976) in their worldwide survey of irrigation and salinity suggested that waters of up to 6,000 mg/L were often classed as acceptable and indeed used. Pillsbury and Blaney (1966) concluded that the upper limit for the salinity level of an irrigation water is about 7.5 dSm^{-1}. Hardan (1978) irrigated pear trees with waters ranging up to 4,000 mg/L without yield reduction. Frenkel and Shainberg (1975) and Keren and Shainberg (1978) reported that cotton is grown commercially in Israel with water having an electrical conductivity of 4.6 dSm^{-1}. The report that 10 t/ha yields of alfalfa are achieved in the USSR with 12,500 mg/L water (Bressler, 1979) may be the result of poor translation or interpretation. Data on cotton irrigation from the same source are more consistent with US experience; good yields were obtained in Usbekisttan with long-term irrigation with drainage water of 5,000 – 6,000 mg/L total dissolved solids.

In the reports cited above, the successful use for irrigation of saline waters of up to about 8 dSm^{-1} (-6,000 mg/L) was noted. It has been claimed that sea water can be used for irrigation (Boyko, 1967; Epstein and Norlyn, 1977), but the reported data are far from convincing. Dhir (1976) reported the use of water ranging up to 15 dSm^{-1} for wheat production in India, but these areas receive annual monsoons. Ayers *et al.* (1952) were able to grow barley in field plots without yield reduction with salinities of up to 20,000 mg/L in the irrigation water, but only when a better quality water was used for stand establishment. These reports can easily be misinterpreted since often the crops were grown in climates where rainfall made significant contributions.

The water suitability assessment procedure described in the preceding section, combined with these latter cited worldwide references, indicate that waters of much higher salinities than those customarily classified as suitable can be used effectively for irrigating selected crops. This finding implies that if a re-evaluation of the UN World Food Conference conclusion were made using modern methods of assessing water suitability for irrigation and, especially, if newer crop/water management strategies were considered, a more optimistic forecast for the future would result.

III - A crop/water management strategy to facilitate the use of saline waters for irrigation

In this section, a crop/water management strategy that should increase the practicality of using saline waters for irrigation, is described. Aspects of this strategy have been recently discussed elsewhere (Rhoades, 1983, 1984, 1985; Rhoades *et al.*, 1988a, b). The impetus for the strategy has its origin in the assumption that typical farmers will not use brackish water for irrigation if access to enough water of lower salinity is available, unless the brackish water can be used without significant losses in yield, cropping flexibility or significant changes of farming practices.

The proposed management strategy, which meets these requirements, is to substitute the saline water (such as drainage or shallow groundwater) for the "good" water when irrigating certain crops in the rotation when they are in a suitably salt-tolerant growth stage; the "good" water is used at the other times. The maximum soil salinity in the rootzone that can result from continuous use of brackish water will not occur when such water is used for only a fraction of the time. The timing and amount of substitution will vary with the quality of the two waters, the cropping pattern, the climate, and the irrigation system. Whatever salt buildup occurs in the soil from irrigating with the brackish water is alleviated in the subsequent cropping period when a more sensitive crop is grown using the low-salinity water for irrigation. (It should be noted that a soil will not generally become unduly saline from use of a saline water for a part of a single irrigation season and often not for several seasons).

Furthermore, the yield of the sensitive crop should not 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 these salts farther down in the profile ahead of the advancing root system and "reclaim" the soil in preparation for the brackish water which will be used again to grow a suitably tolerant crop. This cyclic use of "low" and "high" salinity waters prevents the soil from becoming excessively saline while permitting, over the long period, substitution of the brackish water for a low-salinity water for a large fraction (50%) of the irrigation water needs.

This strategy has been recently tested in a 20-hectare field experiment which was begun on a commercial farm in the Imperial Valley, California in January 1982. Two cropping patterns were tested. One was a two-year successive crop rotation of wheat, sugarbeets and cantaloupe melons. In this rotation, Colorado River water (900 mg/L TDS) was used for the preplant and early irrigations of wheat and sugarbeets and for all irrigations of the melons. The remaining irrigations were with the Alamo River (drainage water of 3500 mg/L TDS). The other was a four-year block rotation consisting of two years of cotton (a salt-tolerant crop) followed by wheat (an intermediate salt-tolerant crop) and then by alfalfa (a more salt-sensitive crop). Drainage water was used for the irrigation of cotton after seedling establishment; beginning with the wheat crop, only Colorado River water was used. It was hypothesized that wheat would withstand the salinity present in the soil resulting from irrigating the cotton with the brackish water and would yield well when irrigated with Colorado River water. Enough desalination of the soil would occur using Colorado River water to subsequently permit alfalfa to be grown without loss of yield.

The yields of the crops grown in the successive – and block – rotation(s) are given in **Tables 2** and **3**, respectively. No significant losses in the yields of the wheat and sugarbeet crops occurred in either cycle of the rotation from substituting drainage water (even in the greater amount; cA 65-75%) for Colorado River water for the irrigation of these crops after seedling establishment. The mean yield of cantaloupe seed obtained in the cA plots was about 10% lower than the control, but the difference was not statistically significant. The yields of the fresh-market melons (numbers of cartons of cantaloupe obtained by commercial harvest operations) in 1985 was higher in the Ca and cA treatments than in the C treatment, but were not significantly different (see **Table 2**). Hence, no significant yield loss was observed from growing cantaloupes using Colorado River water for irrigation in the land previously salinized from the irrigation of wheat and sugarbeets using drainage water.

The yields of each crop obtained in the block rotation are given in **Table 3**. There was no loss in lint yield in the first cotton crop (1982) from use of Alamo River drainage water for irrigation, even when it was used for irrigations during the preplant and seedling establishment periods (treatment A). There was no significant loss in lint yield in the second cotton crop (1983) from use of Alamo River water for the irrigations given following seedling establishment which was accomplished using Colorado River water (the recommended strategy treatment, cA). But there was a significant and substantial loss of lint yield, as expected, where the Alamo River water was used solely for irrigation (the "extreme-control" treatment, A). This loss of yield was caused primarily by a loss of stand that occured in the second year because salinity was excessively high in the seedbed during the establishment period. No loss in yield of wheat grain or alfalfa hay occured in the block rotation associated with the previous use of Alamo River water on these lands under these conditions in which they were irrigated with Colorado River water.

The qualities of all of these crops were never inferior and often were superior, when grown using the drainage water for irrigation or on the land where it had previously been used. These quality data are given elsewhere (Rhoades *et al.*, 1988a).

The average amounts of water applied to each crop and over the entire four-year period are given in **Tables 4** and **5** for the successive – and block – rotation, respectively. These data include all water applied, including that used for preplant irrigations and land preparation purposes. These data show that substantial amounts of drainage water were substituted for Colorado River water in the irrigation of these crops without yield loss.

The estimated amounts of water consumed by the crops through evapotranspiration and lost as deep percolation are given in **Table 6** by individual crop and by succession of crops for both rotations. It was assumed that consumptive use was the same in all treatments, since no substantial losses of yield resulted in any treatment. These data show that the saline drainage water was successfully used for irrigation without excessive leaching.

Data on soil salinity and sodicity are given elsewhere (Rhoades *et al.*, 1988b). Their levels were kept within acceptable limits for seedling establishment and the subsequent growth of the individual crops grown in the rotation when the recommended strategy was employed. These results along with the high crop yields and qualities obtained in this test under actual farming conditions support the credibility of the recommended cyclic crop and water strategy to facilitate the use of saline waters for irrigation.

IV - Blending drainage waters for reuse or discharge

It is not uncommon to hear proposals to expand water supplies for irrigation by blending waters too saline for use by crops with low-salinity water to obtain a resultant salinity of the mixed water that is within acceptable limits for crop production. The author contends that such blending is counter productive (Rhoades, 1983; 1988c). The following logic is applied. A plant must expend bio-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 removes the "good water" fraction from the mix until the fraction of the mix made up of the excessively saline portion is left. This saline fraction is still as unusable (from the the plant energy expenditure point of view) as it was before mixing. But salt-sensitive crops can not concentrate the solution to this point without excessive yield loss. Thus, a fraction of the low-salinity (fully usable) water used to make the blend was made unavailable for transpiration as a consequence of blending.

Thus diluting excessively saline water with less saline water does not stretch the water supply for crops of the same or lower salt tolerance. This "saline water" component is only usable by crops that are more salt-tolerant than those grown which produced the drainage. Bernstein (1966) indicated that, for any succession of crops, the fraction of maximally used drainage water (the argument applies equally well to any water of high salinity) available for reuse is determined by:

$$1 - \frac{EC_a}{EC_b}$$

where the EC values refer to the allowable salinities (expressed in electrical conductivity) in the drainage water for the first crop, a, and the second crop, b. It should be recognized that extremely high irrigation efficiencies are needed to completely utilize most common irrigation waters in a single use. For example, for an irrigation of EC = 1.0 dSm^{-1}, leaching fractions of 1/45 to 1/15 would be needed for the most salt-tolerant and salt-sensitive crops, respectively. With such efficiencies, 67% of the drainage water from the most sensitive crops would be usable for the most tolerant crops. But return of such saline waters to a common water supply depletes that supply of water that could be used by salt-sensitive crops in transpiration.

The above estimate of the usable fraction of drainage (saline) waters for irrigation is based on the assumption of steady-state conditions and use of only one water of fixed salinity level for irrigating the crop. The usable water will not be the same under nonsteady state conditions nor where another water of better quality can be used sequentially with it. If a water is so saline that its use for crop production is already spent, then diluting it with purer water and using the mix for the irrigation of crops of the same or lesser salt-tolerance does not add to or contribute to the usable water supply for crop production. One has, in this process of mixing, simply mixed the usable and unusable waters into one blend which must be separated again during the use by the plant. The author contends that greater flexiblity and opportunity for crop production results if the two water types are used cyclically as previously described. Once the waters are mixed, these alternatives are lost. Detailed arguments to support this argument and to show that a loss in the total usable water of a fixed supply occurs when very saline waters are returned to a good water supply are given elsewhere (Rhoades, 1988c).

V - Conclusion and summary

Rational water assessment procedures indicate that waters of higher salinities than are now customarily classified as suitable can be used effectively for irrigation selected crops with conventional methods of management. It appears that water quality standards have been traditionally based on the availability of good quality water. Where ample water of low salinity is available, waters of relatively low salinity are typically classified as "unusable", but where good quality waters are not available, saline waters are judged more usable. Worldwide literature documents the successful use that can be made of relatively saline waters for irrigation. The practicality of increasing the extent of irrigation agriculture through use of saline waters for irrigation can be enhanced if a modified dual rotation (crop and water) system of management is used. The objective is to substitute the saline water for some of the low-salinity water used for irrigation without significant yield reduction, loss in cropping flexibility or change in current farming operations while increasing the total water supply. The strategy is to irrigate salt-sensitive crops (lettuce, alfalfa, etc.) in the rotation with low-salinity water and salt-tolerant crops (cotton, sugarbeets, wheat, etc.) with saline water. For tolerant crops, the switch to saline water usually occurs after seedling establishment; preplant irrigations and initial irrigations being done with low salinity water. The feasibility of this strategy is supported by data obtained in field experiments.

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Table 1: Relative concentration or electrical conductivity of soil water (saturation paste extract basis) at steady-state compared to that of irrigation water (Fc)

	Fc					
	Leaching fraction					
Rootzone interval	0.05	0.10	0.20	0.30	0.40	0.50
	Linear average (1)					
Upper quarter	0.65	0.64	0.62	0.60	0.58	0.56
Whole rootzone	2.79	1.88	1.29	1.03	0.87	0.77
	Water uptake weighted (2)					
Whole rootzone	1.79	1.35	1.03	0.87	0.77	0.70

(1) Use for conventional irrigation management.

(2) Use for high frequency irrigation management or where matric potential development between irrigations is insignificant.

Table 2: Yields of crops in successive rotation

Treatment 1)	Crop year Wheat/1982 2)	sugar Beets/1983 3)	Cantaloupes/1983 4)	Wwheat/1984 2)	sugar Beets/1985 3)	Cantaloupes/1985 5)
C	3.60 (0.06) [6]	4.3 (0.1)	392 (12)	3.51 (0.09)	4.1 (0.1)	115 (5)
Ca	3.60 (0.08)	4.3 (0.2)	384 (10)	3.46 (0.10)	4.1 (0.1)	142 (8)
cA	3.71 (0.06)	4.1 (0.1)	355 (14)	3.55 (0.09)	3.9 (0.1)	139 (12)

1) C = Colorado River water used solely for irrigation; Alamo River water used in relatively smaller (Ca) and larger (cA) amounts, after seedling establishments with Colorado River water for wheat and sugar beets. Cantaloups only irrigated with Colorado River water.
2) Tons of grain per acre
3) Tons of sugar per acre
4) Lbs. of seed per acre
5) Commercial yield in numbers of cartons per plot; plot size = 750 x 38 feet = 0.6543 acres
6) Value within ( ) is standard error of mean; six replicates

Table 3: Yields of crops in block rotation

Treatment 1)	Crop year Cotton/1982 2)	Cotton/1983 2)	Wheat/1984 3)	Alfalfa/1985 4)
C	2.62 (0.07) [5)]	2.06 (0.10)	3.43 (0.06)	7.8 (0.4)
cA	2.65 (0.06)	2.00 (0.06)	3.43 (0.06)	7.0 (0.5)
A	2.76 (0.04)	1.32 (0.05)	3.41 (0.05)	7.4 (0.3)

1) C = Colorado River water used solely for irrigation; A = Alamo River used solely for irrigation; cA = Alamo River water used for irrigation after seedling establishment with Colorado River water for cotton. Wheat and alfalfa irrigated only with Colorado River water
2) Commercial yield of lint, bales per acre
3) Tons of grain per acre
4) Tons of dry hay per acre
5) Value within ( ) is standard error of mean; six replicates

Table 4: Amounts of Colorado and Alamo river waters used for irrigation in the successive crop rotation (mm 1)

Treatment 2)	1982 Wheat Colorado R.	1982 Wheat Alamo R.	1982 Wheat Total	1982 Wheat % Alamo	1983 Sugar beets Colorado R.	1983 Sugar beets Alamo R.	1983 Sugar beets Total	1983 Sugar beets % Alamo	1983 Cantaloupes Colorado R.	1983 Cantaloupes Alamo R.	1983 Cantaloupes Total	1983 Cantaloupes % Alamo
C	548 (3) 3)	0	548 (3)	0	1,268 (5)	0	1,268 (5)	0	626 (7)	0	626 (7)	0
Ca	417 (5)	129 (1)	545 (4)	24	712 (1)	536 (2)	1,249 (2)	43	623 (2)	0	623 (2)	0
cA	131 (1)	425 (4)	556 (4)	76	448 (3)	800 (3)	1,248 (4)	64	628 (3)	0	628 (3)	0

	1984 Wheat Colorado R.	1984 Wheat Alamo R.	1984 Wheat Total	1984 Wheat % Alamo	1985 Sugar beets Colorado R.	1985 Sugar beets Alamo R.	1985 Sugar beets Total	1985 Sugar beets % Alamo	1985 Cantaloupes Colorado R.	1985 Cantaloupes Alamo R.	1985 Cantaloupes Total	1985 Cantaloupes % Alamo
C	823 (4)	0	823 (4)	0	1,400 (4)	0	1,400 (4)	0	360 (6)	0	360 (6)	0
Ca	431 (2)	396 (2)	827 (2)	48	711 (3)	663 (3)	1,374 (5)	48	354 (4)	0	354 (4)	0
cA	307 (2)	526 (2)	833 (3)	63	491 (2)	873 (4)	1,364 (4)	64	346 (4)	0	346 (4)	0

	Complete rotation Colorado R.	Complete rotation Alamo R.	Complete rotation Total	Complete rotation % Alamo
C	5,025 (12)	0	5,025 (12)	0
Ca	3,248 (9)	1,724 (5)	4,971 (11)	35
cA	2,351 (7)	2,624 (3)	4,975 (10)	53

1) Includes pre-plant water applications
2) C = Colorado River water and solely for irrigation; Alamo River water used for irrigation in relatively smaller (Ca) and larger (cA) amounts after seedling establishments with Colorado River
3) Number within ( ) is standard error of mean

Table 5: Amounts of Colorado and Alamo River waters used for irrigation in the block rotation (mm 1)

	1982 Cotton				1983 Cotton				1984 Wheat			
Treatment 2)	Colorado R.	Alamo R.	Total	% Alamo	Colorado R.	Alamo R.	Total	% Alamo	Colorado R.	Alamo R.	Total	% Alamo
C	1,306 (19)[3]	0	1,306 (19)	0	1,177 (6)	0	1,177 (6)	0	823 (8)	0	823 (8)	0
Ca	515 (12)	774 (30)	1,289 (42)	60	617 (4)	545 (3)	1,162 (6)	47	798 (2)	0	798 (2)	0
cA	0	1,187 (25)	1,187 (25)	100	0	1,149 (7)	1,149 (7)	100	795 (5)	0	795 (5)	0

	Alfalfa				Complete rotation			
	Colorado R.	Alamo R.	Total	% Alamo	Colorado R.	Alamo R.	Total	% Alamo
C	2,048 (6)	0	2,048 (6)	0	5,372 (8)	0	5,372 (8)	0
cA	2,058 (7)	0	2,058 (7)	0	3,995 (18)	1,332 (34)	5,327 (50)	25
A	2,029 (16)	0	2,029 (16)	0	2,824 (17)	2,336 (30)	5,160 (42)	45

1) Includes pre-plant water applications
2) C = Colorado River water and solely for irrigation; Alamo River water used for irrigation in relatively smaller (Ca) and larger (cA) amounts after seedling establishments with Colorado River
3) Number within ( ) is standard error of mean

Table 6: Estimated evapotranspiration and water lost as deep percolation (inches)

Crop	V_{et} (1)	V_{iw} (2)	V_{dw} (3)	LF (4)	Accumulated (5)			
					V_{et}	V_{iw}	V_{dw}	LF
				Successive crop rotation				
1982 wheat	25.8	21.9	-3.9	-0.18	25.8	21.9	-3.9	-0.18
1983 S. beet	40.5	49.1	8.6	0.18	66.3	71.0	4.7	0.07
1983 melons	16.8	24.7	7.9	0.32	83.1	95.7	12.6	0.13
1984 wheat	27.1	32.8	5.7	0.17	110.2	128.5	18.3	0.14
1985 S. beet	42.3	53.7	11.4	0.21	152.5	182.2	29.7	0.16
1985 melons	16.8	13.6	-3.2	-0.24	169.3	195.8	26.5	0.14
				Block rotation				
1982 cotton	38.9	50.7	11.8	0.23	38.9	50.7	11.9	0.23
1983 cotton	40.7	45.7	5.0	0.11	79.6	96.5	16.9	0.18
1984 wheat	27.1	31.4	4.3	0.14	106.7	127.9	21.3	0.17
1985 alfalfa	81.2	81.0	-0.2	-0.00	187.8	208.9	21.1	0.10

(1) Evapotranspiration estimated from pan evaporation and crop factors at Brawley, California
(2) Total amount of water applied for irrigation
(3) Estimate of deep-percolation drainage water, i.e., $V_{iw} - V_{et}$
(4) Estimate of leaching fraction, i.e., V_{dw} V_{iw}
(5) Accumulated over entire experimental period

Figure 1 : Relations between average rootzone salinity (saturation extract basis), electrical conductivity of irrigation water, and leaching fraction to use for conditions of conventional irrigation management

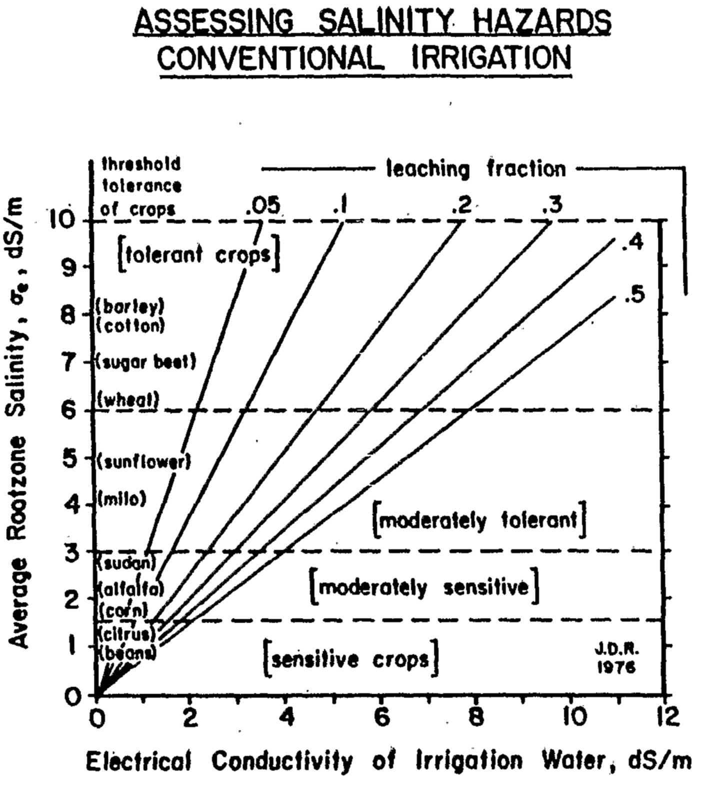

Figure 2: Salt tolerance of grain crops (after Maas and Hoffman, 1977)

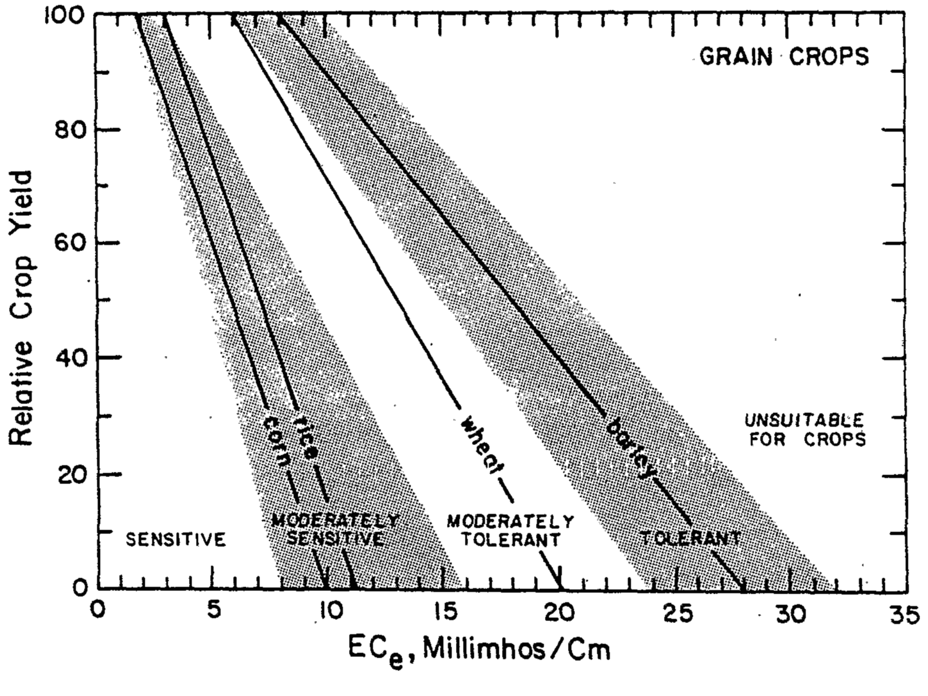

Figure 3: Threshold values of sodium adsorption ratio of topsoil and electrical conductivity of infiltrating water for maintenance of soil permeability