Estimating saline water table contributions to crop water use

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Researchers in several western states have found that, under arid conditions, water tables can supply as much as 60 to 70 percent of a crop's water requirement. Use of high water tables reduces irrigation needs, lowers production costs, reduces deep seepage losses, and decreases the volume of drainage water requiring disposal.

Despite these advantages, irrigation and drainage system design in the San Joaquin and Imperial valleys generally has not taken into account the effects of saline high water tables on crop growth and drainage system performance.

Successful incorporation of these effects into the design of irrigation-drainage systems and into performance models requires determination of the effect of water table depth and salinity on the percentage of crop water demand satisfied by the water table. It was the purpose of this study to define such a relationship and determine how it might be applied in California.

Irrigation-drainage design

Irrigation and drainage systems are usually considered separately without regard for interactions between the water table and the soil root zone (with the exception of leaching and deep percolation losses). Irrigation schedules assume that the soil is adequately drained, either naturally or artificially, and that irrigation should begin when soil moisture is depleted to a given point. Artificial drainage systems, mostly tiling, are designed to lower the water table sufficiently to minimize its damage to crops from waterlogging or salinization of the root zone.

Incorporating the potential contribution of shallow water tables into irrigation-drainage system design requires knowledge of the volume and salinity of water available to crops at different water table depths. Knowing the size of the water reservoir available for crop use may make it possible to reduce irrigation frequency during the growing season. The shallow water table, however, must be replenished periodically. In addition to the labor and cost savings in reducing irrigation frequency, costs can be lowered by installing drainage tile systems at shallower depths or wider spacings than are normally used.

Successful use of the water table also depends on the soil's water retention and transmitting properties, evapotranspiration (ET) demand, distribution of the plant root system, and salinity and toxic ion effects on crop growth. Under field conditions, many of these factors are part of the overall crop response to the saline high water table.

Water table contributions

The soil's water retention and transmission properties are key elements in the ability of crops to extract water from the water table. Several formulas have been derived for estimating rates of upward flow from a water table to a fallow soil based on soil physical considerations. Many of the formulas are of the form

$$q_u = aD^b$$

where q_u is the rate of upward flow from the water table at depth, D. The parameters "a" and "b" are empirical constants that depend on soil hydraulic properties. It has been found that values for "a" depend on the specific soil of interest, whereas values for "b" are relatively constant for soils of the same type.

Available field data, incorporating the effects of variable soil types and soil cracking, suggest that a simpler formula

$$q_u = a - bD$$

adequately describes the dependence of upward flow rates on water table depths for field applications. As in the previous formula, values for the parameter "a" are highly variable, whereas values for "b" depend only on soil type.

Under cropped conditions, water is extracted from the soil and water table by evaporation and plant water uptake. Both are soil-dependent, because the rate at which plant roots can extract water from the soil is also limited by the rate of water transmission through the soil. Water extraction patterns by roots would also tend to smooth extreme variability in soil hydraulic properties. Under cropping, the upward flow rate can be described by the percent ET supplied by the shallow water table to the crop.

Unfortunately, very few studies have examined the relationships between plant water use, water table depth, and water table salinity. Data required to measure such interrelationships in the field are difficult to acquire. Moreover, different relationships are likely for different crops, depending on plant root distribution in the soil. Most information applicable to California's semi-arid to arid regions is for cotton, since this is one of the more common crops grown in such areas. Other crops studied include alfalfa and sugarbeets.

Some researchers have examined the effect of water table depth on use of shallow groundwater of relatively constant salinity by cotton. A study in Texas used lysimeters and a sandy loam soil, and another in Egypt involved lysimeters and a heavy clay soil with average water table salinities of 2.7 and 15.6 dS/m, respectively. Using several years of data from these studies, we identified relationships between plant use of the water table and water table depth. The linear relationships shown in figure 1 fit the data very well and are convenient for use in modeling. Studies by California researchers in fields with typical surface irrigation practices have also yielded some information (fig. 1, table 1). Other, limited data on plant use of the water table are available but were not used here because the irrigation scheduling had forced the plants to extract most of their water requirement from the water table.

Disregarding point "a" (fig. 1) for a loamy soil, results from the California studies compare favorably with those from Texas and Egypt. Point "a" compares reasonably well with the sandy loam data from Texas. Furthermore, of importance to modeling and design of irrigation and drainage systems, the slopes (parameter "b" in the simpler equation for q_u) are nearly constant (table 2).

Analysis of the data on California clay soils indicates that upward flow has little relation to water table salinities in the 3 to

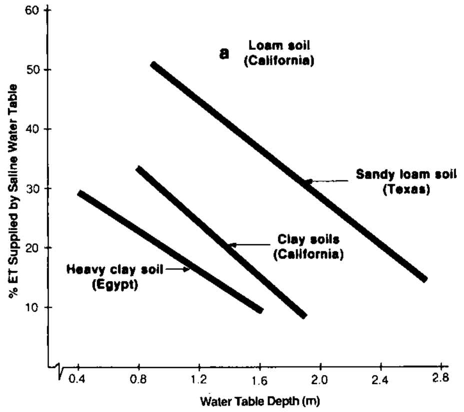

Fig. 1. Contributions (%ET) of saline water tables to cotton water use in the California study were similar to results in Egypt and Texas. Upward flow is affected by water table depth and soil properties (see table 1).

TABLE 1. Summary of data pertaining to crop water use from saline water tables in California

Soil type	Water table Salinity	Water table Depth	Cotton ET supplied by water table*
	dS/m	*m*	*%*
Panoche loam†	5.1	1.44	53 a
Levis silty clay	26.7	1.32	20 b
Merced clay loam	6.7	0.80	35 c
Armona clay loam‡	7.5	1.25	22 d
Oxalis clay loam§	10	1.73	12 e
Oxalis clay loam	10	1.90	10 f

* Letters correspond to data points in figure 1.

† Study by D.W. Grimes et al. 1984. Water Resources Center Report No. 188. University of California, Davis.

‡ Study by B.R. Hanson and S.W. Kite. 1984. ASAE Transactions 27: 1430-34.

§ Study by J.E. Ayars and R.A. Schoneman. 1986. ASAE Transactions 29:1674-78.

TABLE 2. Coefficients of linear regression equations relating water table depth (D) to upward flow rate expressed as %ET of cotton supplied by water table (q_u=a-bD)

Location (soil type)	Equation parameters a	$b(m^{-1})$	R^2
Texas (sandy loam)*	0.698	0.203	0.92
California (clay loam)†	0.511	0.223	0.99
Egypt (heavy clay)‡	0.356	0.167	0.96

* L. N. Namken et al. 1969. Agronomy Journal 61:305-10.

† See table 1.

‡ A.T.M. Moustafa et al. 1975. Ag. Research Review 5:21-24. Ministry of Agriculture, Cairo, Egypt.

27 dS/m (mmho/cm) range, which is consistent with the salt tolerance of cotton. This finding implies that water table salinity variations in this range can be disregarded in modeling and design of irrigation-drainage systems.

Conclusions

We have been able to devise a simple equation to predict water table contributions to crop water use for cotton grown in semi-arid regions such as the San Joaquin Valley. As more information becomes available, similar predictive equations could also be developed for sugarbeets, alfalfa, and other crops. In all cases, however, considerable experimental work in the field is necessary to refine these equations. Long-term effects of salinization of the root zone due to upward flow from the water table may also need to be considered.

Development of predictive equations makes it possible for planners to incorporate interactions between the water table and root zone into design of irrigation-drainage systems on a regional scale, and may help reduce the capital needed to install such systems, lower irrigation costs, and reduce environmental effects associated with disposal of saline drainage water.

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A new disease of myrtle

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Cylindrocladium root and crown rot, once established, is difficult to control

Common myrtle is a perennial ornamental valued for its use in cut flower arrangements. An established field of myrtle (*Myrtus communis*) can be used as a source of cut foliage for several years.

During the summer of 1986, extensive plant death was reported in a mature myrtle planting in San Diego County. Cuttings taken from plants in this field frequently died during rooting despite routine application of Terraclor (quintozene) and Subdue 2E (metalaxyl) to the cut ends before transplant.

Cylindrocladium scoparium was isolated from both cuttings and crowns of myrtle. This soilborne fungus causes root rot, stem canker, damping off, and foliage blight on plants throughout the world. The host range includes more than 100 species of plants, many of them ornamentals, although this is the first report of the pathogen attacking myrtle. This fungus is difficult to isolate from natural soils but is an aggressive colonizer of living and dead plant tissues in disturbed soils such as fumigated fields. The fungus produces microsclerotia within plant tissues; these resistant propagules can sometimes survive fumigation and recolonize the nursery bed.

Mature myrtle plants with cylindrocladium root rot show branch dieback and stunting; cankers may appear in the crown region, and the wood beneath the bark is dark brown. Cuttings exposed to the fungus initially develop lesions on the