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WATER QUALITY: Its Impacts on Plant Production

Text and photos by

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Simple tests can determine what's in your water supply, and simple adjustments can help you achieve the proper balance for healthy plants.

Water quality has significant effects on the growth, quality and nutrition of containerized plant production in greenhouses and nurseries. In the context of plant production, "water quality" refers to the chemical properties of the water and its effects on plants rather than its suitability for drinking. Three aspects of irrigation water quality are of particular importance in greenhouse and nursery production: pH and alkalinity, calcium and magnesium content, and the levels of sodium and chloride.

What's the difference between pH and alkalinity? Alkalinity and pH are two important factors in determining the suitability of water for irrigating plants. The pH is a measure of the concentration of hydrogen ions (H^+) in water or other liquids. In general, water for irrigation should have a pH between 5 and 7. Water with pH below 7 is termed "acidic," and water with pH above 7 is termed "basic"; pH 7 is "neutral." A pH test by itself is useful, but it's not a good indicator of the growing-medium pH, as water is only one factor that influences this element. Other factors are the acidic or basic nature of the solids in a mix, liming rate, acidic or basic fertilizer, and plant root activity.

Alkalinity is a measure of the water's ability to neutralize acidity. An alkalinity test measures the level of bicarbonates, carbonates and hydroxides in water, and test results are generally expressed as "ppm (parts per million) of calcium carbonate ($CaCO_3$)." The desirable range for irrigation water is 0 to 100 ppm $CaCO_3$. Levels between 30 and 60 ppm $CaCO_3$ are considered optimum for most plants.

A water pH test is not a good indicator of alkalinity. Water tests should always include *both* pH and alkalinity tests. Water with high alkalinity (i.e., high levels of bicarbonates or carbonates), sometimes called hard water, always has a pH value 7

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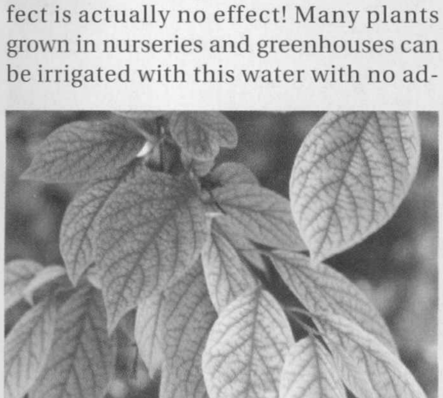
Calibrachoa × *hybrida* (trailing petunia) shows symptoms of iron deficiency, which is often the result of irrigation with high pH, high alkalinity water.

or above, but water with high pH doesn't necessarily have high alkalinity.

In some places, it's quite common for irrigation water to have a high pH (7 to 8) and low alkalinity (less than 100 ppm $CaCO_3$); however, in many cases both pH and alkalinity may be high. What management steps to take depend on which type of water you have and what plants you are growing.

High pH and low alkalinity. Water with high pH (7 to 8) and low alkalinity (less than 100 ppm $CaCO_3$) has several potential effects and required actions. One effect is actually no effect! Many plants grown in nurseries and greenhouses can be irrigated with this water with no adverse effects on growth or quality. The only required action would be to test the water several times a year to make sure there are no large or sudden changes in pH or alkalinity.



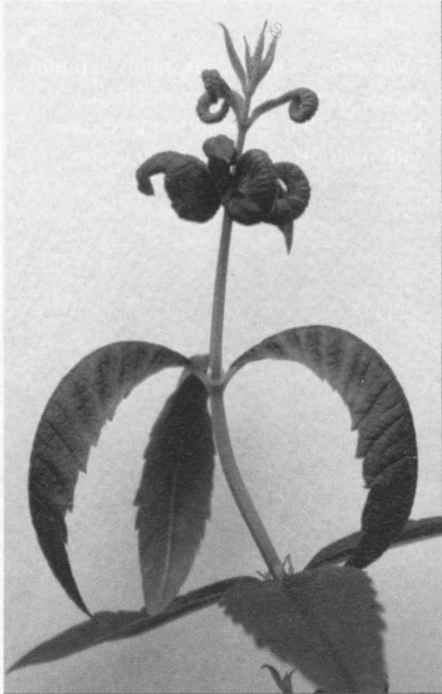
A young liner of *Halesia carolina* (*Carolina silverbell*) is an "acid-loving" woody plant that can develop iron deficiency when pH is too high.

Sometimes, plug seedlings or liners develop chlorosis with high pH, low alkalinity water. Some species, like *Vinca*, *Petunia* and *Calibrachoa*, prefer a low growing-medium pH. Growing media in the very small cell volumes of plug trays and other containers used to root cuttings or start seed is poorly buffered to pH change, and pH may increase with high pH water. Normally, this problem can be solved by using an acidic fertilizer, like 20-10-20, or other fertilizers that are no more than 50 percent nitrate-nitrogen. However, if a large part of a business is producing plugs or liners for sale, water acidification may be necessary if chlorosis is a chronic occurrence. In this case, only species showing chlorosis should be irrigated with acidified water.

High pH and high alkalinity. High pH (7 to 8) and high alkalinity (well above 100 ppm $CaCO_3$, say 150 or more) irrigation water has the most serious effects on species that require low growing-medium pH and are prone to iron-deficiency chlorosis. Many important greenhouse and nursery crops share this requirement and problem (photos, above, right, left). Irrigating with high alkalinity water increases growing-medium pH because of the "liming effect" caused by the carbonates and bicarbonates (sources of alkalinity) in the water. Corrective actions are aimed at lowering growing-medium pH by using acidic fertilizers, avoiding overliming and, in some cases, by water acidification. Also, application of an iron chelate fertilizer solution to prevent or correct iron chlorosis is a very effective action; however, the effect of iron chelate can wear off after plants leave the production facility for marketing.

This petunia shows signs of iron deficiency, but a complete soil test, including pH, should be done to make sure it is not nitrogen deficiency or another problem.

The key is to remember that corrective actions aimed at lowering pH are not meant for all plants, but rather those sensitive to high pH or susceptible to



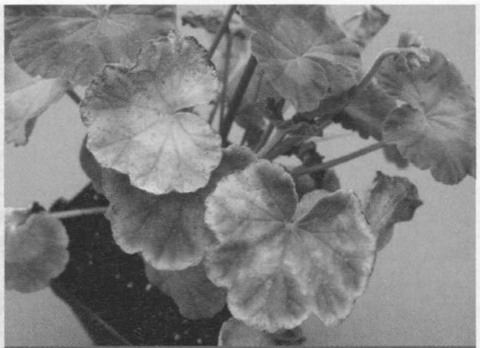
Aloysia triphylla (herb lemon verbena) is sensitive to calcium deficiency. The "pig-tailed" upper leaves illustrate how calcium deficiency affects the growing points of plants.

iron deficiency. No action would be needed for many greenhouse and nursery crops because they are not susceptible to iron chlorosis.

Irrigating with high pH, high alkalinity water can be beneficial for crops, such as marigold and geranium (photo, above right), that are susceptible to iron (Fe) and manganese (Mn) toxicities. The increase in growing-medium pH caused by watering with high pH, high alkalinity water makes Fe and Mn less available for plant uptake and reduces the accumulation of toxic amounts of these elements in the leaves.

Water pH and chemical sprays. Water pH is a critical factor in the effectiveness of some insecticide, fungicide and growth-regulator sprays. Many materials work best when mixed in acidic water, while a few perform best in a neutral or higher pH. The Ohio State University's floriculture Web site has a list of pesticides and growth regulators with their ideal water pH range (http://floriculture.osu.edu/archive/apr04/SpraySolutionPH.html).

Pesticides, such as carbamates, organophosphates, synthetic pyrethroids, chlorinated hydrocarbons, ethephon growth regulator and others, undergo a chemical reaction called hydrolysis, which causes them to break down in water with a pH greater than 7. The more alkaline the water, the more rapidly the pesticide breaks



A geranium shows symptoms of iron/manganese toxicity. This problem occurs when growing medium is too acid — pH 5.5 or less. Don't apply acidified irrigation water or iron chelate fertilizer to plants susceptible to micronutrient toxicity.

down. Hydrolysis can be very fast when the pH of the water is greater than 8 and 9; for every unit increase in pH, the rate of hydrolysis increases 10 times. Some pesticides begin to break down as soon as they are combined with high pH water.

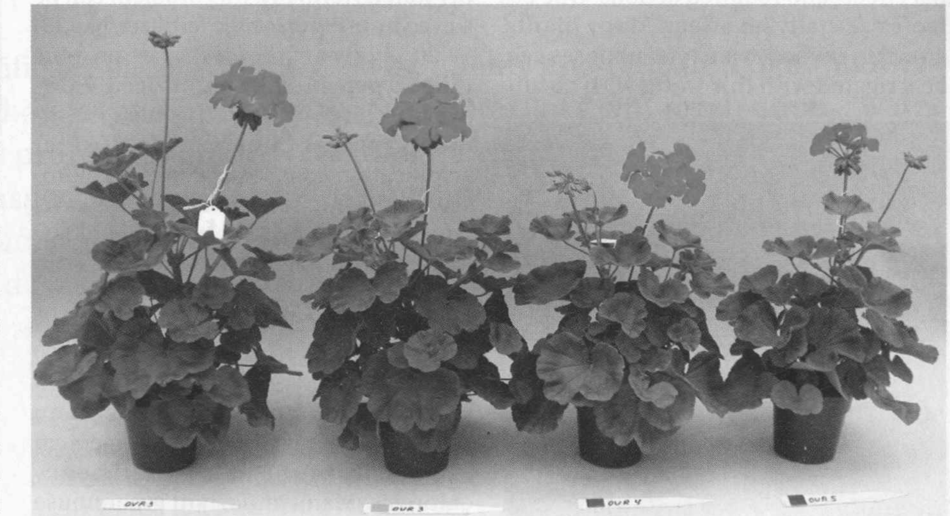
The rate and severity of the reaction is determined by how susceptible the pesticide is to hydrolysis, the amount of time the pesticide is in contact with water (pH less than 7) and the temperature of the diluted pesticide mixture. For example, if a spray tank is allowed to stand several hours or overnight before the contents are used, as much as 50 percent of the active ingredient may be lost.

If your water pH is above 7, adding a buffering (acidifying) agent is the easiest way to change the pH of the water for mixing pesticides that require a low pH. Buffering agents are available from greenhouse and nursery supply companies, and they prevent pesticide hydrolysis during mixing and storage in the spray tank. Buffering agents should not be used with pesticides containing fixed copper or lime, such as copper sulfate or lime sulfur. Too much of a buffer will cause the water to be too acid, and it can be phytotoxic to your plants. A pH of 6 is satisfactory for most pesticides. Appropriate pH adjustment will increase the effectiveness of pesticide treatments and this, in the long term, will also reduce the number of treatments, pesticide resistance and potential of harm to the environment.

Calcium and magnesium. Calcium (Ca) and magnesium (Mg) are both important plant-essential elements. When Ca is deficient, the growing points are affected, resulting in poor flower development, poor root growth or stunting, or abnormal development of new growth (photo, far left). Mg deficiency causes interveinal yellowing on the lower leaves of most species.

Only a few of the many water-soluble fertilizers available for ornamentals provide Ca and Mg because of solubility problems. Therefore, plants often must rely on limestone incorporated in the growing medium and irrigation water to satisfy their Ca and Mg requirement. For many species, Ca and Mg from limestone and water may be adequate, but for plants that are susceptible to deficiencies of these elements, limestone and low Ca and Mg in water alone may not be adequate to prevent deficiency.

High-alkalinity water normally contains significant quantities of both Ca and Mg, reducing the likelihood of deficiency. However, low-alkalinity water generally contains very little Ca and Mg. Growers irrigating with low-alkalinity water should include a so-called "cal-mag" fertilizer in their fertilizer programs or make supple-



Sometimes, elevated sodium chloride in irrigation water can reduce plant growth without causing foliar symptoms. The salinity of the irrigation water applied to these geraniums increases from left to right.

mental applications of calcium nitrate and magnesium sulfate to prevent Ca and Mg deficiency.

Sodium and chloride. Growers in arid regions of the US are accustomed to managing irrigation water containing significant quantities of sodium (Na) and chloride (Cl). Acceptable levels of Na and Cl for ornamentals are less than 50 ppm and less than 140 ppm, respectively. Many growers in the northern US who test their water are surprised to find Na and Cl levels that exceed the acceptable levels. The most likely source of Na and Cl here is road salt, but water softeners and some fertilizers may be contributors.

Na and Cl can be directly toxic to plants, may contribute to raising the soluble salts level of the growing medium or may inhibit water uptake by plants. Plant problems include injury from excess soluble salts, growth reduction, foliar chlorosis and increased susceptibility to disease. Sometimes, plants show no foliar symptoms, but do not meet their normal growth potential — as in the case of geranium treated with elevated Na and Cl (photo, page 28).

A University of Massachusetts Extension greenhouse water study found that water from shallow, private wells and private ponds was the most likely to contain elevated Na and Cl due to road salt contamination. The contamination was most acute when these sources were located close to a road or parking lot. Na and Cl levels were highest in the spring when runoff from snowmelt was highest and in the summer of droughty years when wells and ponds were drawn down. Municipal water generally had acceptably low Na and Cl levels, probably because road salt applications are reduced in areas close to public wells and reservoirs.

Growers who believe their private water sources are vulnerable to contamination or who think their plants are experiencing high Na and Cl problems need to confirm their suspicions by water testing on a routine basis during the production season. If Na and Cl levels remain significantly above acceptable levels for weeks at a time, then some remedies should be considered. Remedies for road salt contamination are expensive and include water treatment by reverse osmosis, drilling deeper wells farther from roads and parking lots, or switching to municipal water if it's available.

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