participated from time to time in teaching activities, both in plant propagation laboratory sections and in the general viticulture courses. His basic activity, however, has been in propagation methods for the grapevine. This work has become very important in the last few years with the great interest in top-working vines of red grape cultivars over to white grape cultivars due to the great demand for the latter.

Our candidate has been a strong and active supporter of the IPPS Western Region from its inception, serving as the Secretary-Treasurer almost from its inception. Dr. Curtis Alley has served the Society faithfully and well for many years and richly deserves the 1980 Western Region Award of Merit

SALT TOLERANCE OF ORNAMENTALS

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Abstract. Three series of tests were conducted from 1977 through 1979 on a number of container ornamentals to determine their tolerance to salt fortified irrigation water at four different levels of salinity, 140, 300, 600 and 1200 mhos × 10^{-5} electrical conductivity (E C.) Plants were evaluated after at least five months of irrigation for their salt tolerance determined by <50% retardation, no mortality and no visual foliar burn Of the 118 cultivars tested, 29 were very tolerant, 38 were moderately tolerant, 43 were sensitive, and 8 were very sensitive

Data on the salinity tolerance of plants is becoming increasingly more important with the increased use or re-use of water and with the increased pumping of underground water causing intrusion of sea water into some aquifers (1,4,5).

Studies have been conducted by some with chlorides and sulfates only, others alternated with fertilizer salts, and some used a base nutrient + other salts. This study used either all fertilizer salt or ½ fertilizer + ½ sodium chloride (2,3,4).

The following reasons prompted us to conduct several series of experiments to screen the salt tolerance of ornamentals: 1) increasing inquiries by our customers for salt tolerant plants or information, 2) our embarking on a total water recycling system, and 3) the need for more information on salt stress of plants for trouble-shooting

MATERIALS AND METHODS

A series of tests were begun in 1977 and continued through 1979 to establish the salt tolerance of many container ornamentals. Four one-gallon plants of each cultivar or species for each of four treatments were permitted to establish for thirty days before commencing the treatments with salt-fortified irrigation water. All plants were hand irrigated. The test involved growing each set of four plants at four salinity levels of irrigation water; 140, 300, 600 and 1200 mhos $\times 10^{-5}$ E.C. The salts used for fortification of the water were:

1. 140 E.C. = all fertilizer salts (K_2SO_4 + NH_4NO_3) (2.7 N:1K)
2. 300 E.C. = ½ fertilizer salt + ½ sodium chloride
3. 600 E.C. = ½ fertilizer salt + ½ sodium chloride
4 1200 E.C. = ½ fertilizer salt + ½ sodium chloride

Fertilizer salts were used for one-half of the source of salt because in some cases, problems associated with salt injury were caused by overfertilization or by poor irrigation practices by some nurserymen in conjunction with their feeding program. The source of almost all of the K and N was the water; all of the remainder of the elements were added to the soil mix consisting basically of ⅔ redwood sawdust + ⅓ loam soil.

Classification of plants for their salt tolerance was based on not more than 50% reduction in growth associated with no visual leaf burn and of negligible mortality, if any. Interpolation was used for classification of the plant, if the tolerable salt level appeared to fall between two test levels. For example, *Bougainvillea* 'Barbara Karst' was classified to tolerate up to 1000 E.C. water even though it survived 1200 E.C. with no visual foliar burn, because at 1200 E.C. there was more than 50% reduction in growth.

RESULTS

Typical evaluations were made as follows:

Plant	Water E.C.	Percent Relative Growth	Percent Dead	Comments
Arbutus unedo	140	100	0	no burn
'Compacta'	300	80	0	no burn
(sensitive)	600	40	75	defoliation
	1200	0	100	defoliation
Bougainvillea	140	90	0	no burn
'Barbara Karst'	300	100	0	no burn
(tolerant)	600	75	0	no burn
	1200	45	0	no burn

A summary of the evaluations in the above manner are compiled in a condense manner in Tables 1, 2, 3, and 4. It should be kept in mind that the tolerances are listed on the basis of the salinity of the water, not of the soil. Soil salinity based on the saturated extract method usually indicated higher salinities than the water; in some cases two to three times higher. It must be kept in mind also that the salt tolerance might be influenced by the season. In Southern California, plants in tests conducted during the winter months will show more tolerance to higher salinity water because of the associated cool weather and added leaching from rains reducing the soil salinity level. By contrast, summer tests will show less tolerance.

Table 1. Plants exhibiting very high tolerance to salts

Plant	Maximum Irrigation Water Salinity Tolerance[1]	Percent Relative Growth	Percent Dead
Araucaria heterophylla	1000	83	0
Asparagus densiflorus 'Sprengeri'	1000	85	0
Bougainvillea 'Barbara Karst'	1000	55	0
B × buttiana 'Orange King'	1200	70	0
B 'Camarillo Fiesta'	1100	55	0
Callistemon citrinus	1000	67	0
× *Cupressocyparis leylandii*	1200	78	0
Cordyline indivisa	1200	80	0
Dietes vegeta (Syn *D iridioides*)	1200+	100	0
Festuca ovina var *glauca*	1200	60	0
Ficus microcarpa var Nitida (Syn *F nitida* Hort)	1000	70	0
Hibiscus rosa-sinensis 'Brilliant'	1000	70	0
H rosa-sinensis 'President'	1200	70	0
Juniperus chinensis 'Robusta Green'	1200	60	0
J chinensis 'Kaizuka' (Syn 'Torulosa')	1200	70	0
Platycladus orientalis aureus nanus	1200	85	0
Spartium junceum	1200	90	0
Yucca aloifolia	1200	50	0

[1] mhos $\times 10^{-5}$ electrical conductivity

Monrovia Nursery uses the low salinity San Gabriel River as their source of irrigation water and for their make-up water in their water recycling facility. In contrast, Colorado River water has a conductivity of approximately 100 mhos $\times 10^{-5}$ or 2.5 times the salt level of San Gabriel water. Consequently, if water is fortified at a suitable fertilizer salt conductivity level for salt sensitive plants, the Colorado River water would have only 41% of the useful fertilizer salt compared with that of San Gabriel River water at the same conductivity. Salt sensitive plants can be grown with poorer quality water such as that from the Colorado River; however it would be a considerably slower process and careful consideration has to be given to the type of medium and irrigation practice.

Table 2. Plants exhibiting moderate tolerance to salinity

Plant	Maximum Irrigation Water Salinity Tolerance[1]	Percent Relative Growth	Percent Dead
Agapanthus umbellatus (*A africanus* or *A orientalis*)	500	73	0[2]
Arecastrum romanzoffianum	500	83	0
Asparagus densiflorus (*A sarmentosus* of Hort)	600	100	0
Brahea edulis	600	100	25
Brunfelsia pauciflora var. *calycina*	400	73	0
Buxus microphylla var. *japonica*	500	62	0
Crassula ovata	600	75	0
Cupressus arizonica	400	59	0
Cupressus sempervirens 'Glauca'	400	100	0
Dodonea viscosa 'Purpurea'	600	70	0
Euonymus japonica 'Grandifolia'	600	90	0
Hibiscus rosa-sinensis 'Ross Estey'	800	82	25
Juniperus chinensis 'Pfitzerana'	600	50	0
Ligustrum japonicum	400	85	0
Nerium oleander 'Cherry Ripe'	600	80	0
Ophiopogon jaburan	600	100	0
Philodendron selloum	500	87	0
Pinus thunbergiana	400	100	0
Rhaphiolepis indica 'Enchantress'	500	90	0
Syzygium paniculatum	500	82	0

1 mhos $\times 10^{-5}$ electrical conductivity
2 Interpolated as no mortality; 25% mortality at 600 mhos $\times 10^{-5}$

Table 3. Plants exhibiting sensitivity to salinity

Plant	Maximum Irrigation Water Salinity Tolerance[1]	Percent Relative Growth	Percent Dead
Arbutus unedo 'Compacta'	300	80	0
Abelia × grandiflora	300	80	0
Berberis × mentorensis	300	85	0
Cedrus deodara	300	85	0
Ceratonia siliqua	300	100	0
Cinnamomum camphora	300	90	25
Clivia miniata 'French Hybrid'	300	80	0
Euonymus japonica 'Silver King'	300	100	0
Ficus benjamina	300	90	0

Table 3. Plants exhibiting sensitivity to salinity (cont'd)

Plant	Maximum Irrigation Water Salinity Tolerance[1]	Percent Relative Growth	Percent Dead
Forsythia × *intermedia* 'Spring Glory'	300	100	0
Gelsemium sempervirens	300	100	0
Ilex × *altaclarensis* 'Wilsonii'	300	85	0
Lantana 'Confetti'	300	80	0
Magnolia grandiflora	300	80	0
Nandina domestica	300	70	0
Ophiopogon japonicus	300	80	0
Pyracantha koidzumii 'Victory'	300	80	0
Podocarpus macrophyllus var *maki*	300	85	0
Washingtonia robusta	300	100	0
Yucca filamentosa	300	80	0

[1] mhos × 10^{-5} electrical conductivity

Table 4. Plants exhibiting extreme sensitivity to salinity

Plant	Maximum Irrigation Water Salinity Tolerance[1]	Percent Relative Growth	Percent Dead
Acanthus mollis 'Oak Leaf'	200	81	20[2]
Cytisus × *praecox* 'Moonlight'	250	60	0
Cedrus atlantica	200	80	30[2]
Ilex cornuta 'Dazzler'	200	68	20[2]
Mahonia aquifolium 'Compacta'	180	75	45[2]
Ensete ventricosum	250	66	0
Pittosporum tobira 'Variegata'	250	79	0
Phormium tenax 'Atropurpureum'	200	62	40[2]

[1] mhos × 10^{-5} electrical conductivity
[2] Interpolated; based on normal increase in soil salinity to 2× the conductivity of the irrigation water With proper selection of medium and leaching practice, this mortality could be reduced substantially

DISCUSSION

It was evident during the course of the tests, that those treatments receiving the higher salinity water had lower water penetration and percolation rates, indicative of sodium-saturated dispersed soil colloids.

Many plants would probably have suffered more if the salts were derived solely from NaCl. There is competitive uptake of the nutrient salts, if these are present, reducing the sodium uptake and also aiding in plant growth or retention of color.

Because excess ammonium N was present in the higher salt levels, there was a reduction in soil pH. Many of the soil samples taken from the higher salt levels had pHs ranging from 4.0 to 4.9, whereas those receiving lower levels had pHs in the 5.1 to 5.7 range.

CONCLUSIONS

1 Nutrients given at high levels help a plant tolerate high salinities better.

2. Soil salinities build up to much higher salt levels than the salinity of the irrigation water, by 2 to 3 times more.

3. High sodium levels disperse soil colloids reducing percolation and aeration.

4. High fertilizer salt levels, especially those derived from ammonium sources, reduce soil pH. Consequently, the effects on the plants may be the result of other causes in addition to the salt levels.

5. Slow overhead irrigation for several hours reduces the salinity build-up of the soil because the residence time of the water in the soil is greater. In contrast, hand watering usually builds up the salinity of the soil even if the cans are flooded and receive the *same* quantity of water.

6. Calcium reduces salt injury by:
   a) helping aggregate colloids in the soil, thereby increasing leachability.
   b) displacing sodium.

7. Abnormal levels of certain elements, such as boron, may aggravate a salinity problem.

8. Coarse soil mixes build up less salinity because they leach easily.

9. High salt levels induce some plants to flower.

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