including those currently in use in the Carneros and MST regions. Original data listed by Maas and Hoffman (1977) are in relation to maximal Cl concentrations in the soil water, but data were converted to maximal tolerance in the irrigation water by assuming that EC of soil water is twice EC_e and that a long-term leaching fraction of 10% is achieved using high-frequency drip irrigation. These are reasonable yet conservative assumptions.

For sensitive grape cultivars (i.e., Black Rose and Cardinal), the maximum Cl concentration of irrigation water to avoid crop injury is about 7.4 meq/L (milliequivalents per liter) (table 3). Since no tolerance data have been compiled for the predominant grape rootstocks in the Carneros and MST regions (101-14, 5C, 3309 and 110R), we took a conservative approach and selected 7.4 meq/L (262 mg/L, milligrams per liter) as an upper limit for Cl in our study. As more research is conducted on these rootstocks, the limit can be adjusted accordingly. Since the Cl content in NSD water averages 4.3 meq/L (table 1), this water will not likely cause Cl toxicity in grapes, assuming good irrigation water management. If winter leaching is also taken into consideration, the case is even stronger that the recycled water will not pose a problem for vineyard production.

Sodium. The ability of vines to tolerate Na varies considerably among rootstocks, but tolerance is also dependent upon Ca nutrition. Much of the early research on Na toxicity was done in the 1940s and '50s before the importance was understood of adequate Ca nutrition for maintaining ion selectivity at the root membrane level. Since then, a considerable amount of literature has indicated Na can cause indirect effects on crops, rather than toxicity exactly, either through nutritional imbalances (e.g., Na-induced Ca or K deficiency) (Grattan and Grieve 1999) or by disrupting soil physical conditions (Ayers and Westcot 1985). These indirect effects make diagnoses of Na toxicity per se very difficult. Moreover, Na toxicity is often reduced or completely overcome if sufficient Ca is made available to roots (Ayers and Westcot 1985) through the addition of gypsum or by acidifying soils high in residual lime.

Ca addition reduces the ratio of Na to Ca (Na:Ca) in the soil water, thereby reducing the SAR and exchangeable sodium percentage (ESP), resulting in both improved soil conditions and reduced Na toxicity. Ayers and Westcot (1985) indicate that there are no "restrictions on use" provided that the SAR is less than 3. They provide no concentration limits for Na above which toxicity will result, presumably because of the indirect interactions

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Irrigation of deciduous orchards and vineyards influenced by plant-soil-water relationships in individual situations

Today this article may seem too simplistic an explanation of basic irrigation concepts — field capacity, permanent wilting point, readily available moisture. But in 1957, much more land in California was still dry-farmed, and the widespread use of irrigation was a new idea to many.


Grapes and Deciduous Fruits
Irrigation of deciduous orchards and vineyards influenced by plant-soil-water relationships in individual situations

1957 "One of the principal cultural practices in deciduous fruit orchards and vineyards is irrigation and its successful accomplishment frequently determines whether the grower makes a profit.

"The cost of irrigation — preparing the land for surface irrigation, the labor of applying the water and the cost of the water — may be one of the important items in the production of fruit. Because experience has shown that much time and labor may be wasted, the selection of a rational program of irrigation is of great importance.

"Whether to irrigate or not, or when to irrigate, are questions that can be answered only from consideration of the moisture properties of the soil, the kind of plant, its depth of rooting, the kind of root system, prevailing climatic conditions, and whether there is a supply of water for irrigation.

"A grower should consider the soil as a reservoir for the storage of water for use by the plants. Therefore, he needs to know how much readily available water can be stored in the soil. . . ."

Veihmeyer FJ, Hendrickson AH. 1957. Grapes and deciduous fruits: Irrigation of deciduous orchards and vineyards influenced by plant-soil-water relationships in individual situations. Calif Agr 11(4):13–8.

Frank J. Veihmeyer was already an emeritus professor of irrigation at UC Davis when this article was published in 1957. He joined the university in 1918 as an assistant professor of irrigation at Davis, then still known as the University Farm. Veihmeyer was recognized and honored worldwide for his research and writings on irrigation. The home of the UC Davis Department of Land, Air and Water Resources, Veihmeyer Hall, is named in his honor.

Emeritus pomologist Arthur H. Hendrickson joined the UC Berkeley faculty in 1913 as assistant in pomology, and in 1924 moved to UC's Agricultural Experiment Station so he could conduct his research full-time. Together, he and longtime research associate Frank Veihmeyer practically invented many of the irrigation science terms defined in this article, words and ideas that today are considered fundamental to understanding hydrology on the farm.

—W. J. Coats

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