drought tips

Number 92-17

Water Quality Guidelines for Vegetable and Row Crops

Agricultural soils and irrigation water contain varying amounts and types of salts, but a soil is not considered saline unless the concentration of salts in the crop rootzone is high enough to reduce crop growth and yield. Vegetable and row crops have varying degrees of tolerance to soil salinity. 'This leaflet provides water quality guidelines and estimated crop yield for various vegetable and row crops under saline conditions.

Vegetable and row crops grown on saline soils may exhibit barren spots surrounded by stunted plants with deep blue-green foliage. White salt deposits may appear on the soil surface. Where salinity is present but less severe, barren spots may be absent but plant growth may be uneven. In certain areas plant growth may be clearly stunted. Since variable water infiltration also causes uneven plant growth, analyzing soil samples from areas of poor and good plant growth can help determine whether soil salinity is the cause of uneven growth.

Salinity Threshold

All vegetable and row crops can tolerate some salts in the rootzone without harm to yield or plant quality. The maximum amount of salt the plant can tolerate in the rootzone with reduction in growth or yield is called the "salinity threshold." Beyond this level crop yields are reduced in proportion to the salt concentration in the rootzone.

Irrigation Management

Effective irrigation management is important anytime, regardless of the availability or quality of water, but becomes essential during a drought. After irrigation water and its dissolved salts move into the crop rootzone, the plant extracts "pure water," for the most part, leaving the salts behind. The amount of salt in the rootzone will increase over time unless more water than the crop uses is applied. This excess water controls soil salinity levels by leaching some of the salt from the rootzone. The fraction of applied water that moves downward through the rootzone and is not used by the crop is called the "leaching fraction."

Soil salinity is expressed as the electrical conductivity of the saturated soil extract (ECe) (with the units usually expressed in mmhos/cm and/or dS/m).

Rootzone salinity (ECe) increases as the leaching fraction decreases for a given irrigation water salinity (ECw). Increasing the leaching fraction when using a more saline irrigation water can result in the same average rootzone salinity as using a less saline irrigation water with a lower leaching fraction. In short, if a more saline water must be used because of drought, applying more water to increase leaching can lessen the effects of salinity on plant growth.

Water Quality Guidelines

Table 1 lists water quality guidelines for the most commonly grown vegetable and row crops in California. These guidelines assume that the soil is well-drained - that is, that adequate soil aeration exists for root respiration and disease control- and that the leaching fraction is 0.15. Under these conditions the relationship between average rootzone salinity (ECe) and ECw is ECe = 1.5 ECw. It is also assumed that all other factors (such as fertility, irrigation scheduling, and pest control) are managed for optimal crop performance. The ECw values given in the table represent the maximums that can be continuously used to achieve the given yield. For example, the ECw values at 100% yield represent the poorest quality water that, if used continuously, will produce ECe levels equal to the salinity thresholds.

It is important to note that most of the experiments that generated this information were conducted in interior regions of the state where the climate is hot and dry during the summer. Vegetable and row crops grown in coastal regions where the climate is more mild will tolerate greater salinities.

Short-Term Versus Long-Term Use of Water

These guidelines are based on the long-term use of the given water quality. Poorer quality water can be tolerated if used on a short-term basis.

Authors: S.R. Grattan, Plant-Water Relations Specialist, UC Davis and J.D. Oster, Soils and Water Specialist, UC Riverside

If good quality water is used to establish the crop, saline water with an ECw that would cause a 25% to 50% yield reduction if used continuously may be used for the remaining two-thirds of the season with little or no yield reduction. Caution is advised in using this irrigation strategy since sufficient rainfall or good quality water is needed the subsequent year to leach most of the salts from the upper two feet of the soil profile before the next crop is planted. In some cases, good quality water following saline water could cause reduced soil-water infiltration.

Toxicity to Specific Elements

With drip or furrow irrigation, chloride and sodium injury does not generally occur in vegetable and row crops. Leaf burn can occur in strawberries, however, particularly under hot and dry conditions. With sprinkler irrigation, chloride and sodium may cause injury to wetted leaves of susceptible plants. Sprinkle irrigation of peppers, potatoes, and tomatoes can cause leaf burn on the edges of older leaves if ECw exceeds about 1.5 mmhos/cm.

Certain vegetable and row crops are sensitive to boron. Generally leaf injury must be severe to cause reduced crop quality and yields. Long-term use of irrigation water containing more than 0.5 ppm of boron can reduce yields of bean, onion, garlic, and strawberry; 0.7 ppm can reduce yields of broccoli, carrot, potato, and lettuce; and 2 ppm can reduce yields of cabbage and cauliflower. Where cool, moist climatic conditions prevail, greater levels of boron can be tolerated, and for the short-term use of an irrigation water, the boron levels given here can be doubled. Soil texture influences the time required for injury to occur. The finer the soil texture, the longer it will take for injury to occur.

Summary

* Vegetable and row crops have varying degrees of tolerance to salinity and boron.

* Many crops can be irrigated with irrigation water that has an ECw of 2 mmhos/cm and boron of 2 ppm and will maintain 90% yield.

* Crops can be irrigated on a short-term basis, or in cool, moist climates using poorer quality water without incurring reduced yields.

Table 1.
Estimated crop yield using irrigation water of various qualities over the long term. Potential yields are based on a 15% leaching fraction.

	YIELD POTENTIAL (%)[1]				RATING[2]	
Crop	100	90	75	50	Salt	Boron
	.... ECW (mmhos/cm)					
Asparagus	2.7	6.1	11.1	19.4	T	VT
Bean	0.7	1.0	1.5	2.4	S	S
Beet, red	2.7	3.4	4.5	6.4	MT	T
Broccoli	1.9	2.6	3.7	5.5	MS	MS
Cabbage	1.2	1.9	2.9	4.6	M	MT
Carrot	0.7	1.1	1.9	3.0	S	MS
Cauliflower	1.9	2.6	3.7	5.5	MS	MT
Celery	1.2	2.3	3.9	6.6	MS	VT
Corn, sweet	1.1	2.3	3.9	6.6	MS	VT
Cucumber	1.7	2.2	2.9	4.2	MS	MS
Eggplant	0.7	1.7	3.1	5.6	MS	----
Lettuce	0.9	1.4	2.1	3.4	MS	MS
Onion	0.8	1.2	1.8	2.9	S	S
Pepper	1.0	1.5	2.2	3.4	MS	MS
Potato	1.1	1.7	2.5	3.9	MS	MS
Radish	0.8	1.3	2.1	3.4	MS	----
Spinach	1.3	2.2	3.5	5.7	MS	----
Squash						
Scallop	2.1	2.6	3.2	4.2	MS	MT
Zucchini	3.1	3.8	4.9	6.7	MT	MT
Strawberry	0.7	0.9	1.2	1.7	S	S
Sweet Potato	1.0	1.6	2.5	4.0	MS	----
Tomato	1.7	2.3	3.4	5.0	MS	T
Turnip	0.6	1.3	2.5	4.3	MS	MT

1. Based on data from E.V. Maas. 1990. "Crop salt tolerance." In Agricultural Salinity assessment and management, ed. K.K. Tanji. ASCE Manual No. 71. ASCE.

2. sensitive (S). moderately sensitive (MS), moderately tolerant (MT), tolerant (T). and very tolerant (VT), to soil salinity, respectively.

drought tips is a publication series developed as a cooperative effort by the following organizations:

California Department of Water Resources, Water Conservation Office
University of California (UC)
UC Department of Land, Air and Water Resources
USDA Drought Response Office
USDA Soil Conservation Service
USDI Bureau of Reclamation, Mid-Pacific Region

Published 1993