earth ball is very different from an artificial mix ball and the care the latter receives the first two weeks after transplanting is critical.

LARRY CARVILLE: Earle, when you dig these field plants and put them in containers, do you backfill the container with soil?

EARLE MARVIN: It depends on the kind of plant. If it's a magnolia or dogwood we may just put bark in the bottom of the container. If it's a crape-myrtle, then the ball is not as deep as the container and we just put regular field soil down in the bottom.

JAKE TINGA: Another comment about the soil-root ball boundary — when you have a pasty soil and you use one of these machine diggers, the whole outside of the ball is compressed and if it's too wet you'll make an adobe brick out of it and the roots can't get out of it when it dries. I've seen pin oaks planted two years which haven't gotten out of the ball. Another thing, the burlap coming up out of the ground acts like a wick and you can induce drying in the zone around the roots in this way.

CHARLIE PARKERSON: Lin, how did you decide on your container spacing?

LIN TABER: We used trial and error. With our larger containers we try to arrive at a spacing that will allow plenty of room to work with these plants even after they are of salable size. I've found, by trial and error, that I'd rather space the plants a little wide in the beginning than have to go back and respace the beds later on. As for placing our boxes at 45° angles to the beds, our fork lift driver suggested this to save time, and it does. In our watering we are moving toward individual container watering with spitters, not drippers, because spitters are easier to see working. We have had problems with the drippers becoming plugged up or coming out of the container.

SOME WATER QUALITY PROBLEMS FACED BY HORTICULTURISTS

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Water quality is a subject of major concern to all horticulturists. Water problems to nurserymen in coastal areas relate to salt intrusion into wells and heavy salt drift, but in urban areas nurserymen are faced with high levels of chloride (Cl) and fluoride (F) in domestic water supplies. Many water resources are contaminated with numerous organic and inorganic compounds such as proteins, detergents and pesticides, which can be lethal and often serve as substrates for pathogens and other undesirable biological growth. All forms of contamination cause economic losses in nurseries by poor plant growth or death.

Soluble salts (SS) are chemical compounds formed when base ions combine with acid ions to form neutral salts. Some examples of base ions are calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K). Acid ions include sulfate (SO_4), bicarbonate (CHO_3) and chlorine (Cl). Problems of salinity arise when SS reach damaging concentrations in irrigation water and media.

Monitoring of SS is often accomplished using a Wheatstone bridge or "Solubridge" which measures electrical conductance of a solution. Acceptable and unacceptable SS values are indicated in Table 1. Sodium levels may be particularly high along coastal areas, creating serious salinity problems. Sodium absorption ratio (SAR) is a useful indicator of harmful sodium levels. SAR is obtained from the molar activities of the Na, Ca and Mg in irrigation water. Safe and hazardous SAR levels are shown in Table 1.

Table 1. Water Quality Values for Inorganic Compounds[1].

Determination and Value of Measurement	Description of Water Quality
1. Electrical Conductance (EC. $\times 10^{-3}$)	1.
a. less than 0.75 or 55 ppm	a. no salinity hazard
b. 0.76-3.0 (or 500-1500 ppm)	b. Increasing salinity hazard, especially to seedlings
c. 3.1-or above 1500 ppm	c. Usually unsatisfactory for irrigation
2. Sodium Absorption Ratio (SAR) $= \frac{Na+}{\sqrt{\frac{Ca++ + Mg++}{2}}}$	2.
a. less than 5	a. no Na hazard
b. 5 to 15	b. Increasing Na hazard
c. above 15	c. Unsatisfactory for irrigation
3. Boron	3.
a. less than 0.5 ppm	a. no hazard
b. 0.5 to 2.0 ppm	b. Injury to sensitive plants
c. over 4.0 ppm	c. Unsatisfactory for irrigation

[1] Adapted from: Furuta, T. 1974. Environmental Plant Production and Marketing. Cox Publishing Co., Arcadia, Calif.

High SS cause diffusion of water from plant cells (exosmosis) and ultimately cause cellular death. In addition, accumulation of certain ions in leaf tissue results in cellular collapse.

Foliar applications of NaCl and $CaCl_2$ at a 4.2 mmho/cm rate caused leaf burn and reduced yield of bell peppers (2). Na or Cl accumulation in shrubs probably causes injury by interfering with normal stomatal function, causing water loss and leaf injury symptoms similar to drought (3). In addition to causing severe plant cellular damage, Na also causes breakdown of soil structure (1).

Methods of dealing with salinity in order to grow plants are not totally satisfactory. Plants such as azaleas and camellias cannot tolerate the high pH values of most saline water. Phosphoric or sulfuric acid can be added to reduce pH values to acceptable levels (4). Such treatment does not correct salinity, but reduces bicarbonate content to acceptable levels for growth.

Frequent and thorough irrigations with saline water prevents accumulation of salts in growing media, and a well drained medium is essential for the volume of water required to effectively leach.

Fertilizers having a low salt index should be selected for the cultural program. Numerous fertilizers and their salt index values are listed in Table 2. As an example of fertilizer selection, potassium nitrate should be used instead of potassium chloride because it leaves less salt residues in the media.

Table 2. Salt Index of Several Fertilizer Materials.[1]

Fertilizer	Salt Index[2]	Fertilizer	Salt Index
Ammonium nitrate	105	Potassium chloride	116
Ammonium sulfate	69	Potassium nitrate	74
Calcium nitrate	53	Potassium sulfate	46
Diammonium phosphate	34	Sodium nitrate	100
Dolomite	1	Sulfate of potash-magnesium	43
Gypsum	8	Superphosphate, single	8
Lime-Calcium Carbonate	5	Superphosphate, triple	10
Magnesium sulfate	44	Urea	75
Monoammonium phosphate	30		

[1] Adapted from: Rader, Jr., L.F., L.M. White, and C.W. Whittaker. 1943. The salt index — a measure of the effect of fertilizers on the concentration of the soil solution. *Soil Sci.* 55:201-218.

[2] Salt Index compared against equal weight of sodium nitrate which was assigned a value of 100.

Deionization is sometimes used to remove salts, especially on high value ornamentals. This involves removal of anions and cations by exchange resins. The process is very expensive, and ions such as Na and boron (B) are not always completely removed. In addition, deionized water is corrosive to metals in pipes and fixtures. Water softeners should *never* be used as a remedy for "hard" or saline irrigation water, since they exchange Mg or Ca with Na which, of course, intensifies problems to plant growth.

The most plausible solution to high SS is to grow salt-tolerant plants and employ good management practices. There are compilations of foliage (9) and woody plants (6) that are tolerant of saline water.

Specific ions, particularly microelements including the heavy metals, often reach sufficient concentrations to affect water quality. B, for example, causes burning of leaves and plant losses at even low concentrations (Table 1). B is often in water supplies because of its extensive use in laundry detergents and cleaning agents. Halogens, particularly Cl and F also have negative effects on plant growth and are injected into many municipal water supplies. Some of the first research on F showed its negative effects on the keeping quality of chrysanthemums and gladiolus cut flowers (13). F has particularly adverse effects on foliage of tropical plants such as *Cordyline terminalis* (5,8). Levels as low as 0.25 ppm F in the irrigation caused leaf damage. Cl at high concentrations also results in cellular destruction (4).

Water quality is related to organic and biological activity of water. Plugging of drip irrigation tubes, mist nozzles and other irrigation equipment is often encountered using well or other natural sources of water. A severe problem is caused by a white, gelatinous sulfur slime associated with a sulfur bacteria, *Thiothrix nivea* (7). This organism occurs in water containing hydrogen sulfide and traces of dissolved oxygen. Shallow wells, 20 to 50 feet in depth, may contain both hydrogen sulfide and iron (Fe). A filamentous hydrophilic sludge is caused by oxidation and precipitation of soluble ferrous (Fe) in the water and, when iron bacteria are present, clogging of drip irrigation can occur with only 0.4 ppm of Fe in the water source (7).

Fe can be held in solution by organic materials such as tannins, phenolics and humic acids (10,11). The pH of irrigation water affects complexing of Fe on these organic materials, for Fe is more stable at a higher pH (6.5) than at a lower pH (4.0). Fe content in water can be detected using commercially available test kits with such procedures as the orthophenanthroline technique. Sophisticated filtration systems have been designed to remove some of the biological pollutants from water sources, but these are expensive and not totally effective.

Pesticides are also common contaminates of irrigation water. Many nurseries inject pesticides through irrigation systems and these are often recycled after drainage into small reservoirs. Many herbicides are damaging to plant growth and often have long residual effects (12). The best solution to this problem is a carefully planned pest control program and thorough knowledge of the potency and longevity of all pesticide materials.

Water quality and quantity are critical factors in considering the site for a plant nursery. Quality relates to the amount of physical, biological, or chemical contamination in irrigation water. Any one of these factors can severely limit plant growth and production. Correction of poor water quality is often expensive and, even with space age technology, is not totally effective.

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