Salt Tolerance of Vegetables

Catherine M. Grieve, Ph.D.

Today, shelves of supermarkets are well-stocked with colorful displays of traditional and exotic fresh vegetables, all produced under the very best management practices and, in areas of irrigated agriculture, with the very highest quality water available. The challenge to growers, irrigation specialists, and researchers in the near future will be to maintain the high quality and wide variety of vegetables available to consumers in spite of factors that may limit the use of high quality water. In the first place, supplies of high quality irrigation waters allocated for agriculture are threatened by increased competition with urban users. Secondly, in those farming areas that lack suitable drainage outlets, strategies for the on-farm reuse of saline drainage water are under development. As a consequence, growers must rely more heavily on low-quality saline water resources. Most vegetable crops are sensitive, or at best, moderately sensitive to salinity. Guidelines will be needed so that growers can select crops that are sufficiently salt tolerant to produce well under their specific field conditions.

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Measurement of Salt Tolerance

As the salt concentration in the rootzone increases above a certain threshold level, growth rate slows and the ultimate size and yield of the marketable product decreases. Salt tolerance can be measured on the basis of two parameters: the threshold (t), the electrical conductivity (EC) that causes a significant reduction in yield, and (s) the percentage of expected yield reduction for each unit of added salinity above the threshold value. Electrical conductivity is an indicator of the salinity hazard and increases in direct proportion to the salt concentration in the rootzone. Soil conductivity is generally shown as ECe and irrigation water salinity as ECi., both given in units of decisiemens per meter (dS/m). As a rule-of-thumb, ECe = 1.5 ECi. Both t and s vary among vegetable species. The more salt tolerant crops have a high threshold value and a small rate of growth decline, while sensitive crops have a low threshold and a high rate of growth decline.

The maximum yield of asparagus, the most salt-tolerant vegetable crop commercially available, occurs at a soil salinity of 4.1 dS/m (equivalent to 4.1 mmhos/cm) after which spear yield slowly declines 2 percent for each additional EC unit. At the opposite end of the salt tolerance spectrum is the sensitive bean whose yield is reduced 19 percent for every EC unit in excess of 1.0 dS/m.

Salt tolerance information for the common vegetables is far from complete, and is lacking for most of the speciality crops, such as tatsoi, radicchio, daikon, and yam. Garden orach and purslane (verdolaga) are examples of relatively salt tolerant vegetable species, but these minor crops have limited planted acreage in the United States.

Stage of Growth

Crop salt tolerance depends not only on the concentration of salts in the rootzone, but also on the stage of plant growth when salinity is applied. Although salt stress may delay plant emergence, most crops are capable of germinating at higher salinity levels than they would tolerate at later growth stages. Seedlings, however, are generally very salt sensitive, but become more tolerant with age. In practice, vegetables should be established with the best quality water available. Then, if marginal quality water must be used during part of the growing season, it should be used later, rather than earlier in the season.

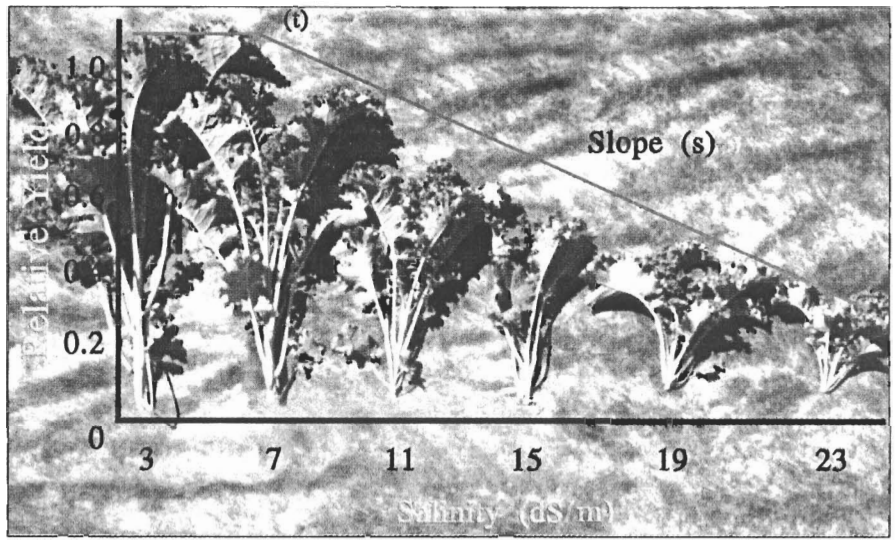


Photo courtesy of the USDA-ARS in Riverside, CA

Size of kale decreases rapidly as salt concentration in irrigation water increases.

On the positive side, irrigation with salty water does result in some beneficial effects.

Salt Effects on Yield and Quality of Vegetables

All plant parts are stunted by salinity. Roots, leafy and flowering heads, stems, and other harvested parts all exhibit characteristic decreases in size. There are, of course, exceptions. Sweet corn ear size remains unaffected at moderate salinity levels, although the number of marketable ears per plant decreases appreciably.

Salinity-related nutritional disorders may injure vegetables and reduce quality. Species whose marketable product are heads enveloped by large wrapper leaves are particularly susceptible to salt-induced injury. Salinity has been implicated in internal browning of Brussel sprouts, escarole, and Chinese cabbage, tipburn of lettuce, and blackheart of celery. Irrigation with salty water may cause blossom end-rot of tomato as well as internal rot of pepper and eggplant. Injury can often be avoided by the application of calcium-based sprays or soil amendments.

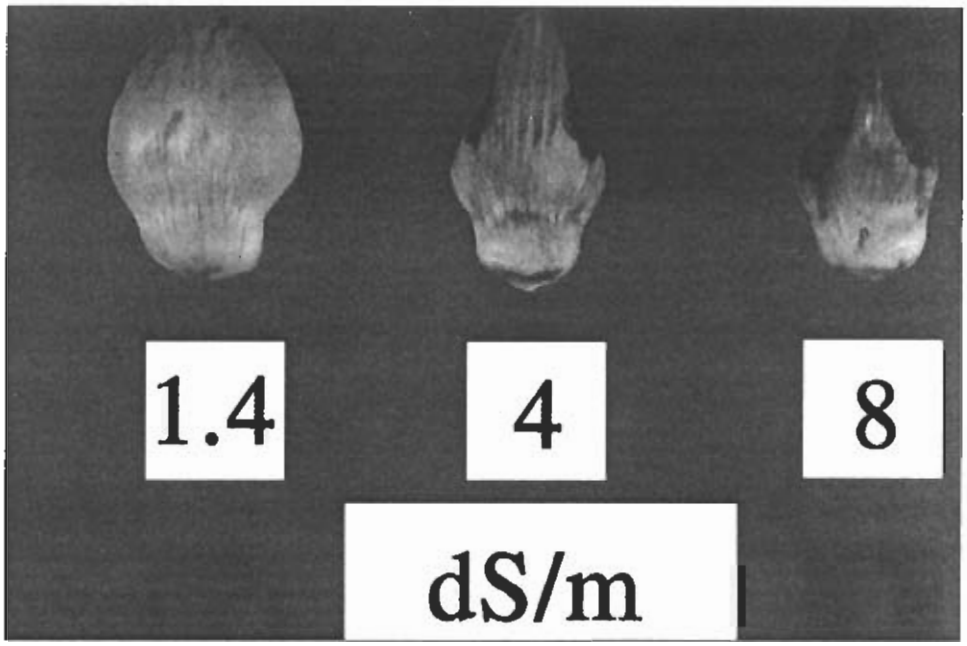
Crop salt-tolerance estimates are based on plant response during the normal season of production for crops in irrigated areas. Environmental factors, however, influence the tolerance of certain vegetables. High temperatures increase the salt sensitivity of beans, carrots, and onions, while species such as garden beets and Swiss chard are less affected. Warm, dry, windy environments, coupled with salinity, may increase the incidence of internal injury. Artichoke buds are not only smaller under these conditions, but may be unmarketable due to inner bract necrosis. In milder coastal, Mediterranean-type climates, bud injury caused by salinity is rare.

On the positive side, irrigation with salty water does result in some beneficial effects. Fewer "extra large" potatoes are produced in favor of the more commercially acceptable "large" tubers. Low to moderate salinity may increase vegetable qual-

ity. Cabbage heads are more compact, tomatoes, cucumbers, and carrots have more sugars, asparagus is more flavorful, potatoes are less starchy. Celery is more disease resistant. Color, texture, and the flavor of leafy vegetables remains highly acceptable, and their mineral nutrient composition for consumers compares favorably with values given in nutrition tables for the same vegetables grown under nonsaline conditions.

These benefits, however, do not outweigh the reduction in plant size. However, smaller size alone may not be detrimental for produce acceptability, particularly for shredded salad mixes and other convenience-food items. For certain culinary purposes, 'baby-sized' leaves can be used at any stage of maturity.

Vegetable species have a reasonable capacity for high growth under saline conditions. If, however, these vegetables are to have market potential, irrigation practices must be closely managed to control soil salinity within acceptable levels.



In hot dry climates, irrigation with salty water may cause internal necrosis of artichoke buds. All photos courtesy of USDA-ARS, George E. Brown Jr. Salinity Laboratory, Riverside, CA.

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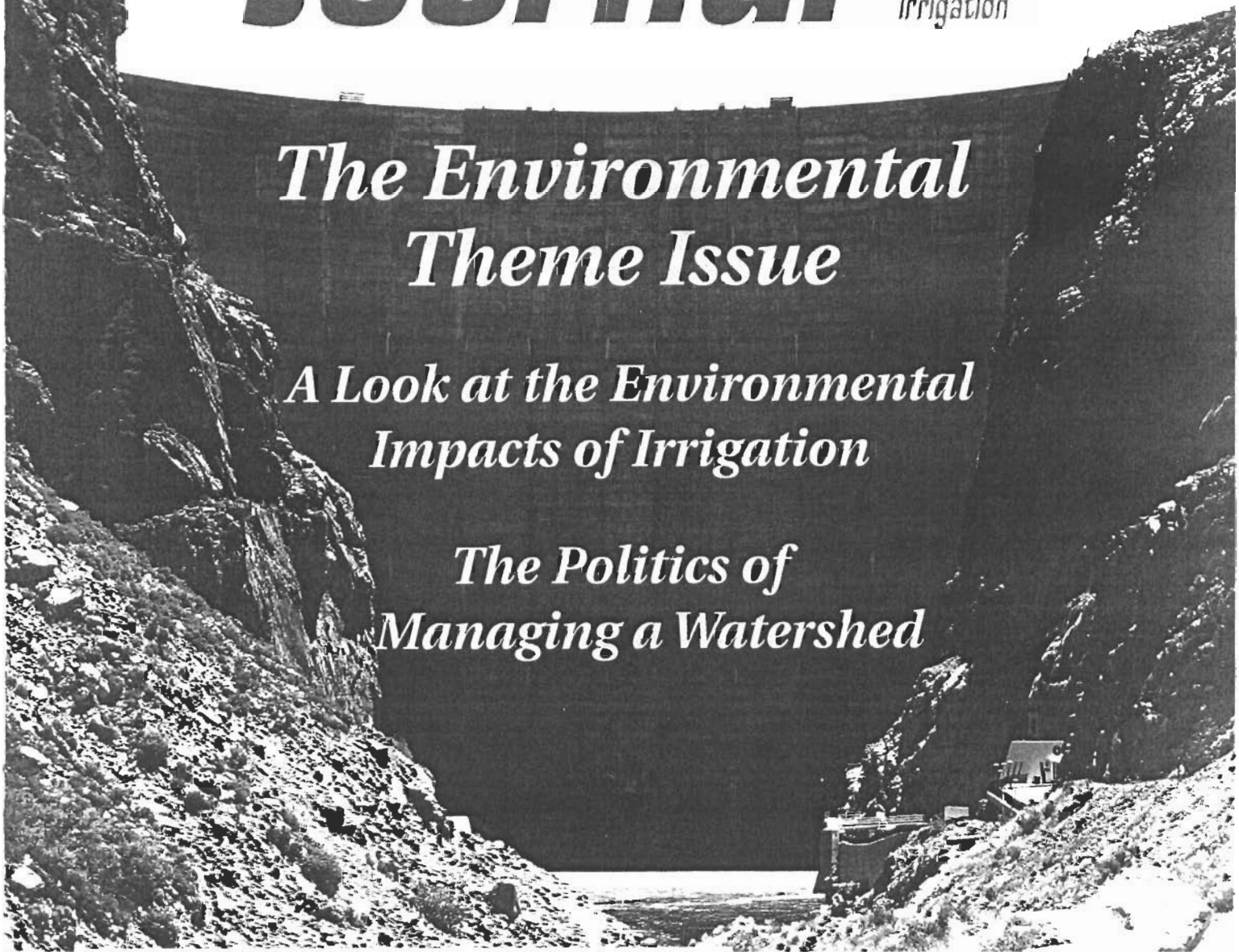

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