Water Quality and Treatments

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WHILE MANY CHALLENGES IN GREENHOUSE PRODUCTION ARE BEYOND OUR CONTROL, POOR WATER QUALITY SHOULD NOT BE ONE OF THEM.

By John M. Dole

Growing and selling plants in today's market can be challenging for many reasons outside of our control, such as the weather and the economy. One factor, however, is under our control and should not be a problem — poor quality water. Water high in alkalinity or salts will cause a host of problems during production: poor root growth, chlorotic or necrotic foliage, missed timing from slow growth and more. These problems can all be prevented.

Testing

The first step is to test your water. Water samples can be commercially tested through the cooperative extension service or a laboratory; the pH and EC can be determined in-house. Test your water more than once, because the quality can change seasonally or over time.

Electrical Conductivity

One of the most important factors is the electrical conductivity (EC), a measure of soluble salts. The greater the soluble salt concentration, the more easily an electrical current will pass through a water solution. Water with a low EC, 0.2 to 0.5 $mS \bullet cm^{-1}$ (1 $mS \bullet cm^{-1}$ = 1 $dS \bullet m^{-1}$ = 1 mmho/cm = 100 mmho x 10^{-5}/cm = 1000 µmho/cm = 640 to 700 ppm) will give you the greatest number of irrigation options and will reduce future problems from the accumulation of high soluble salts in the root substrate. Plant species vary in their tolerance to high substrate EC, which can stunt plant growth, cause marginal leaf burn and increase the likelihood of root and crown diseases. Plugs are especially sensitive to high EC due to the low substrate volume. Water with an EC of 0.75 $mS \bullet cm^{-1}$ or higher will be too high for plug production and 1.5 $mS \bullet cm^{-1}$ or higher will be problematic for general plant production.

pH and Alkalinity

The irrigation water pH should be 5.5 to 6.8 and alkalinity should be between 0.8 and 1.3 millequivalent/liter (me/l) or between 40 and 65 ppm. pH is a measure of the concentration of H+ in a solution and

is measured on a scale from 0 to 14. Alkalinity is typically assumed by most laboratories to be equal to the total carbonate and bicarbonate content of the water, expressed as calcium carbonate ($CaCO_3$). Other ions also contribute to alkalinity but are usually present in low concentrations. Carbonates include calcium carbonate and various bicarbonates, which include calcium bicarbonate, sodium bicarbonate and magnesium bicarbonate. Thus, irrigating with water that is high in alkalinity is equivalent to applying lime (calcium and magnesium carbonate) to the substrate.

Typically, water alkalinity determines if substrate pH will change and how quickly that change will occur. Water high in alkalinity usually has a high pH, but moderate to low pH water can have high alkalinity. Thus, water alkalinity is more important to consider than water pH. At excessively high or low substrate pH, some plant nutrients will be unavailable for the roots to absorb. High water pH can also reduce the solubility of some fertilizers, pesticides and plant growth regulators.

High water alkalinity may be a problem depending on the crop production time, container size, and crop species. The increase in substrate pH due to alkalinity will not be a problem for many bedding plants due to short crop times; however, the pH increase will be a problem for the long-term


Reverse osmosis system in a commercial greenhouse.

Table 1. Classification of water alkalinity and associated options for prevention of alkalinity related problems.

Alkalinity range (me/l)	Class	Management Strategies
0 to 1	Low	• Pure water with little buffering capacity • Monitor substrate pH regularly • Rotate between acidic and basic fertilizers as needed • If alkalinity is too low, use extra lime in the substrate or inject potassium bicarbonate at 0.12 $g \cdot l^{-1}$ (0.1 lbs/100 gal).
1 to 3.6	Acceptable for:	• Acceptable rate varies with container size. • Rotate between acidic and basic fertilizers as needed and/or lower rates of lime in the substrate. • If fertilizer rotation is inadequate, inject phosphoric, sulfuric or nitric acid. Use sulfuric or nitric if the additional P from phosphoric acid is not desired.
1 to 1.5	Plugs	
1.6 to 2.4	Small pots	
2.0 to 2.8	4- to 5-inch pots	
2.4 to 3.6	6 inch or larger pots	
1.5 to 4	Marginal	• Range depends on pot size. • Use acidic fertilizers and/or lower rates of lime in substrate. • If the use of acidic fertilizers is inadequate, inject phosphoric, sulfuric or nitric acid. Use a sulfuric or nitric if the additional P from phosphoric acid is not desired.
1.5 and higher for plugs		
2.4 and higher for small pots		
2.8 and higher for large pots		
4 to 8	High	• Inject one or more of the following depending on the desired nutrient rates: phosphoric, sulfuric or ntric acid.
8 or greater	Very high	• Use reverse osmosis.

Low pH induced iron/manganese toxicity on lower gerbera leaf.

production of many potted and cut flower crops. While plugs are a short-term crop, they are particularly sensitive to high substrate pH due to the small container volume. High water alkalinity can cause the pH of plugs to rapidly rise to unacceptable levels. Regardless of the level, alkalinity is too high anytime it causes the substrate pH to rise to an unacceptable level.

Several control options are available for high alkalinity (Table 1). For growers who use basic fertilizers such as calcium nitrate and potassium nitrate the water pH and alkalinity can be on the low end of the recommended range to prevent the substrate pH from increasing to unacceptable levels during production. Growers who use acidic fertilizers, especially in warm climates, can readily use water with the pH and alkalinity in the center or upper part of the recommended range for an individual species.

Producers can rotate among acidic and basic fertilizers. According to Paul Fisher and his group at the University of Florida, fertilizers high in ammonium levels will be strongly acidic and those high in urea will be weakly acidic. Nitrate-based fertilizers will tend to be weakly basic. Thus, it is easier to reduce substrate pH through fertilizer selection than it is to increase substrate pH. For those trying to reduce substrate pH, high ammonium fertilizers are not feasible in some situations. High ammonium fertilizers should not be used when the substrate temperature is below 55° F due to slow conversion of ammonium to nitrates by nitrifying bacteria in the substrate. Ammonium can also produce excessive growth, which can counteract height control measures for some crops.

For high alkalinity levels, acid injection may be required. If the alkalinity is 8 me/l or greater, then reverse osmosis may be the only option.

Nutrient Content

Water that is specifically high in calcium and magnesium is known as hard water (hardness of 150 ppm or higher). Most plant species are tolerant to high calcium and magnesium levels, but overhead irrigation with hard water can leave unsightly white salt deposits on the foliage, especially with mist propagation.

Finally, the nutrient content of the water should be checked. While low levels of some nutrients can be beneficial, high levels of one or more nutrients may indicate that the nutrition program should be adjusted. If the water has high levels of nitrogen, calcium or magnesium, less of those nutrients can be added as fertilizers. High nitrogen levels can be especially prevalent in areas with sandy soil, shallow wells or intensive agriculture. Unfortunately, high levels of calcium, magnesium and iron can be antagonistic to other nutrients such as manganese or boron and reduce their uptake. Also, very high boron levels, greater than 1 ppm, can be toxic.

Water Treatments

A number of options exist if the water quality is poor. The first option is to locate another source of water which has higher quality, such as municipal, well or surface water, for example from a pond. In addition, rain water can also be collected. If using poor quality well water, check with a hydrologist to see if another well could be drilled; water quality can vary with the depth of the well. Often it is difficult and expensive to find another water source and water treatments will need to be considered.

> Always pour acid into water — not water into acid.

Reverse Osmosis

Reverse osmosis is the most commonly used method for producing low EC water. Reverse osmosis (RO) forces water through a semi-permeable membrane, leaving 90 to 99 percent of the soluble salts behind. One drawback to reverse osmosis is the large quantity of waste water produced, which contains high amounts of salts. Disposal of this brine should be handled carefully due to environmental and regulatory concerns. Also, proper filtration and maintenance is essential for efficient operation of an RO unit. Other pretreatments may be necessary including chlorination and acid injection. After RO treatment the resulting water has a low pH, around 5, with little or no alkalinity. RO-treated water is usually too pure and too expensive to use directly on crops and is often blended back with untreated water to raise the pH and alkalinity to the desired level.

Reducing Problems from High EC Water

If water treatment is not an option for handling water with a high EC, cultural practices can be used to reduce the problem. Increased leaching rates will prevent soluble salts from building up in the substrate and will prevent plant damage. High EC water is particularly difficult on the production of seedlings and cuttings. Growers may need to buy plugs and rooted cuttings instead of propagating their own plant materials, or use high-quality water for propagation. For firms recirculating irrigation water, the use of controlled-release fertilizers can also be used to reduce the nutrient content of water. Generally, proper use of controlled-release fertilizers will allow a greater percentage of the nutrients applied to be taken up by the plant. Consequently, less fertilizer is leached out of the pots with controlled-release fertilizers which helps to keep the EC of the recirculated water low.

High substrate EC induced marginal necrosis on lower poinsettia leaf.

Acid Injection

Water with a high pH can be easily adjusted by injecting phosphoric, nitric, or sulfuric acid into the water. The higher the alkalinity, the more acid needed to reduce the pH. The acid converts the bicarbonates and carbonates to carbon dioxide gas which allows the pH to decrease. Phosphoric acid, however, is relatively weak and often stronger acids such as nitric or sulfuric acid are needed. If either phosphoric or nitric is used, be sure to adjust the nutritional program because of the added nitrogen or phosphorous. The amount of acid required is based on the amount of bicarbonate in the irrigation water. Citric acid can also be used on plugs, but it is expensive.

Remember, acids are dangerous and proper care and injection equipment must be used. Always pour acid into water — not water into acid! Wear protective clothing and use non-metal containers and pipes because acid can corrode metals. Acids should be injected into the irrigation water separate from fertilizers using dual-headed injectors.

Specific Nutrients

Water can occasionally be high in specific nutrients without having a high overall salt content which would require reverse osmosis. Specific treatments may be needed if the water is especially high in iron, manganese, calcium, magnesium, fluoride, chlorine and boron.

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